PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install portable dock equipment as required for a complete installation.

B. Adjust portable dock equipment to function smoothly and safely, lubricate as recommended by manufacturer.

C. Test lifts for vertical travel and adjust to maintain operating range indicated.

D. After completing installation of exposed, factory-finished portable dock equipment, inspect exposed finishes and repair damaged finishes.

3.2 DEMONSTRATION

A. Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain portable dock equipment as directed.

END OF SECTION 111323

SECTION 111916 - DETENTION GUN LOCKERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes pistol lockers.

1.2 COORDINATION

A. Detention Specialist: Coordinate with Section 013513.16 "Special Project Procedures for Detention Facilities" for requirements of this Section that are to be performed by a Detention Specialist or other entity.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: Include plans, elevations, sections, and attachment details.

D. Samples: For factory-applied color finishes.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Anchor inspection reports.

C. Field quality-control reports.

1. Field quality-control certification signed by Contractor and Detention Specialist.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."

3. AWS D1.6/D1.6M, "Structural Welding Code - Stainless Steel."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

2.2 PISTOL LOCKERS

A. Cabinet: Minimum 20 inches (508 mm) wide by 15 inches (381 mm) high by 10 inches (254 mm) deep; formed from 0.134-inch (3.42-mm) nominal-thickness steel sheet or 0.141-inch (3.57-mm) nominal-thickness stainless-steel sheet as directed. Line each compartment with mothproofed felt or nonabsorbing, closed-cell padding.

1. Compartments: Six.

B. Doors: Formed from 3/16-inch- (4.8-mm-) thick steel plate, 0.180-inch (4.55-mm) nominal-thickness steel sheet, same material as cabinet as directed, supported by heavy-duty continuous bottom hinge.

C. Locks: As directed Snap or Cylinder type, keyed differently and master keyed; provide one lock for each compartment.

1. Lock Preparation: Prepare door panel to accept cylinder specified in Section 087163 "Detention Door Hardware."

D. Mounting: Surface or Recessed, with mounting flange formed from same material as body as directed.

E. Materials:

1. Steel Plates, Shapes, and Bars: ASTM A36/A36M.
2. Cold-Rolled Steel Sheet: ASTM A1008/A1008M, CS (Commercial Steel), Type B; suitable for exposed applications.
3. Hot-Rolled Steel Sheet: ASTM A1011/A1011M, CS (Commercial Steel), Type B; free of scale, pitting, or surface defects; pickled and oiled.
4. Stainless-Steel Sheet, Strip, Plate, and Flat Bars: ASTM A666 or ASTM A240/A240M, austenitic stainless steel, Type 304.

F. Finishes: Steel Factory Prime Finish or Steel Baked-Enamel or Powder-Coat Finish as directed.

1. Color and Gloss: As indicated by manufacturer's designations, Match Architect's sample or as selected by Architect from manufacturer's full range.
2. Stainless-Steel Finish: No. 3.

2.3 FABRICATION

A. Shop Assembly: Preassemble items in shop to greatest extent possible to minimize field splicing and assembly.

B. Coordinate dimensions and attachment methods of detention gun lockers with those of adjoining construction to produce integrated assemblies with closely fitting joints and with edges and surfaces aligned unless otherwise indicated.

C. Shear and punch metals cleanly and accurately. Remove burrs.

D. Form and grind edges and corners to be free of sharp edges or rough areas.

E. Form metal in maximum lengths to minimize joints. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing the Work.

F. Weld corners and seams continuously to comply with referenced AWS standard.

G. Provide for anchorage of type indicated; coordinate with supporting structure. Fabricate and space anchoring devices to secure detention gun lockers rigidly in place and to support expected loads.

H. Cut, reinforce, drill, and tap detention gun lockers as indicated to receive hardware, fasteners, and similar items.

I. Form exposed work true to line and level with accurate angles, surfaces, and straight sharp edges.

J. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners where possible.

2.4 ACCESSORIES

A. Concealed Bolts: ASTM A307, Grade A unless otherwise indicated.

B. Cast-in-Place Anchors in Concrete: Fabricated from corrosion-resistant materials capable of sustaining, without failure, a load equal to 4 times the load imposed, as determined by testing according to ASTM E488/E488M, conducted by a qualified testing agency; of type indicated below.

1. Threaded or wedge type; galvanized ferrous castings, either ASTM A47/A47M malleable iron or ASTM A27/A27M cast steel. Provide bolts, washers, and shims as needed; hot-dip galvanized according to ASTM A153/A153M or ASTM F2329/F2329M.

C. Embedded Plate Anchors: Fabricated from mild steel shapes and plates, minimum 3/16 inch (4.8 mm) thick; with minimum 1/2-inch- (12.7-mm-) diameter, headed studs welded to back of plate.

D. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Inspect built-in and cast-in anchor installations before installing detention gun lockers, to verify that anchor installations comply with requirements. Prepare inspection reports.

B. Fastening to In-Place Construction: Provide anchorage devices and fasteners where necessary for securing detention gun lockers to in-place construction. Include threaded fasteners for concrete and masonry inserts and other connectors.

C. Cutting, Fitting, and Placement: Obtain manufacturer's written approval for cutting, drilling, and fitting required for installing detention gun lockers. Set detention gun lockers accurately in location, alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack; and measured from established lines and levels.

D. Provide temporary bracing or anchors in formwork for items that are to be built into concrete or masonry or similar construction.

E. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations.

F. Adjust doors and latches of detention gun lockers to operate easily without binding. Verify that integral locking devices operate properly.

G. Assemble detention gun lockers requiring field assembly with security fasteners with no exposed fasteners on exposed faces and frames.

3.2 FIELD QUALITY CONTROL

A. Inspect installed products to verify compliance with requirements. Prepare inspection reports and indicate compliance with and deviations from the Contract Documents.

B. Prepare field quality-control certification, endorsed by Detention Specialist, that states installed products and their installation comply with requirements in the Contract Documents.

END OF SECTION 111916

SECTION 113013 - RESIDENTIAL APPLIANCES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cooking appliances.
2. Kitchen exhaust ventilation.
3. Refrigeration appliances.
4. Cleaning appliances.
5. Trash compactors.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

C. Samples: For each exposed product and for each color and texture specified.

1.4 INFORMATIONAL SUBMITTALS

A. Product certificates.

B. Field quality-control reports.

C. Sample warranties.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

A. Gas-Fuel Conversion: Provide gas-fueled appliances with manufacturer's high-altitude and propane conversion kit installed by a qualified service agency according to manufacturer's written instructions for Project location and type of fuel.

1.7 WARRANTY

A. Special Warranties: Manufacturer agrees to repair or replace residential appliances or components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: As directed Two or Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Appliances: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Gas-Fueled Appliances: Certified by a qualified testing agency for each type of gas-fueled appliance according to ANSI Z21 Series standards.

2.2 COOKTOPS

A. Electric Cooktop CT #:
1. Electric Burner Elements: As directed Two, Four or Six coil, radiant or induction-type burners.
2. Top Material: As directed Manufacturer's standard, Ceramic glass, Porcelain-enameled steel or Stainless steel.

B. Gas Cooktop CT #:
1. Gas Burners: As directed Two, Four or Six.
2. Top Material: As directed Manufacturer's standard, Ceramic glass, Porcelain-enameled steel, Stainless steel.

2.3 RANGES

A. Electric Range RG #: As directed Freestanding, Slide-in or Drop-in range with one or two oven(s) and complying with AHAM ER-1.
1. Electric Burner Elements: As directed Four or Six coil, radiant or induction-type burners.
2. Anti-Tip Device: Manufacturer's standard.
3. Material: As directed Porcelain-enameled or Stainless steel with manufacturer's standard or ceramic-glass cooktop.

B. Gas Range RG #: As directed Freestanding or Slide-in range with one or two oven(s).
1. Gas Burners: As directed Four or Six.
2. Anti-Tip Device: Manufacturer's standard.
3. Material: As directed Porcelain-enameled, Stainless steel with manufacturer's standard or ceramic-glass cooktop.

C. Dual Fuel Range RG #: Freestanding, Slide-in range with gas burners and one or two electric oven(s).
1. Gas Burners: As directed Four or Six.

2. Anti-Tip Device: Manufacturer's standard.
3. Material: As directed Porcelain-enameled or Stainless steel with manufacturer's standard or ceramic-glass cooktop.

2.4 WALL OVENS

A. Electric Wall Oven WO #: As directed One or Two-oven unit.
1. Mounting: As directed Built-in wall or undercounter.
2. Capacity: 3.3 cu. ft. (0.09 cu. m).
3. Material: As directed Porcelain-enameled steel, Stainless steel or Manufacturer's standard.

B. Gas Wall Oven WO #: As directed One or Two-oven unit.
1. Mounting: As directed Built-in wall or undercounter.
2. Capacity: 3.3 cu. ft. (0.09 cu. m).
3. Material: As directed Porcelain-enameled steel, Stainless steel or Manufacturer's standard.

2.5 MICROWAVE OVENS

A. Microwave Oven MO #:
1. Mounting: As directed Undercabinet or Wall cabinet.
2. Capacity: 1.5 cu. ft. (0.04 cu. m) or 2.0 cu. ft. (0.06 cu. m).
3. Exhaust Fan: As directed Variable, Two or Four-speed fan, vented to outside, non-vented, recirculating type with charcoal filter and with manufacturer's standard capacity.
4. Microwave Power Rating: Manufacturer's standard or 1000 W, as directed.
5. Material: As directed Porcelain-enameled steel, Stainless steel or Manufacturer's standard.

2.6 KITCHEN EXHAUST VENTILATION

A. Overhead Exhaust Hood EX #:
1. Type: As directed Wall-mounted, Suspended-island-canopy, exhaust-hood system.
2. Exhaust Fan: As directed Variable, Two or Three-speed fan built into hood, remotely located, with separate housing and with manufacturer's standard, 500-cfm (236-L/s), 900-cfm (425-L/s) capacity.

a. Venting: Vented to outside through roof, Vented to outside through wall, Non-vented, recirculating type with charcoal filter or as indicated on Drawings.

3. Finish: Baked enamel or Stainless steel as directed.

2.7 REFRIGERATOR/FREEZERS

A. Refrigerator/Freezer RF #: One-door refrigerator with freezer compartment inside, Two-door, side-by-side refrigerator/freezer, Two-door refrigerator/freezer with freezer on top or Two-door refrigerator/freezer with freezer on bottom and complying with AHAM HRF-1

1. Type: As directed Freestanding, Built in, Undercounter.
2. Storage Capacity:

    a. Refrigeration Compartment Volume: 15.6 cu. ft. (0.44 cu. m).
    b. Freezer Volume: 5.13 cu. ft. (0.15 cu. m).

3. General Features:

    a. Dispenser in door for ice and cold water with dispenser lock.
    b. Interior light in refrigeration compartment.
    c. As directed Automatic or Manual defrost.
    d. Interior light in freezer compartment.
    e. Automatic icemaker and storage bin.

4. ENERGY STAR: Provide appliances that qualify for the EPA/DOE ENERGY STAR product-labeling program.
5. Front Panel(s): As directed Manufacturer's standard, Wood panel(s) to match kitchen cabinets, Porcelain enamel, Stainless steel, Wood-panel insert(s) specified in Section 064113 "Wood-Veneer-Faced Architectural Cabinets" to match kitchen cabinets, Wood-panel insert(s) specified in Section 123530 "Residential Casework" to match kitchen cabinets or Reversible panel(s) with choice of colors.

2.8 FREEZERS

A. Freezer FR #: As directed One or Two freezer compartment(s) with door(s) configured as pull-out drawer(s) and complying with AHAM HRF-1.
    1. Type: Freestanding, Built in or Undercounter.
    2. Storage Capacity: As directed 5.13 cu. ft. (0.15 cu. m) or 15.0 cu. ft. (0.42 cu. m)
    3. Features:

        a. As directed As directed Automatic or Manual defrost.
        b. Interior light in compartment.
        c. Automatic icemaker and storage bin.

    4. ENERGY STAR: Provide appliances that qualify for the EPA/DOE ENERGY STAR product-labeling program.
    5. Front Panel(s): As directed Manufacturer's standard, Wood panel(s) to match kitchen cabinets, Porcelain enamel, Stainless steel, Wood-panel insert(s) specified in Section 064113 "Wood-Veneer-Faced Architectural Cabinets" to match kitchen cabinets, Wood-panel insert(s) specified in Section 123530 "Residential Casework" to match kitchen cabinets.

2.9 ICEMAKERS

A. Icemaker IC #:
    1. Type: Undercounter.
    2. Ice Capacity:

        a. Production: As directed 30 lb (13.6 kg) or 50 lb (22.7 kg) per day.

b. Storage: As directed 25 lb (11.3 kg) or 35 lb (15.9 kg).

3. Features:

a. Automatic defrost.
b. Automatic shutoff.

4. Front Panel: Manufacturer's standard, Wood panel to match kitchen cabinets, Porcelain enamel, Stainless steel, Wood-panel insert specified in Section 064113 "Wood-Veneer-Faced Architectural Cabinets" to match kitchen cabinets, Wood-panel insert specified in Section 123530 "Residential Casework" to match kitchen cabinets.

2.10 DISHWASHERS

A. Dishwasher DW #: Complying with AHAM DW-1.
1. Type: Built-in undercounter, Built-in under sink or Portable.
2. ENERGY STAR: Provide appliances that qualify for the EPA/DOE ENERGY STAR product-labeling program.
3. Front Panel: As directed Manufacturer's standard, Wood panel to match kitchen cabinets, Porcelain enamel, Stainless steel, Wood-panel insert specified in Section 064113 "Wood-Veneer-Faced Architectural Cabinets" to match kitchen cabinets, Wood-panel insert specified in Section 123530 "Residential Casework" to match kitchen cabinets or Reversible panel with choice of colors.

2.11 CLOTHES WASHERS AND DRYERS

A. Clothes Washer CW #: Complying with AHAM HLW-1.
1. Type: As directed Freestanding, Stacking, Undercounter, top or front-loading unit.
2. Capacity: 2.7 cu. ft. (0.08 cu. m), 3.2 cu. ft. (0.09 cu. m), 3.8 cu. ft. (0.11 cu. m) as directed.
3. Agitator: As directed Center spindle or Impeller (without spindle).
4. Pedestal: As directed 8-inch- (203-mm-) high, 15-inch- (381-mm-) high or Manufacturer's standard height laundry pedestal with storage drawer, matching appliance finish.
5. ENERGY STAR: Provide appliances that qualify for the EPA/DOE ENERGY STAR product-labeling program.
6. Water-Efficient Clothes Washer: Provide clothes washer with modified energy factor greater than or equal to 2.0 and water factor less than 5.5.
7. Appliance Finish: Enamel or Stainless steel.
8. Front-Panel Finish: As directed Manufacturer's standard, Wood panel to match kitchen cabinets, Porcelain enamel, Stainless steel, Wood-panel insert specified in Section 064113 "Wood-Veneer-Faced Architectural Cabinets" to match kitchen cabinets, Wood-panel insert specified in Section 123530 "Residential Casework" to match kitchen cabinets.

B. Clothes Dryer CD #: Complying with AHAM HLD-1.
1. Type: As directed Freestanding, Stacking, Undercounter, frontloading, gas, electric, electric, or ventless unit.
2. Capacity: As directed 5.7 cu. ft. (0.16 cu. m) or 7.0 cu. ft. (0.20 cu. m).

3. Features:

   a. Interior drum light.
   b. Stacking kit to stack dryer over washer.
   c. Pedestal: 8-inch- (203-mm-) high, 15-inch- (381-mm-) high or Manufacturer's standard height laundry pedestal with storage drawer, matching appliance finish.

4. Appliance Finish: As directed Enamel or Stainless steel.
5. Front-Panel Finish: As directed Manufacturer's standard, Wood panel to match kitchen cabinets, Porcelain enamel, Stainless steel, Wood-panel insert specified in Section 064113 "Wood-Veneer-Faced Architectural Cabinets" to match kitchen cabinets, Wood-panel insert specified in Section 123530 "Residential Casework" to match kitchen cabinets.

2.12 CLOTHES WASHER/DRYER COMBINATIONS

A. Clothes Washer/Dryer Combination CWD #: Complying with AHAM HLW-1.
   1. Type: Freestanding washer/dryer unit with dual-drum design and electric dryer, dual-drum design and gas dryer or all-in-one, single-drum design; washer is top or front loading.
   2. Washer-Drum Capacity: As directed 1.5 cu. ft. (0.04 cu. m), 2.0 cu. ft. (0.06 cu. m) or 2.6 cu. ft. (0.07 cu. m).
   3. Dryer-Drum Capacity: As directed 2.0 cu. ft. (0.06 cu. m), 3.4 cu. ft. (0.10 cu. m) or 5.9 cu. ft. (0.17 cu. m).
   4. Washer/Dryer Drum Capacity: 2.3 cu. ft. (0.07 cu. m) or 3.6 cu. ft. (0.10 cu. m).
   5. ENERGY STAR: Provide appliances that qualify for the EPA/DOE ENERGY STAR product-labeling program.
   6. Water-Efficient Clothes Washer: Provide clothes washer with modified energy factor greater than or equal to 2.0 and water factor less than 5.5.
   7. Appliance Finish: As directed Enamel or Stainless steel.

2.13 TRASH COMPACTORS

A. Trash Compactor TC #: Complying with AHAM TC-1.
   1. Type: Built in or Convertible.
   2. Capacity: As directed 1.4 cu. ft. (0.04 cu. m) or 1.7 cu. ft. (0.05 cu. m).
   3. Front Panel: As directed Manufacturer's standard, Wood panel to match kitchen cabinets, Enameled steel, Stainless steel, Wood-panel insert specified in Section 064113 "Wood-Veneer-Faced Architectural Cabinets" to match kitchen cabinets, Wood-panel insert specified in Section 123530 "Residential Casework" to match kitchen cabinets.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Built-in Equipment: Securely anchor units to supporting cabinets or countertops with concealed fasteners. Verify that clearances are adequate for proper functioning and that rough openings are completely concealed.

B. Freestanding Equipment: Place units in final locations after finishes have been completed in each area. Verify that clearances are adequate to properly operate equipment.

C. Range Anti-Tip Device: Install at each range according to manufacturer's written instructions.

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform visual, mechanical, and electrical inspection and testing for each appliance according to manufacturers' written recommendations. Certify compliance with each manufacturer's appliance-performance parameters.
2. Leak Test: After installation, test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After installation, start units to confirm proper operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and components.

B. An appliance will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 113013

SECTION 113200 - UNIT KITCHENS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes unit kitchens with laminate-clad wood or metal cabinets.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Include diagrams for power, signal, and control wiring.

D. Samples for Initial Selection: For unit kitchen cabinet and countertop finishes, door and drawer styles, and appliance finishes.

E. Samples for Verification: For each type of exposed unit kitchen and appliance finish required, in manufacturer's standard sizes, and including the following:

1.3 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each configuration of unit kitchen and each type of appliance.

B. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each unit kitchen and each appliance to include in operation and maintenance manuals.

1.5 QUALITY ASSURANCE: As directed.

1.6 WARRANTY

A. Manufacturer's Special Warranty: Manufacturer agrees to provide on-site service for sealed compressor systems of refrigerator or icemaker as follows:

1. Warranty Type: Full warranty including parts and labor or Limited warranty including parts and labor for the first year and parts thereafter.

2. Warranty Period: Years from date of Substantial Completion, as directed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Accessibility Requirements: For unit kitchens indicated to be accessible, comply with the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines, ICC A117.1 and HUD's "Fair Housing Accessibility Guidelines", as directed.

2.2 LAMINATE-CLAD WOOD CABINETS

A. Quality Standard: Provide cabinets that comply with KCMA A161.1.

1. KCMA Certification: Provide cabinets with KCMA's "Certified Cabinet" seal affixed in a semi-exposed location of each unit and showing compliance with the above standard.

B. Materials:
1. Medium-Density Fiberboard: ANSI A208.2, Grade 130.
2. Particleboard: ANSI A208.1, Grade M-2.
3. Veneer-Faced Panel Products (Hardwood Plywood): HPVA HP-1, Type I.
4. Solid Wood: Clear hardwood lumber of species indicated, free of defects, selected for compatible grain and color, and kiln dried to 7 percent moisture content.
5. High-Pressure Decorative Laminate: NEMA LD 3.

C. Frameless-Style Base Cabinets:

1. Back Panels: 1/4-inch (6-mm) thick plywood, hardboard, or particleboard with melamine bonded to both surfaces.
2. Top and Bottom Panels: 3/4-inch (19-mm) thick particleboard with melamine bonded to both sides.
3. End Panels: 5/8-inch (16-mm) thick particleboard with melamine bonded to both sides.
4. Exposed End Panels: 3/4-inch (19-mm) thick, hardwood-veneer plywood.
5. Door and Drawer Fronts: 3/4-inch (19-mm) thick, solid wood stiles and rails, with solid wood or hardwood plywood center panels.
6. Door and Drawer Fronts: 3/4-inch (19-mm) thick plywood with Grade HGS high-pressure decorative laminate bonded to front and edges, and Grade CLS high-pressure decorative laminate bonded to inside surface.
7. Door and Drawer Fronts: 3/4-inch (19-mm) thick, medium-density fiberboard with 16-mil (0.4-mm) thick, vinyl film (thermofoil) bonded to exposed surfaces and melamine bonded to inside surfaces.
8. Door and Drawer Fronts: 5/8-inch (16-mm) thick particleboard with melamine bonded to both sides.

a. Styles and Colors: As directed.

9. Drawers: Four sided, with 1/2-inch (13-mm) thick particleboard fronts, backs, and sides, and 1/4-inch (6-mm) thick particleboard bottom, with melamine bonded to both sides and PVC edges.
10. Shelves: 3/4-inch (19-mm) thick particleboard with melamine bonded to both sides and PVC edges.
11. Toe Kicks: 3/4-inch (19-mm) thick, medium-density fiberboard with 16-mil (0.4-mm) thick, vinyl film (thermofoil) bonded to exposed surfaces.

D. Wall Cabinets: Same material and finish as base cabinets, with adjustable shelves.

E. Wall Shields: Fabricated as directed. Provide wall shields for back wall and side walls between countertop splash and wall cabinets.

F. Scribe Strips for Recessed Cabinets: Same material, finish, and color as cabinet.

G. Pulls: As directed.

1. Metal and Finish: As directed.

H. Wood Finishes: Factory finished with manufacturer's standard stain, sealer, and clear finish coat. Defer only final touchup until after installation.

2.3 METAL CABINETS

A. Materials:

1. Cold-Rolled Steel Sheet, Zinc Coated: ASTM A879/A879M, Commercial Steel (CS), Type B.
2. Medium-Density Fiberboard: ANSI A208.2, Grade 130.
3. Solid Wood: Clear hardwood lumber of species indicated, free of defects, selected for compatible grain and color, and kiln dried to 7 percent moisture content.

B. Steel Base Cabinets: Fabricate frames and sides from 0.048-inch (1.21-mm) or 0.036-inch (0.791-mm) nominal-thickness, cold-rolled steel sheet; welded and reinforced with internal gussets and bracing; with powder-coated finish.

1. Door and Drawer Fronts: 0.048-inch (1.21-mm) or 0.036-inch (0.791-mm) nominal-thickness, cold-rolled steel sheet, textured or smooth; welded, reinforced, and sound-deadened; with powder-coated epoxy finish.
2. Door and Drawer Fronts: 0.038-inch (0.95-mm) thick, stainless-steel sheet; welded, reinforced, and sound deadened.
3. Door and Drawer Fronts: 3/4-inch (19-mm) thick, solid wood stiles and rails, with solid wood center panels.
4. Door and Drawer Fronts: 3/4-inch (19-mm) thick, medium-density fiberboard with 16-mil (0.4-mm) thick, vinyl film (thermofoil) bonded to exposed surfaces and melamine bonded to inside surfaces.

a. Styles and Colors: As selected by Architect from manufacturer's full line.

C. Toe Kicks: 3/4-inch (19-mm) thick, medium-density fiberboard with 16-mil (0.4-mm) thick, vinyl film (thermofoil) bonded to exposed surfaces.

D. Toe Kicks: Cold-rolled steel sheet, thickness to match base cabinets, powder coated, with four adjustable feet.

E. Legs and Feet: Stainless-steel tubing legs with adjustable bullet feet.

F. Undercounter Storage Cabinet: Same material and finish as base cabinets, with adjustable shelf and drawer or with two drawers.

G. Wall Cabinets: Same material and finish as base cabinets, with flush double bottoms, adjustable shelves, wall hanging bracket, and adjustable front legs.

H. Wall Shields: Fabricated as directed. Provide wall shields for back wall and side walls between countertop splash and wall cabinets.

I. Shelves: Manufacturer's standard rolled-front shelves, fixed or adjustable, of same material and finish as cabinets.

J. Pulls: As directed,

1. Metal and Finish: As directed.

K. Wood Finishes: Factory finished with manufacturer's standard stain, sealer, and clear finish coat. Defer only final touchup until after installation.

2.4 COUNTERTOPS

A. Materials:

1. Stainless-Steel Sheet: ASTM A240/A240M, Type 304.
2. Medium-Density Fiberboard: ANSI A208.2, Grade 130.
3. Particleboard: ANSI A208.1, Grade M-2.
4. High-Pressure Decorative Laminate: NEMA LD 3.
5. Solid-Surfacing Material: Homogenous solid sheets fabricated from reacted monomers and resins, mineral fillers, and pigments; in thickness indicated; complying with ISSFA-2.

B. Countertop and Integral Sink: Seamless, one-piece countertop and sink with integral embossed drainboard and backsplash and side splashes.

1. Stainless Steel: 0.038-inch (0.95-mm) thick sheet bonded to 3/4-inch (19-mm) plywood.
2. Solid-Surfacing Material: Minimum 1/2 inch (13 mm) thick.

C. Countertop for Drop-in Sink: Seamless, one-piece countertop with integral backsplash and side splashes.

1. Stainless Steel: 0.038-inch (0.95-mm) thick sheet bonded to 3/4-inch (19-mm) plywood.
2. High-Pressure Decorative Laminate: Grade HGS, bonded to 3/4-inch (19-mm) plywood.

3. High-Pressure Decorative Laminate: Grade HGP, post formed, bonded to 3/4-inch (19-mm) particleboard with Grade BKL unfinished backing sheet bonded to reverse side.

D. Countertop for Undercounter-Mounted Sink: Seamless, one-piece countertop with integral backsplash and side splashes; fabricated from 1/2-inch (13-mm) thick, solid-surfacing material.

E. Stainless-Steel Finishes: Remove tool and die marks and stretch lines, or blend into finish. Grind and polish surfaces to produce uniform finish, free of cross scratches. Run grain of directional finishes with long dimension of each piece. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

1. Bright, Directional Polish: No. 4.

2.5 FIXTURES

A. Stainless-Steel Sinks: 0.050 inch (1.27 mm) or 0.038 inch (0.95 mm) thick; seamless; single compartment, drop in or undercounter mounted.

B. Solid-Surfacing Material Sinks: Seamless, single compartment, undercounter mounted.

C. Supplies: NPS 3/8 (DN 12) or NPS 1/2 (DN 15) chrome-plated copper with stops.

D. Sink Faucet: Single-lever control; polished chrome-plated mixing or European-style, pull-out spray faucet with limited-swing spout and aerator.

E. Sink Faucet: Separate hot and cold controls with wrist-blade handles; polished chrome-plated mixing faucet with limited-swing spout or gooseneck spout and aerator.

F. Sink Outlet with Disposer: 3-1/2-inch (89-mm) diameter outlet.

G. Sink Outlet without Disposer: 3-1/2-inch (89-mm) diameter outlet with screw-in stainless-steel cup strainer and 1-1/2-inch (38-mm) diameter tailpiece.

H. Drain Piping: NPS 1-1/2 (DN 40) chrome-plated cast-brass trap, tubular brass waste to wall, and wall escutcheon.

I. Disposers: Continuous-feed, household, food-waste disposers. Include 115-V ac, 1725-rpm, 1/3-hp motor with overload protection and reset button; three-conductor, grounded power cord; wall switch; corrosion-resistant chamber with jam-resistant, stainless-steel grinder or shredder; NPS 1-1/2 (DN 40) outlet; quick-mounting, stainless-steel sink flange; anti-splash guard; and combination cover/stopper.

2.6 APPLIANCES

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1. Built-in Refrigerators: Listed and labeled for recessed installation. Mount label to be visible after installation of unit; include electrical rating, type of refrigerant, and minimum installation clearances.
2. Refrigerated Unit Kitchens: Listed and labeled for entire unit as a single integrated system. Mount label to be visible after installation of unit; include electrical rating, type of refrigerant, and minimum installation clearances.

B. Appliance Standards:

1. Refrigerators and Freezers: UL 250 or AHAM ER-1.
2. Electric Ranges: UL 858 or AHAM HRF-1.
3. Microwave Ovens: UL 923.

C. Refrigerator: Built-in, dual-compartment refrigerator fabricated with one-piece seamless steel or ABS plastic inner liner; refrigerator compartment with slide-out or removable shelves and meat tray; adjustable automatic temperature control; reversible door with magnetic gaskets and storage shelves; interior light; closed compartment for storage of pre-frozen food and two ice cube trays; 115-V ac.

1. Minimum Capacity: 4.3 cu. ft. (0.12 cu. m) or 5.1 cu. ft. (0.14 cu. m) with 21-lb (9.5-kg) or 30-lb (13.6-kg) freezer capacity.
2. Defrost System: Manual defrost or Automatic defrost timer.
3. ENERGY STAR: Provide appliances that qualify for the EPA/DOE's ENERGY STAR product labeling program.
4. Finish: As directed.
5. Finish Panel: Manufacturer's standard door trim kit with filler panel or integral finish panel; match material and finish of base cabinets.

D. Electric Cooktops:

1. Width: 12 inches (305 mm).
2. Electric Burner Elements: Two.

    a. Radiant Type: One 1000-W and one 1400-W element or One 1200-W and one 1700-W element.

3. Controls: Knob adjustable, located on front.
4. Electric Power Supply: 115 V, 60 Hz, 1 phase, 30 A or 240 V, 60 Hz, 1 phase, 30 A, as directed, with wiring terminated at factory-installed junction box.
5. Cook Surface Material: Ceramic glass.
6. Top Material Color/Finish: As directed.

E. Electric Wall Oven: One-oven unit.

1. Mounting: Built-in wall or undercounter.
2. Capacity: 3.3 cu. ft. (0.09 cu. m).
3. Operation: Baking or convection and self-cleaning.
4. Broiler: Located in top of oven or separate roll-out drawer on bottom.
5. Oven Door(s): Counterbalanced, removable, with observation window and full-width handle.
6. Electric Power Rating:

a. Oven(s): 2400 W, as directed.
b. Broiler: 3500 W, as directed.

7. Electric Power Supply: 240 V, 60 Hz, 1 phase, 30 A, as directed.
8. Controls: Digital panel or Manual-dial controls and timer display.
9. Material: Porcelain-enameled steel or Stainless steel, as directed.

a. Color/Finish: White or Black, as directed.

F. Microwave Oven:

1. Mounting: Undercabinet or Wall cabinet.
2. Type: Conventional or Convection.
3. Dimensions:

a. Width: 24 inches (610 mm) or 30 inches (762 mm), as directed.
b. Depth: 19-1/2 inches (495 mm), as directed.
c. Height: 14 inches (356 mm) or 18 inches (457 mm), as directed.

4. Capacity: 1.5 cu. ft. (0.04 cu. m) or 2.0 cu. ft. (0.06 cu. m), as directed.
5. Oven Door: Door with observation window and pull handle or push-button latch release, as directed.
6. Exhaust Fan: Two -speed fan, vented to outside, with permanent washable filter and with manufacturer's standard capacity. Provide exhaust duct and wall or roof cap and shutter. See Section 233113 "Metal Ducts."
7. Exhaust Fan: Two-speed fan, non-vented, recirculating type with charcoal filter and with manufacturer's standard capacity.
8. Microwave Power Rating: Manufacturer's standard.

a. Convection Element Power Rating: Manufacturer's standard rating.

9. Electric Power Supply: 20 V, 60 Hz, 1 phase, 15 A, as directed.
10. Controls: Digital panel controls and timer display.
11. Other Features: Turntable and temperature probe, as directed.
12. Material: Porcelain-enameled steel or Stainless steel, as directed.

a. Color/Finish: White or Black, as directed.

G. Overhead Exhaust Hood: Vented to outside.

1. Type: Wall-mounted exhaust-hood system.
2. Dimensions:

a. Width: 24 inches (610 mm) or 30 inches (762 mm) .

3. Exhaust Fan: Two speed fan built into hood and with manufacturer's standard. capacity.

a. Venting: Vented to outside through wall with weatherproof wall cap, backdraft damper, and rodent-proof screening. See Section 233113 "Metal Ducts."
b. Fan Control: Hood-mounted fan switch, with separate hood-light control switch.

4. Duct Type: Manufacturer's standard.
5. Finish: Baked enamel or Stainless steel, as directed.

    a. Color: White or as directed.

6. Features:

    a. Permanent, washable filter(s).
    b. Built-in lighting.

H. Overhead Exhaust Hood: Non-vented, recirculating type.

1. Type: Wall-mounted exhaust-hood system.
2. Dimensions:

    a. Width: 24 inches (610 mm) or 30 inches (762 mm).

3. Exhaust Fan: Two speed fan built into hood and with manufacturer's standard capacity.

    a. Charcoal filter.
    b. Fan Control: Hood-mounted fan switch, with separate hood-light control switch.

4. Finish: Baked enamel or Stainless steel.

    a. Color: White or as directed.

5. Features:

    a. Permanent, washable filter(s).

I. Dishwasher: Complying with AHAM DW-1 and ASSE 1006.

1. Type: Built-in undercounter or under sink.
2. Dimensions:

    a. Width: 18 inches (457 mm) or 24 inches (610 mm).

3. Sound Level: Maximum 42 or 48 dB.
4. Tub and Door Liner: As directed with sealed detergent and automatic rinsing-aid dispensers.
5. Controls: Touch-pad or Rotary-dial controls with four wash cycles and hot-air and heat-off drying cycle options.
6. Power: 115-V ac, with wiring terminated at factory-installed junction box.
7. Features:

    a. Waste food disposer.
    b. Self-cleaning, food-filter system.
    c. Hot-water booster heater for 140 deg F (60 deg C) or 160 deg F (71 deg C) wash water with incoming water at 100 deg F (38 deg C).

8. ENERGY STAR: Provide appliances that qualify for the EPA/DOE's ENERGY STAR product labeling program.

9. Front Panel: As directed.
10. Appliance Color/Finish: As directed.

    a. Built-in lighting.

2.7 ACCESSORIES

A. Locks: Brass-cylinder type; furnish two keys per lock. Provide, as directed.

B. Fluorescent Light Fixtures: Surface mounted to underside of overhead cabinet; with 15-W lamp, on-off switch, grounded convenience receptacle, and translucent plastic lens.

C. Cutlery Drawers: Concealed drawer in undercounter storage compartment with pull-out divided tray.

D. Cutting Boards: Pull-out hardwood board.

2.8 FABRICATION

A. General: Factory fabricate, finish, and assemble unit kitchens, with base cabinets, appliances, and countertop shipping as a one-piece assembly. Securely fasten components, fixtures, and appliances together.

    1. Provide manufacturer's standard hardware including concealed, adjustable plated-steel hinges; steel drawer slides with nylon rollers; and catches and rubber bumpers on doors and drawers. Unless otherwise indicated, provide chromium-plated metal or satin-finished stainless steel for exposed hardware.

B. Accessible Units: Fabricate unit kitchens to comply with accessibility regulations as follows:

    1. Standard, Accessible Countertops: Fabricate unit kitchens with one-piece countertop located at height of 34 inches (864 mm) above floor.
    2. Pipe Enclosure Panels: Provide manufacturer's standard panels to enclose plumbing under countertop, of same material and finish as cabinets. Install panel to prevent exposure of sharp or abrasive surfaces under the countertop.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine walls and partitions for proper backing for unit kitchens.

B. Examine roughing-in for electrical power plumbing and mechanical system(s) to verify actual locations of connections before installation of unit kitchens.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. General: Install level, plumb, and true; shim as required, using concealed shims. Provide fasteners, clips, backing materials, brackets, anchors, fillers, scribes, trim, and accessories necessary for complete installation.

B. Comply with requirements specified in Section 221116 "Domestic Water Piping," Section 221123 "Domestic Water Pumps," and Section 221316 "Sanitary Waste and Vent Piping" for connecting unit kitchens to plumbing and mechanical system(s).

C. Comply with requirements for connecting unit kitchens to electrical power system.

3.3 ADJUSTING AND CLEANING

A. Test, adjust, and verify operation of each appliance, plumbing fixture, and component of unit kitchens. Repair or replace items found to be defective or operating below rated capacity.

END OF SECTION 113200

SECTION 114000 - FOODSERVICE EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes equipment for foodservice facilities.

B. Owner-Furnished Equipment: Where indicated, Owner will furnish equipment for installation by Contractor.

C. Related Requirements:

1. Section 233813 "Commercial-Kitchen Hoods" for ventilation hoods.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference as directed.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For fabricated equipment. Include plans, elevations, sections, roughing-in dimensions, fabrication details, utility service requirements, and attachments to other work.

C. Samples for Initial Selection: For units with factory-applied color finishes.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: For foodservice facilities.

1. Indicate locations of foodservice equipment and connections to utilities.
2. Key equipment using same designations as indicated on Drawings.
3. Include plans and elevations; clearance requirements for equipment access and maintenance; details of equipment supports; and utility service characteristics.
4. Include details of seismic bracing for equipment.

B. Sample warranties.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 WARRANTY

A. Refrigeration Compressor Warranty: Manufacturer agrees to repair or replace compressors that fail in materials or workmanship within specified warranty period.

1. Warranty Period: (As directed) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. NSF Standards: Provide equipment that bears NSF Certification Mark or UL Classification Mark certifying compliance with applicable NSF standards.

B. BISSC Standards: Provide bakery equipment that complies with BISSC/Z50.2.

1. Provide BISSC-certified equipment, with certification verified by a third-party agency.

C. UL Certification: Provide electric and fuel-burning equipment and components that are evaluated by UL for fire, electric shock, and casualty hazards according to applicable safety standards, and that are UL certified for compliance and labeled for intended use.

D. Steam Equipment: Provide steam-generating and direct-steam heating equipment that is fabricated and labeled to comply with 2013 ASME Boiler and Pressure Vessel Code.

E. Regulatory Requirements: Install equipment to comply with the following:

1. ASHRAE 15, "Safety Code for Mechanical Refrigeration."
2. NFPA 54, "National Fuel Gas Code."
3. NFPA 70, "National Electrical Code."
4. NFPA 96, "Ventilation Control and Fire Protection of Commercial Cooking Operations."

F. Seismic Restraints: Comply with SMACNA's "Kitchen Ventilation Systems and Food Service Equipment Fabrication and Installation Guidelines," Appendix A, "Seismic Restraint Details," unless otherwise indicated.

2.2 FABRICATED EQUIPMENT

A. Stainless Steel Sinks:
1. Description: As directed-compartment sink(s). Fabricate units of welded stainless steel, sound deadened.

a. Bowls: Stainless steel, Type 304, 0.078 inch (1.98 mm) or 0.062 inch (1.59 mm) thick.
b. Integral Drainboards: Stainless steel, Type 304, 0.078 inch (1.98 mm) or 0.062 inch (1.59 mm) thick.
c. Body: Stainless steel, as directed.

1) Back Splash: 13 inches (330 mm) or 18 inches (457 mm), as directed.

2) Side Splash: 13 inches (330 mm) or 18 inches (457 mm), as directed.

d. Legs and Feet: Stainless steel tubing legs with adjustable bullet feet.
e. Accessories:

1) Faucets and Spouts: As directed.
2) Prerinse Faucet: As directed.
3) Vacuum breaker.
4) Lever waste with overflow.
5) Basket strainer.
6) Continuous waste.
7) Scrap trough.
8) Control bracket for food waste disposer controls.
9) Scrap block and hole.
10) Stainless steel pot rack.

2. Stainless Steel Sheet: ASTM A240/A240M, austenitic stainless steel, type as indicated.
3. Fabrication: Prepare sink for installation of the following equipment items:

a. Water heater.
b. Food waste disposer; weld disposer cone or collar into sink.
c. Undercounter dishwasher.

4. Stainless Steel Finish: Directional satin finish, ASTM A480/A480M, No. 4, as directed.

B. Stainless Steel Tables

1. Description: As directed.

a. Tops: Stainless steel, thick, reinforced and sound deadened as directed.

1) Back Splash: 1-1/2 inches (38 mm) or 5 inches (127 mm), as directed.
2) Edge: As directed.

b. Welded or adjustable undershelf: Stainless steel, Type 304, 0.050 inch (1.27 mm) thick or Metallic-coated steel, 0.052-inch (1.32-mm) nominal thickness.
c. Crossbracing: Stainless steel or Metallic-coated steel tubing, bolted or welded to legs.
d. Cabinet:

1) Body: Stainless steel, Type 430, 0.050 inch (1.27 mm) thick.
2) Doors: Sliding or Hinged, stainless steel, Type 304, 0.038 inch (0.95 mm) thick.
3) Drawers: As directed.

e. Sink: Stainless steel, Type 304, 0.078 inch (1.98 mm) thick, welded into tabletop and including the following:

1) Faucet and Spout:

2) Vacuum breaker.
3) Leverwaste with overflow
4) Basket strainer.
5) Tail piece.

f. Legs: Stainless steel or Metallic-coated steel tubing.
g. Feet: As directed.
h. Accessories:

1) Control panel.
2) Control bracket for food waste disposer controls.
3) Aluminum pan rack slides, six or three slides each.
4) Urn trough.
5) Spice bins.

2. Materials:

a. Stainless Steel Sheet: ASTM A240/A240M, austenitic stainless steel, type as indicated.
b. Metallic-Coated Steel Sheet: ASTM A653/A653M, Commercial Steel (CS), Type B, with minimum G90 (Z275) coating.

3. Fabrication: Prepare table for installation of the following equipment items:

a. Food waste disposer; weld disposer cone or collar into sink.
b. Heat lamp.

4. Stainless Steel Finish: Directional satin finish, ASTM A480/A480M, No. 4t finish.

2.3 FOODSERVICE EQUIPMENT

A. Food Waste Disposer Units:

1. Description: 3, 5 or 7 hp as directed, with dual-direction shredding elements, and the following:

a. Stainless steel or Corrosion-resistant housing.
b. Flow control.
c. Solenoid valve.
d. Vacuum breaker.
e. Fixed nozzle.
f. Control Panel:

1) Autoreversing and internal timed water flush.
2) Stainless steel mounting bracket.

g. Prerinse: Backsplash mounted with hot- and cold-water mixing valve and with stainless steel or corrosion-resistant exposed metal parts and the following:

1) Wall support bracket.
2) Flexible, 3/8-inch (10-mm) metal-encased hose with a minimum length of 29 inches (737 mm) and supported by spiral spring.
3) Spray-head assembly with lockable lever handle.

h. Accessories:

1) Collar adaptor for sink or trough.
2) Cone with adaptor ring.

a) Size: As directed.

3) Cone cover in size that matches cone.
4) Silver accumulator.

i. Electrical Service: Equip unit for connection to service as directed.

B. Ranges:

1. Description:

a. Top Configuration:

1) Open-Burner Unit:

a) Standard Burners: As directed.
b) Wok or Saute Head: As directed.

2) Griddle: Flat or Raised.
3) Radiant Broiler: As directed.

b. Base Configuration:

1) Standard Oven(s): One or Two.
2) Convection Oven(s): One or Two.
3) Storage Base: One.

c. Accessories:

1) High or Double-deck back shelf.
2) Stainless steel sides.
3) Stainless steel back.
4) Legs for curb base.
5) Toe Base: 4 inches (102 mm) high.
6) Casters: As required.
7) Oven Rack(s): One for each oven.

d. Electrical Service: Equip unit for connection to service as directed.
e. Gas Service: Natural or Liquefied propane gas, as directed.

C. Microwave Ovens:

1. Description: 1200-W cooking power.

a. Electrical Service: Equip unit with plug and cord for 120-V service.

D. Refrigeration Equipment: Refrigerators or Freezers.
1. Description: As directed.

a. Exterior Finish: Stainless steel.
b. Interior Finish: Stainless steel or as directed.
c. Doors: Full length or Half-length.
d. Accessories:

1) Casters.
2) Stainless steel back with rear louvers.
3) Re-hinging feature for doors.
4) Hinged glass doors and fluorescent fixtures.
5) Tray Slides: For sheet pans.
6) Chrome-Plated or stainless steel shelves: As directed.
7) Loading Rack: As directed.
8) Transfer Carriage: As directed.

e. Electrical Service: Equip unit with plug and cord for service as directed.

E. Ice-Making Machine:
1. Description: Undercounter or Freestanding units.

a. Production: Ice, as directed.
b. Capacity: As directed in lb(kg) per 24-hour period.
c. Accessories:

1) Storage Bin:

a) Storage Capacity: As directed in lb (kg).

2) Stainless steel stand and legs.
3) Water filter.

d. Electrical Service: Equip unit for connection to service as directed.

F. Food Preparation Equipment: As directed.

1. Description: As directed.
2. Accessories: As directed.
3. Electrical Service: Equip unit with plug and cord for service as directed.

G. Warewashing Machines:

1. Description: As directed.

    a. Capacity: As directed.
    b. Accessories: As directed.
    c. Electrical Service: Equip unit for connection to service as directed.

H. Modular Counters:

1. Description: As directed.

    a. Cabinet Face Panels: As directed.
    b. Accessories:

        1) Tray slide.
        2) Work shelf.
        3) Casters.
        4) Electrical receptacle.
        5) Cam-action latch locks with trigger release to mate with adjoining modular counters.
        6) Tempered-glass, food-protector shield.

    c. Electrical Service: Equip unit for connection to service as directed.
    d. Color: As directed.

2.4 MISCELLANEOUS MATERIALS

A. Installation Accessories, General: NSF certified for end-use application indicated.

B. Elastomeric Joint Sealant: ASTM C920; silicone. Type S (single component), Grade NS (nonsag), Class 25, Use NT (nontraffic) related to exposure, and Use M, G, A, or O as applicable to joint substrates indicated.

1. Public Health and Safety Requirements:

    a. Sealant is certified for compliance with NSF standards for end-use application indicated.
    b. Washed and cured sealant complies with the FDA's regulations for use in areas that come in contact with food.

2. Cylindrical Sealant Backing: ASTM C1330, Type C, closed-cell polyethylene, in diameter greater than joint width.

2.5 FINISHES

A. Stainless Steel Finishes: Remove tool and die marks and stretch lines, or blend into finish. Grind and polish surfaces to produce uniform finish, free of cross scratches.

B. Powder-Coat Finishes: Comply with resin manufacturer's written instructions for application, baking, and minimum dry film thickness.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install foodservice equipment level and plumb, according to manufacturer's written instructions.

1. Connect equipment to utilities.
2. Provide cutouts in equipment, neatly formed, where required to run service lines through equipment to make final connections.

B. Complete equipment assembly where field assembly is required.

1. Provide closed butt and contact joints that do not require a filler.
2. Grind field welds on stainless steel equipment until smooth and polish to match adjacent finish.

C. Install equipment with access and maintenance clearances that comply with manufacturer's written installation instructions and with requirements of authorities having jurisdiction.

D. Install cabinets and similar equipment on bases in a bed of sealant.

E. Install closure-trim strips and similar items requiring fasteners in a bed of sealant.

F. Install joint sealant in joints between equipment and abutting surfaces with continuous joint backing unless otherwise indicated. Produce airtight, watertight, vermin-proof, sanitary joints.

3.2 CLEANING AND PROTECTING

A. After completing installation of equipment, repair damaged finishes.

B. Clean and adjust equipment as required to produce ready-for-use condition.

C. Protect equipment from damage during remainder of the construction period.

3.3 DEMONSTRATION

A. Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain foodservice equipment.

END OF SECTION 114000

SECTION 115123 - LIBRARY STACK SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes steel-bracket shelving and wood-case shelving.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. ns, sections, and details.

1. Include methods of anchoring them to building structures at locations recommended by manufacturer and as required for seismic restraint.

D. Samples: For each exposed product and for each color and texture specified.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Design Calculations: For seismic design of library stack systems, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Shelf Units: Five percent of quantity installed for each size and type indicated, but no fewer than 10 units or as directed.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of library stack systems that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Years from date of Substantial Completion, as directed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Library stack systems shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

2.2 STEEL-BRACKET SHELVING

A. Steel-Bracket Shelving: ANSI Z39.73 shelving designed for library use, consisting of two uprights and two spreaders per section forming a four-sided frame, with adjustable shelves on one or both sides of uprights cantilever-hung by brackets.

B. Bookstack Units:

1. Type: As directed.
2. Configuration: Double or Single-faced units with gusset plates.
3. Width: 36 inches (914 mm).
4. Height: As directed.
5. Shelf Depth: As directed.
6. Base Support: Base shelf or Open base with support feet.

a. Base Shelf Style: Flat or Flat with integral backstop.

7. Shelves: Provide the following style and number of adjustable shelves:

a. Flat with integral backstops; shelves, as directed.
b. Sloping with integral backstops; shelves, as directed.
c. Adjustable divider with integral backstops; shelves, as directed
d. Fixed periodical; Number of shelves, as directed.
e. Hinged periodical; Number of shelves, as directed.
f. Zigzag paperback shelf; Number of shelves, as directed.
g. Cascade newspaper display; Number of shelves, as directed.
h. Horizontal newspaper display; Number of shelves, as directed.
i. Multimedia, single or double tier; Number of shelves, as directed.
j. Multimedia browser bin, single or double tier; Number of shelves, as directed.
k. Hinged flipper door unit; Number of shelves, as directed.
l. Work shelf; Number of shelves, as directed.

C. Frames:

1. Uprights: Steel channels, 0.060 inch (1.52 mm) thick, with slots to receive shelf bracket tabs at 1 inch (25 mm) o.c.

    a. Sloped Display Frames: Where indicated, provide upright post frames with additional steel angles, 0.060 inch (1.52 mm) thick, 36 inches (914 mm) high, slotted to receive shelving and welded to frame or gusset plates at 10-degree angle to allow better visibility of lower two shelves.

2. Spreaders: Tube steel, 0.060 inch (1.52 mm) thick.
3. Longitudinal Bracing: Provide one diagonal steel rod with turnbuckles or intermediate spreader for each unit in each range of shelving, as directed.
4. Reinforcing Gusset Plates: Triangular steel plates, 0.060 inch (1.52 mm) thick, with return flange along bottom edge.

D. Adjustable Shelves: 0.048-inch (1.22-mm) thick cold-rolled steel sheet. Provide two brackets per shelf; 0.060-inch (1.52-mm) thick cold-rolled steel.

E. Base Shelves: One-piece shelves, 0.048-inch (1.22-mm) thick cold-rolled steel sheet, designed to receive and fit snugly around uprights, with kick plate 3 inches (76 mm) high. Provide two brackets per base shelf; 0.060-inch (1.52-mm) thick cold-rolled steel sheet, with return flange along bottom edge. Provide perforated bases at locations where base shelves cover supply-air grilles.

F. Support Feet: Square steel tube, 0.060 inch (1.52 mm) thick, with black vinyl caps at open ends of tube shape, designed to receive and fit snugly around uprights, extending from both faces of double-faced units or one face of single-faced units.

G. Levelers: Adjustable pin levelers at carpeted surfaces and adjustable glides elsewhere.

H. End Panels: Provide one at end of each range, as directed.

1. Steel End Panels: Cold-rolled steel sheet, 0.048 inch (1.22 mm) thick, with smooth or patterned finish.
2. Solid-Wood End Panels: 3/4 to 1 inch (19 to 25 mm) thick.
3. Veneer-Faced End Panels: 3/4 to 1 inch (19 to 25 mm) thick.

    a. Style: As directed.
    b. Face: As directed.

I. Canopy Tops: Provide full length of each range, as directed with manufacturer's standard attachment brackets for type of top indicated.

1. Steel Top Panels: Cold-rolled steel sheet, 0.048 inch (1.22 mm) thick, with smooth or patterned finish.
2. Veneer-Faced Top Panels: 3/4 to 1 inch (19 to 25 mm) thick.

    a. Face: As directed.

J. Back Panels: Provide one-piece panels at each single-faced unit; 0.048-inch- (1.22-mm-) thick cold-rolled steel sheet, with smooth or patterned finish, sized to completely fill space between uprights.

2.3 WOOD-CASE SHELVING

A. Wood-Case Library Shelving: Shelving designed for library use, consisting of base frame and full end, top, and back panels, with end panels made to receive pins to support adjustable shelves.

B. Bookstack Units:

1. Type: Units, as directed.
2. Configuration: Single or Double-faced units.
3. Width: 36 inches (914 mm)
4. Height: As directed.
5. Shelf Depth: As directed.
6. Shelves: Provide the following style and number of adjustable shelves:

    a. Flat; Number of shelves, as directed.
    b. Adjustable divider; Number of shelves, as directed.
    c. Fixed periodical; Number of shelves, as directed.
    d. Hinged periodical; Number of shelves, as directed.
    e. Cascade newspaper display; Number of shelves, as directed.
    f. Horizontal newspaper display; Number of shelves, as directed.
    g. Multimedia; Number of shelves, as directed.
    h. Picture book; Number of shelves, as directed.

C. Base Frames: Solid hardwood toe kick, back rail, and two end cleats, 3 to 4 inches (76 to 102 mm) high, designed to support bottom shelf and fabricated to attach and tie together vertical panels.

D. Bottom Shelf: Solid hardwood boards glued together, 3/4 inch (19 mm) thick, or veneer panels, 1 inch (25 mm) thick, with 1/4-inch (6.3-mm) solid-wood banding.

E. Adjustable Shelves:

1. Adjustable Wood Shelves: Panels consisting of solid hardwood boards glued together, 3/4 inch (19 mm) thick, or veneer panels, 1 inch (25 mm) thick, with 1/4-inch (6.3-mm) solid-wood banding, grooved on underside to rest securely on supporting pins.
2. Adjustable Steel Shelves: 0.048-inch- (1.22-mm-) thick cold-rolled steel sheet.

F. End Panels: Panels consisting of solid hardwood boards glued together, 3/4 inch (19 mm) thick, or veneer-faced panels, five or nine ply, 1 inch (25 mm) thick, with 1/4-inch (6.3-mm) solid-wood banding. Provide two rows of holes at 1-1/4-inch (32-mm) intervals for 5/16-inch (7.9-mm) shelf-support pins on one side of end panels and both sides of intermediate panels.

G. Tops: 3/4- to 1-inch (19- to 25-mm) thick veneer or plastic laminate-faced panels banded with 2- to 3-inch (50- to 76-mm) solid hardwood or plastic laminate-faced fasciae on one side for single-faced units and on two sides for double-faced units, fabricated to attach and tie together vertical panels for continuous horizontal shelving.

H. Back Panels: Veneer-faced panels, 1/4 inch (6.3 mm) thick, at each single-faced unit.

I. Divider Panels: Veneer-faced panels, 1/4 inch (6.3 mm) thick, at each double-faced unit.

2.4 WOOD MATERIALS

A. Solid Wood: Clear hardwood lumber, selected for compatible grain and color.

1. Wood Species and Cut: Red oak, plain sliced, as directed.
2. Staining and Finish: As directed.

B. Veneer-Faced Panels: HPVA HP-1, with face veneer of species indicated, with Grade A faces.

1. Face Veneer Species and Cut: Red oak, plain sliced, as directed.
2. Staining and Finish: As directed.

C. High-Pressure Decorative Laminate: NEMA LD 3, Grade VGS and Grade HGL.

1. Colors, Textures, and Patterns: As directed.

D. Thermoset Decorative Overlay: Thermally fused, melamine-impregnated decorative paper.

1. Colors: As directed.

E. End Panel Fabric: Manufacturer's standard fire-resistive fabric covering.

1. Colors: As directed.

F. Edgebanding: As directed.

1. Colors: As directed.

G. Slatwall: Manufacturer's standard slatwall end panel, consisting of grooved medium-density fiberboard ready to accept slatwall hangers and display units.

1. Colors: As directed.

2.5 FINISHES

A. Baked-Enamel or Powder-Coat Finish: Manufacturer's standard two-coat, baked-on finish, consisting of prime coat and thermosetting topcoat to achieve a minimum dry film thickness of 2 mils (0.05 mm).

1. Color and Gloss: As directed.

B. Finishing: Apply manufacturer's standard, baked, clear finish, consisting of a sealer and a topcoat. Sand and wipe clean between applications of sealer and topcoat.

2.6 ACCESSORIES

A. Floor Anchors: Galvanized steel, post-installed expansion anchors, power-actuated fasteners or threaded concrete screws, as directed.

B. Wall Anchors: Manufacturer's standard galvanized-steel anchors.

C. Top Bracing: Minimum 1- by 1-3/4-inch (25- by 44-mm) transverse struts, 0.048-inch- (1.22-mm-) thick steel channels, welded or bolted to top of stack units and securely fastened to structure.

D. Filler Panels: Provide corner, peninsula and intermediate wall filler panels; 0.048-inch- (1.22-mm-) thick cold-rolled steel, with fitted caps, in color and finish to match shelving. Locate where indicated to fill gaps at abutting shelving units.

E. Findable Book Supports: Unattached book support, 6 inches (152 mm) or 9 inches (229 mm) high, with cork pad on bottom, for use on shelf surface.

1. Provide two per shelf or directed.

F. Sliding Book Supports: Movable, 3/16-inch (4.8-mm) diameter wire supports attached to plastic slider blocks, designed for insertion into track on backstop or shelf.

1. Provide two per shelf or directed.

G. Adjustable Shelf Dividers: One-piece, steel or wood shelf partitions, with hooks or tabs to fit in slots in divider shelves.

1. Provide five per shelf or as directed.

H. Sliding Reference Shelves: High-pressure laminate over particleboard core, 3/4 to 1 inch (19 to 25 mm) thick, mounted on sliding extension hardware to allow shelves to retract for storage when not in use.

1. Provide one per range or as directed.

I. Center Backstops: Adjustable steel shelf backstops, 0.048 inch (1.22 mm) thick, with stiffening flanges and hooks for attachment to uprights.

1. Provide one per shelf.

J. Shelf Label Holders: Clear plastic, 5 inches (127 mm) long, designed to snap over adjustable shelves.

1. Provide one per shelf.

K. Adhesive Shelf Label: Blank labels, 3/4 inch (19 mm) high, backed with pressure-sensitive adhesive for direct attachment to shelf.

1. Provide one per shelf.

L. Range Finders: Units attached to and extending from range end in V-shape, sized to hold 3-by-5-inch (76-by-127-mm) cards.

1. Provide one for each end of each range.

M. Cardholders: Sized to hold 3-by-5-inch (76-by-127-mm) cards.

1. Provide one for single-faced units and two for double-faced units at each end of each range.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Vacuum finished floor and wet mop resilient flooring over which shelving is to be installed.

B. Install library stack systems at locations indicated on Drawings and according to manufacturer's written instructions.

C. Level and plumb bookstack units to a tolerance of 1/8 inch in 96 inches (3 mm in 2438 mm).

D. Install type of shelves at locations indicated and at spacing indicated or, if not indicated, at equal spacing in each unit.

E. Install bookstacks using floor anchors, wall anchors, or top bracing in locations recommended by manufacturer and as indicated on Shop Drawings.

END OF SECTION 115123

SECTION 115213 - PROJECTION SCREENS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Manually operated, front-projection screens.
2. Electrically operated, front-projection screens and controls.

B. Related Requirements:

1. Section 115213.19 "Rear Projection Screens."

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Show layouts and types of front-projection screens. Include the following:

1. Location of seams in viewing surfaces.
2. Anchorage details, including connection to supporting structure for suspended units.
3. Location of wiring connections for electrically operated units.
4. Wiring diagrams for electrically operated units.

PART 2 - PRODUCTS

2.1 MANUALLY OPERATED, FRONT-PROJECTION SCREENS

A. General: Manufacturer's standard spring-roller-operated units, consisting of case, screen, mounting accessories, and other components necessary for a complete installation.

1. Tab Tensioning: Provide units that have a durable low-stretch cord, such as braided polyester, on each side of screen that is connected to edge of screen by tabs to pull screen flat horizontally.

B. Surface-Mounted, Metal-Encased, Manually Operated Screens without Tab Tensioning: Units designed and fabricated for surface mounting on wall or ceiling, fabricated from formed-steel sheet not less than 0.027 inch (0.7 mm) thick or from aluminum extrusions; with flat back design and vinyl covering or baked-enamel finish. Provide units with matching end caps and concealed mounting.

C. Surface-Mounted, Metal-Encased, Manually Operated Screens with Tab Tensioning: Units designed and fabricated for surface mounting on wall or ceiling, fabricated from formed-steel sheet not less than 0.027 inch (0.7 mm) thick or from aluminum extrusions; with flat back

design and vinyl covering or baked-enamel finish. Provide units with matching end caps and concealed mounting.

2.2 ELECTRICALLY OPERATED, FRONT-PROJECTION SCREENS

A. General: Manufacturer's standard units consisting of case, screen, motor, controls, mounting accessories, and other components necessary for a complete installation.

1. Controls: Remote, key-operated, three-position control switch.

    a. Provide locking cover plates for switches.
    b. Provide key-operated, power-supply switch.
    c. Provide infrared or radio-frequency remote control consisting of battery-powered transmitter and receiver.
    d. Provide video interface control for connecting to projector. Projector provides signal to raise or lower screen.

2. Motor in Roller: Instant-reversing motor of size and capacity recommended by screen manufacturer; with permanently lubricated ball bearings, automatic thermal-overload protection, and positive-stop action to prevent coasting.
3. Screen Mounting: Top edge securely anchored to rigid metal roller and bottom edge formed into a pocket holding a 3/8-inch- (9.5-mm-) diameter metal rod with ends of rod protected by plastic caps.
4. Tab Tensioning: Provide units that have a durable low-stretch cord, such as braided polyester, on each side of screen that is connected to edge of screen by tabs to pull screen flat horizontally.

B. Surface-Mounted, Metal-Encased, Electrically Operated Screens without Tab Tensioning: Motor-in-roller units designed and fabricated for surface mounting on wall or ceiling, fabricated from formed-steel sheet not less than 0.027 inch (0.7 mm) thick or from aluminum extrusions; with flat back design and vinyl covering or baked-enamel finish. Provide with matching end caps and concealed mounting.

C. Surface-Mounted, Metal-Encased, Electrically Operated Screens with Tab Tensioning: Motor-in-roller units designed and fabricated for surface mounting on wall or ceiling, fabricated from formed-steel sheet not less than 0.027 inch (0.7 mm) thick or from aluminum extrusions; with flat back design and vinyl covering or baked-enamel finish. Provide with matching end caps and concealed mounting.

D. Suspended, Electrically Operated Screens without Ceiling Closure and without Tab Tensioning: Motor-in-roller units designed and fabricated for suspended mounting, with bottom of case entirely or partially open under screen compartment.

1. Provide screen case, as directed.

E. Suspended, Electrically Operated Screens without Ceiling Closure and with Tab Tensioning: Motor-in-roller units designed and fabricated for suspended mounting, with bottom of case entirely or partially open under screen compartment.

1. Provide screen case as directed.

F. Suspended, Electrically Operated Screens with Automatic Ceiling Closure and without Tab Tensioning: Motor-in-roller units designed and fabricated for suspended mounting; with bottom of case composed of two panels, fully enclosing screen, motor, and wiring; one panel hinged and designed to open and close automatically when screen is lowered and fully raised, the other removable or openable for access to interior of case.

1. Provide screen case as directed.

G. Suspended, Electrically Operated Screens with Automatic Ceiling Closure and with Tab Tensioning: Motor-in-roller units designed and fabricated for suspended mounting; with bottom of case composed of two panels, fully enclosing screen, motor, and wiring; one panel hinged and designed to open and close automatically when screen is lowered and fully raised, the other removable or openable for access to interior of case.

1. Provide screen case as directed.

2.3 FRONT-PROJECTION SCREEN MATERIAL

A. Matte-White Viewing Surface: Peak gain of not less than 0.9, and gain of not less than 0.8 at an angle of 50 degrees from the axis of the screen surface.

B. Matte-Gray Viewing Surface: Peak gain of not less than 0.8, and half-gain angle of not less than 50 degrees from the axis of the screen surface.

C. Matte Reflective Viewing Surface: Peak gain of not less than 1.3, and half-gain angle of at least 40 degrees from the axis of the screen surface.

D. Wide-Angle Reflective Viewing Surface: Peak gain of not less than 1.5, and half-gain angle of at least 35 degrees from the axis of the screen surface.

E. Multipurpose Reflective Viewing Surface: Peak gain of not less than 1.8, and half-gain angle of at least 25 degrees from the axis of the screen surface.

F. High-Gain Reflective Viewing Surface: Peak gain of not less than 2.4, and half-gain angle of at least 20 degrees from the axis of the screen surface.

G. Material: Vinyl-coated, glass-fiber fabric or vinyl sheet.

H. Seamless Construction: Provide screens, in sizes indicated, without seams.

I. Edge Treatment: Black or Without black masking borders.

J. Size of Viewing Surface: As directed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install front-projection screens at locations indicated to comply with screen manufacturer's written instructions.

B. Install front-projection screens with screen cases in position and in relation to adjoining construction indicated. Securely anchor to supporting substrate in a manner that produces a smoothly operating screen with vertical edges plumb and viewing surface flat when screen is lowered.

1. Install low-voltage controls according to NFPA 70 and complying with manufacturer's written instructions.

a. Wiring Method: Install wiring in raceway except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Use UL-listed plenum cable in environmental air spaces, including plenum ceilings. Conceal raceway and cables except in unfinished spaces.

2. Test electrically operated units to verify that screen controls, limit switches, closures, and other operating components are in optimum functioning condition.

END OF SECTION 115213

SECTION 115213.19 - REAR PROJECTION SCREENS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes rigid rear-projection screens.

B. Related Requirements:

1. Section 064023 "Interior Architectural Woodwork" for wood frames for field-installed, rear-projection screens.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Show layouts and types of rear-projection screens. Include the following:

1. Frame details.
2. Anchorage details.
3. Details of juncture of exposed surfaces with adjacent finishes.
4. Accessories.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations for Rear-Projection Screens: Obtain rear-projection screens or each type of rear-projection screen from single manufacturer. Obtain accessories, including necessary mounting hardware, from screen manufacturer.

1. Obtain rear-projection screens from same manufacturer as front-projection screens.

2.2 RIGID REAR-PROJECTION SCREENS

A. Wide-Angle Acrylic Screens: Coated acrylic sheet with peak gain of not less than 0.6 or 0.7, and half-gain angle of at least 45 – 70 degrees from the axis of the screen surface.

B. Wide-Angle Glass Screens: Coated glass with peak gain of not less than 0.6 or 0.7, and half-gain angle of at least 45 – 70 degrees from the axis of the screen surface.

C. Wide-Angle Acrylic Screens: Coated acrylic sheet with peak gain of not less than 1.0, and half-gain angle of at least 35 degrees from the axis of the screen surface.

D. Wide-Angle Glass Screens: Coated glass with peak gain of not less than 1.0, and half-gain angle of at least 35 degrees from the axis of the screen surface.

E. Moderate-Gain Acrylic Screens: Coated acrylic sheet with peak gain of not less than 1.3, and half-gain angle of at least 33 degrees from the axis of the screen surface.

F. Moderate-Gain Glass Screens: Coated glass with peak gain of not less than 1.3, and half-gain angle of at least 33 degrees from the axis of the screen surface.

G. Moderate-Gain Acrylic Screens: Coated acrylic sheet with peak gain of not less than 1.5, and half-gain angle of at least 30 degrees from the axis of the screen surface.

H. Moderate-Gain Glass Screens: Coated glass with peak gain of not less than 1.5, and half-gain angle of at least 30 degrees from the axis of the screen surface.

I. General-Purpose Acrylic Screens: Coated acrylic sheet with peak gain of not less than 1.8, and half-gain angle of at least 28 degrees from the axis of the screen surface.

J. General-Purpose Glass Screens: Coated glass with peak gain of not less than 1.8, and half-gain angle of at least 28 degrees from the axis of the screen surface.

K. High-Gain Acrylic Screens: Coated acrylic sheet with peak gain of not less than 2.0, and half-gain angle of at least 25 degrees from the axis of the screen surface.

L. High-Gain Glass Screens: Coated glass with peak gain of not less than 2.0, and half-gain angle of at least 25 degrees from the axis of the screen surface.

M. High-Gain Acrylic Screens: Coated acrylic sheet with peak gain of not less than 2.3, and half-gain angle of at least 25 degrees from the axis of the screen surface.

N. High-Gain Glass Screens: Coated glass with peak gain of not less than 2.3, and half-gain angle of at least 25 degrees from the axis of the screen surface.

O. High-Performance Screens: Acrylic screen with Fresnel lens on rear surface and with peak gain of not less than 2.0, and half-gain angle of at least 35 degrees from the axis of the screen surface.

P. High-Performance Screens: Acrylic screen with Fresnel lens on rear surface and with peak gain of not less than 3.5, and half-gain angle of at least 32 degrees from the axis of the screen surface.

Q. High-Performance Screens: Acrylic screen with Fresnel lens on rear surface and linear lenses on front surface and with peak gain of not less than 4.0, and horizontal half-gain angle of at least 28 degrees from the axis of the screen surface.

R. Screen Substrate:

1. Glass: Clear float glass complying with ASTM C1036 for Type I (transparent glass, flat), Class 1 (clear), and Quality q3 (glazing select), thickness as directed.

2. Acrylic Sheet: Colorless, transparent, cast-acrylic sheet with a luminous transmittance of 92 percent per ASTM D1003 and complying with ASTM D4802, Category A-1 (cell cast), Finish 1 (smooth or polished), thickness as directed.
3. Acrylic Fresnel Lens: Optically clear acrylic lens complying with ASTM D4802, Category A-1 (cell cast), thickness as directed.

S. Optical Coating: Durable, washable coating bonded to one side of substrate.

T. Optical Tint: As directed.

U. Protective Coating: Provide formulation designed by screen manufacturer as a permanent topcoat over optical coatings to protect against abrasion.

V. Size of Viewing Surface: As directed.

2.3 RIGID REAR-PROJECTION SCREEN ACCESSORIES

A. Factory Frames: Screen manufacturer's standard frames of profile indicated, fabricated to sizes required to fit screens from aluminum extrusions complying with ASTM B221 (ASTM B221M) for 6063-T5 alloy and temper.

1. Class II, Clear Anodic Finish: AA-M12C22A41 (Mechanical Finish: nonspecular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class II, clear coating 0.010 mm or thicker) complying with AAMA 611.
2. Class II, Color Anodic Finish: AA-M12C22A42/A44 (Mechanical Finish: nonspecular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class II, integrally colored or electrolytically deposited color coating 0.010 mm or thicker) complying with AAMA 611.

    a. Color: As directed.

B. Glazing Accessories for Factory Frames: Provide gaskets and setting blocks with proven record of compatibility with screen and frame surfaces, of sizes and shapes to accommodate thickness of screen indicated and to fit glazing channel provided.

C. Glazing Accessories for Field-Framed Screens: Provide materials compatible with screen and frame surfaces while complying with applicable requirements in Section 088000 "Glazing."

PART 3 - EXECUTION

3.1 RIGID REAR-PROJECTION SCREEN INSTALLATION

A. Install rear-projection screens at locations indicated to comply with screen manufacturer's written instructions. Handle screens carefully during installation using procedures and tools recommended by screen manufacturer; do not abrade screen surfaces.

B. Install optically coated, rear-projection screens with optical coating toward projector or audience.

C. Install high-performance, rear-projection screens with orientation as indicated in manufacturer's written instructions.

D. Install factory-framed, rear-projection screens in prepared wall openings. Securely anchor frames to surrounding construction so frames are level and plumb and screen surfaces are flat.

E. Install rear-projection screens with glass substrates, in frames specified in other Sections, to comply with applicable requirements in Section 088000 "Glazing" and with screen manufacturer's written instructions. Set rear-projection screens with surfaces flat and edges level and plumb.

F. Install rear-projection screens with plastic substrates, in frames specified in other Sections, to comply with screen manufacturer's written instructions. Clamp units only at top edge and allow for expansion and contraction of plastic glazing material by providing frame with adequate bite and edge clearances.

END OF SECTION 115213.19

SECTION 115313 - LABORATORY FUME HOODS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bench-top laboratory fume hoods.
2. Floor-mounted laboratory fume hoods.
3. Piping and wiring within fume hoods for service fittings, light fixtures, fan switches, and other electrical devices included with fume hoods.
4. Fume hood base cabinets.
5. Fume hood base stands.
6. Work tops within fume hoods.
7. Laboratory sinks and cup sinks in fume hoods.
8. Water, laboratory gas, and electrical service fittings in fume hoods.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For laboratory fume hoods.

1. Include plans, elevations, sections, and attachment details.
2. Indicate details for anchoring fume hoods to permanent building construction including locations of blocking and other supports. Include calculations demonstrating that anchorages comply with seismic performance requirements.
3. Indicate locations and types of service fittings together with associated service supply connection required.
4. Indicate duct connections, electrical connections, and locations of access panels.
5. Include roughing-in information for mechanical, plumbing, and electrical connections.

C. Samples: For fume hood exterior finishes, interior lining, epoxy work tops and phenolic-composite work tops as directed.

D. Delegated-Design Submittal: For fume hoods indicated to comply with seismic performance requirements and design criteria.

1.3 INFORMATIONAL SUBMITTALS

A. Product Test Reports: Showing compliance with specified performance requirements for as-manufactured containment and static pressure loss, based on evaluation of comprehensive tests performed by manufacturer and witnessed by a qualified testing agency.

B. Field quality-control reports.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Constant Volume Fume Hoods with Steel Exterior:

B. Constant Volume Fume Hoods with Fiberglass Exterior:

C. Constant Volume Fume Hoods with VAV Control and Steel Exterior:

D. Constant Volume Fume Hoods with VAV Control and Fiberglass Exterior:

E. Bypass Fume Hoods with Steel Exterior:

F. Bypass Fume Hoods with Fiberglass Exterior:

G. Restricted-Bypass Fume Hoods with VAV Control and Steel Exterior:

H. Restricted-Bypass Fume Hoods with VAV Control and Fiberglass Exterior:

I. Product Designations: Drawings indicate sizes, types, and configurations of fume hoods by referencing designated manufacturer's catalog numbers. Other manufacturers' fume hoods of similar sizes, types, and configurations, and complying with the Specifications, may be considered. See Section 016000 "Product Requirements."

2.2 PERFORMANCE REQUIREMENTS

A. Containment: Provide fume hoods that comply with the following when tested according to ASHRAE 110:

1. As-Manufactured (AM) Rating: AM 0.05 (0.05 ppm), AM 0.02 (0.02 ppm) or AM 0.01 (0.01 ppm) as directed.
2. Average Face Velocity: 100 fpm (0.51 m/s) plus or minus 10 percent with sashes fully open.
3. Face-Velocity Variation: Not more than 10, 15 or 20 percent of average face velocity across the face opening with sashes fully open as directed.

B. Static-Pressure Loss: Not more than 1/2-inch wg (124 Pa) at 100-fpm (0.51-m/s) face velocity with sash fully open when measured at four locations 90 degrees apart around the exhaust duct and at least three duct diameters downstream from duct collar.

C. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design fume hoods for seismic performance.

D. Seismic Performance: Fume hoods, including attachments to other work, shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. Design earthquake spectral response acceleration, short period (Sds) for Project as directed.
2. Component Importance Factor: 1.5.

2.3 FUME HOODS

A. Product Standards: Comply with SEFA 1, "Laboratory Fume Hoods - Recommended Practices." Provide fume hoods UL listed and labeled for compliance with UL 1805.

B. Constant-Volume Fume Hoods: Provide constant-volume fume hoods without bypass where indicated.

C. Bypass Fume Hoods: Provide bypass fume hoods where indicated. Compensating bypass above the sash opens as sash is closed. Provide sufficient bypass capacity so that face velocity with sash opening of 6 inches (150 mm) does not exceed 3 times the face velocity with sash fully open.

D. Restricted-Bypass Fume Hoods: Provide restricted-bypass fume hoods where indicated. Partial compensating bypass above the sash opens after sash is closed to less than 20 or 40 percent open as directed. Design partial bypass to maintain exhaust capacity of at least 25 cfm per sq. ft. (127 L/s per sq. m) of work surface regardless of sash position.

E. VAV Control: Where indicated, equip or Equip fume hoods with an electronic control unit with a sensing device that monitors face velocity, and a motorized damper on the exhaust connection that maintains a constant face velocity by controlling air volume in response to control unit. Equip units with manual override switch that opens motorized damper to provide maximum exhaust capacity regardless of sash position.

1. Provide output transmitter on electronic control unit that produces zero- to 10-V dc signal proportional to fume hood exhaust volume for interface with building's HVAC control system.

2.4 MATERIALS

A. Steel Sheet: Cold-rolled, commercial steel (CS) sheet, complying with ASTM A1008/A1008M; matte finish; suitable for exposed applications.

B. Stainless Steel Sheet: ASTM A240/A240M or ASTM A666, Type 304, stretcher-leveled standard of flatness.

1. For perchloric acid fume hoods, use Type 316L instead of Type 304.

C. Glass-Fiber-Reinforced Polyester: Polyester laminate with a chemical-resistant gel coat on exposed faces, having a flame-spread index of 25 or less according to ASTM E84.

D. Epoxy: Factory-molded, modified epoxy-resin formulation with smooth, nonspecular finish.

1. Physical Properties:

a. Flexural Strength: Not less than 10,000 psi (70 MPa).
b. Modulus of Elasticity: Not less than 2,000,000 psi (1400 MPa).
c. Hardness (Rockwell M): Not less than 100.
d. Water Absorption (24 Hours): Not more than 0.02 percent.

e. Heat Distortion Point: Not less than 260 deg F (127 deg C).
f. Flame-Spread Index: 25 or less according to ASTM E84.

2. Chemical Resistance: As follows when tested with indicated reagents according to NEMA LD 3, Test Procedure 3.4.5:

a. No Effect: Acetic acid (98 percent), acetone, ammonium hydroxide (28 percent), benzene, carbon tetrachloride, dimethyl formamide, ethyl acetate, ethyl alcohol, ethyl ether, methyl alcohol, nitric acid (70 percent), phenol, sulfuric acid (60 percent), and toluene.
b. Slight Effect: Chromic acid (60 percent) and sodium hydroxide (50 percent).

3. Color: As directed Black, Gray or Beige.

E. Polypropylene: Unreinforced polypropylene complying with ASTM D4101, Group 01, Class 1, Grade 2.

F. Glass: Clear, laminated tempered glass complying with ASTM C1172, Kind LT, Condition A, Type I, Class I, Quality-Q3; with two plies not less than 3.0 mm thick and with clear, polyvinyl butyral interlayer.

1. Permanently mark safety glass with certification label of the SGCC, the SGCC or another certification agency acceptable to authorities having jurisdiction or the manufacturer as directed. Label shall indicate manufacturer's name, type of glass, thickness, and safety glazing standard with which glass complies.

G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

H. Fasteners: Provide stainless steel fasteners where exposed to fumes.

2.5 FABRICATION

A. General: Assemble fume hoods in factory to greatest extent possible. Disassemble fume hoods only as necessary for shipping and handling limitations. Fume hoods shall be capable of being partly disassembled as necessary to permit movement through a 35-by-79-inch (889-by-2007-mm) door opening.

B. Steel Exterior: Fabricate from steel sheet, 0.048 inch (1.21 mm) thick, with component parts screwed together to allow removal of end panels, front fascia, and airfoil and to allow access to plumbing lines and service fittings. Apply chemical-resistant finish to interior and exterior surfaces of component parts before assembly.

C. Fiberglass Exterior: Fabricate from glass-fiber-reinforced polyester components not less than 1/4 inch (6.35 mm) thick, bonded together to maximum extent practical. Trim edges of panels with PVC extrusion. Limit removable parts to access panels, front fascia, and airfoil.

D. Product Option: Provide either steel or fiberglass exterior as specified above.

E. Ends: Fabricate with double-wall end panels without projecting corner posts or other obstructions to interfere with smooth, even airflow. Close area between double walls at front of fume hood and as needed to house sash counterbalance weights, utility lines, and remote-control valves.

F. Splay top and sides of face opening to provide an aerodynamic shape to ensure smooth, even flow of air into fume hood.

G. Interior Lining: Provide one of the following unless otherwise indicated:

1. Glass-fiber-reinforced polyester, not less than 3/16 inch (4.75 mm) thick.
2. Epoxy, not less than 1/4 inch (6.35 mm) thick.
3. Glass-fiber-reinforced epoxy, not less than 3/16 inch (4.75 mm) thick.
4. Stainless steel, not less than 0.050 inch (1.27 mm) thick with epoxy coating.
5. Phenolic composite, not less than 1/4 inch (6.35 mm) thick.
6. Polypropylene, not less than 1/4 inch (6.35 mm) thick.
7. Unplasticized PVC, not less than 1/4 inch (6.35 mm) thick.

H. Lining Assembly: Unless otherwise indicated, assemble with stainless steel fasteners or epoxy adhesive, concealed where possible. Seal joints by filling with chemical-resistant sealant during assembly.

1. Fasten lining components together with stainless steel cleats or angles to form a rigid assembly to which exterior panels are attached.
2. Fasten lining components to a rigid frame assembly fabricated from stainless steel and to which exterior panels are attached.
3. Punch fume hood lining side panels to receive service fittings and remote controls. Provide removable plug buttons for holes not used for indicated fittings.

I. Molded Glass-Fiber-Reinforced Polyester Lining: Molded unit consisting of end panels, back panel, preset rear baffle, and top bonded together into a single piece; reinforced to form a rigid assembly to which exterior is attached.

1. Punch fume hood lining side panels to receive service fittings and remote controls. Provide removable plug buttons for holes not used for indicated fittings.

J. Stainless Steel Lining Assembly: Welded unit consisting of end panels, back panel, top, and work top; reinforced to form a rigid assembly to which exterior is attached.

1. For perchloric acid and radioisotope fume hood linings, cove corners and weld seams completely, and grind surfaces smooth and polish as needed to produce uniform, directionally textured finish with no evidence of welds and free of cross scratches. Passivate and rinse surfaces; remove embedded foreign matter and leave surfaces clean.

K. Rear Baffle: Unless otherwise indicated, provide baffle, of same material as fume hood lining, at rear of hood with openings at top and bottom. Secure baffle to cleats at rear of hood with stainless steel screws. Fabricate baffle for easy removal for cleaning behind baffle.

1. Provide preset baffles unless otherwise indicated.
2. Provide adjustable baffles with remote-control adjustment from outside front of fume hood where indicated.

3. Provide epoxy-coated, stainless steel screen at bottom baffle opening to prevent paper from being drawn into the exhaust plenum behind baffles.

L. Exhaust Plenum: Full width of fume hood and with adequate volume to provide uniform airflow from hood, of same material as hood lining, and with duct stub for exhaust connection.

1. Duct-Stub Material: As directed Epoxy-coated steel, stainless steel or glass-fiber-reinforced polyester or unless otherwise indicated.
2. Duct-Stub Material for Perchloric Acid and Radioisotope Hoods: Stainless steel.

M. Bypass Grilles: Provide grilles at bypass openings of fume hoods.

N. Sashes: Provide operable sashes of type indicated.

1. Fabricate from 0.050-inch- (1.27-mm-) thick stainless steel, 0.048-inch- (1.21-mm-) thick steel sheet, with chemical-resistant finish or PVC extrusions as directed. Form into four-sided frame with bottom corners welded and finished smooth. Make top member removable for glazing replacement. Set glazing in chemical-resistant, U-shaped gaskets.
2. Counterbalance vertical-sliding sash with sash weight and stainless steel cable system to hold sash in place regardless of position. Provide ball-bearing sheaves, plastic glides in stainless steel guides, and stainless steel lift handles. Provide rubber bumpers at top and bottom of each sash unit.
3. Fabricate horizontal-sliding sashes hung from adjustable nylon-tired, ball-bearing sheaves supported on an overhead stainless steel track. Provide a lower track for guiding sashes only. Sashes shall bypass and be removable. Provide flush finger pulls and rubber bumpers at both stiles of each sash.

O. Airfoil: Unless otherwise indicated, provide airfoil at bottom of fume hood face opening with 1-inch (25-mm) space between airfoil and work top. Sash closes on top of airfoil, leaving 1-inch (25-mm) opening for air intake. Airfoil directs airflow across work top to remove heavier-than-air gases and to prevent reverse airflow.

1. Fabricate airfoil from stainless steel coated with polytetrafluoroethylene or polyvinylidene fluoride.

P. Light Fixtures: Provide vaporproof, two-tube, rapid-start, fluorescent light fixtures, of longest practicable length; complete with tubes at each fume hood. Shield tubes from hood interior with 1/4-inch- (6.35-mm-) thick laminated glass or 3-mm-thick tempered glass, sealed into hood with chemical-resistant rubber gaskets. Provide units with fluorescent tubes easily replaceable from outside of fume hood.

1. Provide fluorescent tubes with color temperature of 3500 K and minimum color-rendering index of 85.
2. Provide vaporproof, acid-resistant, incandescent light fixtures complete with 100-W, Type A, long-life bulbs instead of fluorescent fixtures at perchloric acid and radioisotope fume hoods. Provide two fixtures for hoods up to 60 inches (1524 mm) long and one fixture for every 24 inches (610 mm) of length for longer hoods.

Q. Perchloric Acid Fume Hood Washdown System: Provide perchloric acid fume hoods with washdown system consisting of stainless steel spray nozzles, washdown valve, and associated piping. Design system to thoroughly rinse all surfaces of fume hood interior, including areas

behind and above baffles, and to direct rinse water toward drain trough at rear of work top. Provide T-fitting for extending system to additional spray nozzles in exhaust ducts.

R. Filler Strips: Provide as needed to close spaces between fume hoods or fume hood base cabinets and adjacent building construction. Fabricate from same material and with same finish as fume hoods or fume hood base cabinets, as applicable.

S. Ceiling Extensions: Provide filler panels matching fume hood exterior to enclose space above fume hoods at front and sides of fume hoods and extending from tops of fume hoods to ceiling.

T. Finished Back Panels: Where rear surfaces of fume hoods are exposed to view, provide finished back panels matching rest of fume hood enclosure.

U. Comply with requirements in other Sections for installing water and laboratory gas service fittings, piping, electrical devices, and wiring. Install according to Shop Drawings. Securely anchor fittings, piping, and conduit to fume hoods unless otherwise indicated.

2.6 FUME HOOD BASE CABINETS, BASE STANDS, WORK TOPS, TROUGHS SINKS AND SERVICE FITTINGS AS DIRECTED

A. Comply with Section 123553.13 "Metal Laboratory Casework", Section 123553.16 "Plastic-Laminate-Clad Laboratory Casework", Section 123553.19 "Wood Laboratory Casework" or Provide metal base cabinets in finish matching fume hood exterior finish.

B. Work Tops: Epoxy, Phenolic composite, Epoxy or phenolic composite, Stainless steel or as indicated.

1. Work-Top Configuration: Raised (marine) edge with beveled or rounded edge and corners.
2. Where epoxy sinks occur in epoxy work tops, provide integral sinks bonded to tops with invisible joint line.
3. Where epoxy sinks occur in phenolic-composite work tops, provide drop-in sinks with 1/4-inch (6-mm) thick lip around perimeter of sink.
4. Where stainless steel sinks, cup sinks, or troughs occur in stainless steel tops, factory weld into one integral unit.
5. For perchloric acid fume hoods, provide stainless steel work tops with 1/2-inch (13-mm) raised front edge and integral drain trough at back of top with top sloped to trough.

C. Cup Sinks: As directed Epoxy, Polypropylene, Stainless steel, 3-by-6-inch (75-by-150-mm) oval, 3-by-9-inch (75-by-228-mm) oval, 5-inch (127-mm) diameter or Material and size as indicated.

1. Provide with polypropylene or stainless steel strainers and integral tailpieces as directed.
2. Provide epoxy and polypropylene cup sinks with polypropylene strainers and integral tailpieces.
3. Provide stainless steel cup sinks with stainless steel strainers and integral tailpieces.

D. Work Surface of Floor-Mounted Fume Hoods: Integral floor with 1/2-inch- (13-mm-) high, raised (marine) edge.

1. Solid epoxy floor, 1 inch (25 mm) thick.
2. Solid phenolic-composite floor, 1 inch (25 mm) thick.
3. Stainless steel floor pan.

E. Structural Performance of Radioisotope Fume Hood Components: Capable of withstanding the following loads without permanent deformation, excessive deflection, or binding of cabinet drawers and doors:

1. Work Tops: 200 lb/ft. (297 kg/m).
2. Base Cabinets: 75 lb/ft. (112 kg/m) within cabinets, 50-lb/ft. (74-kg/m) work top, 200 lb/ft. (297 kg/m) on work top, plus weight of hood.

F. Fume Hood Base Stands: Welded steel tubing legs, not less than 2 inches (50 mm) square with channel stretchers and aprons. Weld or bolt stretchers to legs and cross-stretchers, and bolt legs to aprons. Provide leveling device welded to bottom of each leg.

1. Knee Space: As directed, Provide clear floor space not less than 30 inches (760 mm) or 36 inches (915 mm) wide by 25 inches (635 mm) deep by 27 inches (685 mm) high within fume hood base stands unless otherwise indicated.

2.7 CHEMICAL-RESISTANT FINISH

A. Preparation: Clean steel surfaces, other than stainless steel, of mill scale, rust, oil, and other contaminants. After cleaning, apply a conversion coating suited to the organic coating to be applied over it.

B. Chemical-Resistant Finish: Immediately after cleaning and pretreating, apply fume hood manufacturer's standard two-coat, chemical-resistant, baked-on finish consisting of prime coat and thermosetting topcoat. Comply with coating manufacturer's written instructions for applying and baking to achieve a minimum dry film thickness of 2 mils (0.05 mm).

1. Chemical and Physical Resistance of Finish System: Finish complies with acceptance levels of cabinet surface finish tests in SEFA 8M. Acceptance level for chemical spot test shall be no more than four Level 3 conditions.
2. Colors for Fume Hood Finish: As indicated by manufacturer's designations, Match Architect's samples or As selected by Architect from manufacturer's full range.

2.8 ACCESSORIES

A. Airflow Indicator and Alarm: Provide each fume hood with manufacturer's standard airflow indicator with audible and visual alarm that activates when airflow sensor reading is outside of preset range.

B. Airflow Indicator: Provide each fume hood with airflow indicator of one of the following type(s):

1. Indicator Type: Direct-reading aneroid (Magnehelic-type) gage that measures exhaust duct static pressure of fume hood as an indication of airflow.

2. Indicator Type: Thermal anemometer that measures fume hood face velocity and indicates whether it is below normal, normal, or above normal.
3. Indicator Type: Thermal anemometer that measures fume hood face velocity and displays data as digital readout.

C. Airflow Alarm: Provide fume hoods with audible and visual alarm that activates when airflow sensor reading is outside of preset range.

1. Provide with thermal-anemometer or aneroid (Magnehelic-type) gage airflow sensor.
2. Provide with reset and test switches.
3. Provide with switch that silences audible alarm and automatically resets when airflow returns to within preset range.

D. Sash Alarm: Provide fume hoods with audible and visual alarm that activates when sash is opened beyond preset position.

1. Provide with silence and test switches.

E. Sash Stops: Provide fume hoods with sash stops to limit hood opening to 50 percent of sash height. Sash stops can be manually released to open sash fully for cleaning fume hood and for placing large apparatus within fume hood.

F. Bypass Grille Blank-off Panel: Provide fume hoods with blank-off panel on bypass grille designed for use with sash stops to reduce exhaust air volume and provide design face velocity with sash at 50 percent open position.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General: Install fume hoods according to manufacturer's written instructions. Install level, plumb, and true; shim as required, using concealed shims, and securely anchor to building and adjacent laboratory casework. Securely attach access panels but provide for easy removal and secure reattachment. Where fume hoods abut other finished work, apply filler strips and scribe for accurate fit, with fasteners concealed where practical.

B. Comply with requirements in Section 123553.13 "Metal Laboratory Casework", Section 123553.16 "Plastic-Laminate-Clad Laboratory Casework" or Section 123553.19 "Wood Laboratory Casework" for installing fume hood base cabinets, work tops, and sinks as directed.

C. Comply with requirements for installing water and laboratory gas service fittings and electrical devices.

1. Install fittings according to Shop Drawings, installation requirements in SEFA 2.3, and manufacturer's written instructions. Set bases and flanges of sink and work top-mounted fittings in sealant recommended by manufacturer of sink or work-top material. Securely anchor fittings to fume hoods unless otherwise indicated.

3.2 FIELD QUALITY CONTROL

A. Field test installed fume hoods according to "Flow Visualization and Velocity Procedure" requirements in ASHRAE 110.

1. Test one installed fume hood, selected by Architect, for each type of hood installed, according to ASHRAE 110. If tested hood fails to meet performance requirements, field test additional hoods as directed by Architect.

B. Field test installed fume hoods according to ASHRAE 110 to verify compliance with performance requirements.

1. Adjust fume hoods, hood exhaust fans, and building's HVAC system, or replace hoods and make other corrections until tested hoods perform as specified.
2. After making corrections, retest fume hoods that failed to perform as specified.

END OF SECTION 115313

SECTION 116123 - FOLDING AND PORTABLE STAGES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Folding and portable stage platforms.
2. Folding and portable seating-platform risers.
3. Folding and portable standing choral risers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For each exposed product and for each color and texture specified.

1.3 INFORMATIONAL SUBMITTALS

A. Product certificates.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Structural Performance: Folding and portable stages and components shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:

1. Stage Platforms: As directed.
2. Risers: As directed.
3. Stair Treads and Platforms: As directed.
4. Guards and Handrails: As directed.

B. Fire-Test-Response Characteristics: As determined by testing identical products according to test method indicated below, by a qualified testing agency.

1. Flame-Propagation Resistance of Drapery Fabric: Passes NFPA 701.

a. Permanently attach label to fabric indicating whether fabric is inherently and permanently flame resistant, or is treated with flame-retardant chemicals, and whether it requires retreatment after cleaning or after a designated time period of use.

2. Carpet and Resilient Floor Covering: Critical radiant flux Class I, not less than 0.45 W/sq. cm or Class II, not less than 0.22 W/sq. cm when tested according to NFPA 253 as directed.

C. Accessibility Standard: Comply with applicable provisions in the DOJ's 2010 ADA Standards for Accessible Design, the ABA Standards of the Federal agency having jurisdiction and ICC A117.1 for accessibility to folding and portable stages if direct circulation path from the seating area to the stage is required as directed.

2.2 STAGE PLATFORMS

A. Folding and Portable Stage Platforms: Modular, stage platforms 8 inches (203 mm), 16 inches (406 mm), 24 inches (610 mm), 32 inches (810 mm) or 40 inches (1016 mm) high as directed.

B. Frame: Platform frame, legs, and braces shall be cold-rolled galvanized steel, cold-formed steel tubing, steel mechanical tubing, or extruded-aluminum shapes. Supporting members shall fold within platform frame for minimum storage volume, with fail-safe catches and bracing members to securely lock supports in open position. Provide nonmarking plastic or rubber tips for legs to protect permanent flooring, and coupler devices designed to lock platform units together securely and in correct position.

C. Platform Deck: Manufacturer's standard platform panel construction, with steel or aluminum trim at perimeter of each panel, and the following:

1. Finish: Unfinished hardboard, Carpet, Vinyl flooring, Painted or Manufacturer's standard as directed.
2. Color: As indicated by manufacturer's designations, Manufacturer's standard neutral color or As selected by Architect from manufacturer's full range.

2.3 SEATING-PLATFORM RISERS

A. Folding and Portable Seating-Platform Risers: Modular, seating-platform risers fabricated with two, three or four risers with chair surface not less than 36 inches (914 mm) or 48 inches (1219 mm) deep, riser heights in 8-inch (203-mm) increments as directed.

B. Frame: Platform frame, legs, and braces shall be cold-rolled galvanized steel, cold-formed steel tubing, steel mechanical tubing, or extruded-aluminum shapes. Supporting members shall fold within platform frame for minimum storage volume, with fail-safe catches and bracing members to securely lock supports in open position. Provide nonmarking plastic or rubber leg tips to protect permanent flooring, and coupler devices designed to lock platform units together securely and in correct position.

C. Platform Deck: Manufacturer's standard platform panel construction, with steel or aluminum trim at perimeter of each panel, and the following:

1. Finish: Unfinished hardboard, Carpet, Vinyl flooring, Painted or Manufacturer's standard as directed.
2. Color: As indicated by manufacturer's designations, Manufacturer's standard neutral color or As selected by Architect from manufacturer's full range.

2.4 STANDING CHORAL RISERS

A. Folding and Portable Standing Choral Risers: Modular, standing choral risers fabricated as two or three-riser units with treads not less than 16 inches (406 mm) or 18 inches (457 mm) deep as directed, riser heights in 8-inch (203-mm) increments beginning at 8 inches (203 mm) above floor.

B. Frame: Platform frame, legs, and braces shall be cold-rolled galvanized steel, cold-formed steel tubing, steel mechanical tubing, or extruded-aluminum shapes. Supporting members shall fold for minimum storage volume, with fail-safe catches and bracing members to securely lock supports in open position. Provide with nonmarking, integral wheels or casters for transporting units from storage location, nonmarking plastic or rubber leg tips to protect permanent flooring, and coupler devices designed to lock platform units together securely and in correct position.

C. Treads: Manufacturer's standard tread construction, with steel or aluminum trim at perimeter of each unit, and with the following:

1. Finish: Unfinished hardboard, Carpet, Vinyl flooring, Painted or Manufacturer's standard.
2. Color: As indicated by manufacturer's designations, Manufacturer's standard neutral color or As selected by Architect from manufacturer's full range.

2.5 ACCESSORIES

A. Stairs: Stage manufacturer's portable stair assembly not less than 36 inches (914 mm) in nominal width, with treads and framing to match stage system.

1. Provide detachable railing on one side or on both sides as directed.

B. Step-Lighting System: Equip steps with manufacturer's standard low-voltage step-lighting system.

C. Ramps: Stage manufacturer's portable ramp assembly not less than 48 inches (1219 mm) in nominal width, with surface and framing system to match stage system.

1. Provide detachable railing on one side or on both sides as directed.

D. Railings: Platform or riser manufacturer's metal railing system consisting of 1-1/4- or 1-1/2-inch (32- or 38-mm) OD tubing and necessary fittings to attach to platforms or risers.

E. Guardrails: Platform or riser manufacturer's guardrail system consisting of 1-1/4- or 1-1/2-inch (32- or 38-mm) OD tubing and necessary fittings to attach to platforms or risers.

1. Infill Balusters: Spaced less than 4 inches (102 mm) apart.

F. Chair Stops and Toe Boards: Chair stops or toe board, or both, at platform around openings and at edges where railings and open-sided platforms are located.

G. Storage Trucks: Manufacturer's standard wheeled storage platforms designed to store entire quantity of stage units and accessories required for Project. Fabricate trucks of welded steel with four heavy-duty wheels or casters, including not less than two swivel casters. Fabricate wheels and casters from materials that will not damage or mark floors.

H. Closure Panels: Equip stage platforms and risers with perimeter closure panels to match horizontal surfaces, not less than 3/4-inch (19-mm) plywood or medium-density fiberboard, or 1/2-inch (12.7-mm) plywood and hardboard lamination.

I. Curtain Closures: Manufacturer's standard drapery-fabric closures, including accessories necessary for attaching drapery fabric.

1. Skirting Closures: Manufacturer's standard metal supports and drapery-fabric curtain skirting at perimeter edge of platform system.
2. Backdrop Frame and Curtain: Manufacturer's standard, 8-foot- (2.4-m-), 10-foot- (3-m-) or 12-foot- (3.7-m-) high as directed, curtain fabricated from drapery fabric.
3. Guardrail Covers: Manufacturer's standard covers fabricated from drapery fabric and sized to fit required guardrails.
4. Drapery Fabric Color: Black, Brown, As indicated by manufacturer's designations, Manufacturer's standard neutral color, Match Architect's sample or As selected by Architect from manufacturer's full range.

PART 3 - EXECUTION

3.1 DEMONSTRATION

A. Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain folding and portable stages as directed.

B. Assemble folding and portable stages in location directed by Architect or Owner to verify that components are complete and in proper working order as directed. Begin assembly demonstration using units in their as-stored condition.

C. Disassemble folding and portable stages after assembled configuration has been approved by Architect or Owner as directed, and store units in location indicated on Drawings.

END OF SECTION 116123

SECTION 116143 - STAGE CURTAINS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Stage curtains, scrims, and drops.
2. Draw-curtain tracks.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For each installation and for special components not dimensioned or detailed in manufacturer's product data.

C. Samples: For each exposed product and for each color and texture specified.

D. Delegated-Design Submittal: For stage-curtain systems and attachments to structure, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans and other details, drawn to scale, and coordinated with each other, using input from installers of the items involved.

B. Product certificates.

C. Sample warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer of stage curtains.

1.7 WARRANTY

A. Manufacturer's Special Warranty: Manufacturer agrees to repair or replace components of stage-curtain systems that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 STAGE-CURTAIN SYSTEMS

A. Description: Complete stage-curtain systems, including stage curtains and tracks; with necessary accessories for support and operation.

2.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design stage-curtain systems, including comprehensive engineering analysis and attachments to building structure, using performance requirements.

B. Structural Performance: Stage-curtain systems and attachments to structure shall withstand the effects of gravity and operational loads.

C. Fire-Test-Response Characteristics: Provide stage curtains meeting the following requirements as determined by testing identical products by UL or another testing and inspecting agency acceptable to authorities having jurisdiction.

1. Flame-Propagation Resistance: Passes NFPA 701.

a. Permanently attach label to each fabric of curtain assembly indicating whether fabric is inherently and permanently flame resistant or is treated with flame-retardant chemicals and whether it requires retreatment after cleaning or after a designated time period of use.
b. Permanently attach 12-inch- (300 mm-) square swatch of same fabric and dye lot for each fabric of a curtain assembly to the back of assembly for use as fire-resistance test strip.

2.3 CURTAIN FABRICS

A. General: Provide fabrics inherently and permanently flame resistant or chemically flame resistant by immersion treatment according to performance requirements indicated. Provide fabrics of each type and color from same dye lot.

B. Heavyweight Woven Cotton Velour: Napped fabric of 100 percent cotton weighing not less than 25 oz./linear yd. (775 g/linear m), with pile height not less than 79 mils (2 mm); 54-inch (1372-mm) minimum width.

1. Color/Texture/Pattern: As indicated by manufacturer's designations, Match Architect's samples or As selected by Architect from manufacturer's full range.

C. Medium-Weight Woven Cotton Velour: Napped fabric of 100 percent cotton weighing not less than 20 oz./linear yd. (620 g/linear m), with pile height not less than 75 mils (1.9 mm); 54-inch (1372-mm) minimum width.
   1. Color/Texture/Pattern: As indicated by manufacturer's designations, Match Architect's samples or As selected by Architect from manufacturer's full range.

D. Lightweight Woven Cotton Velour: Napped fabric of 100 percent cotton weighing not less than 15 oz./linear yd. (465 g/linear m), with pile height not less than 59 mils (1.5 mm); 54-inch (1372-mm) minimum width.
   1. Color/Texture/Pattern: As indicated by manufacturer's designations, Match Architect's samples or As selected by Architect from manufacturer's full range.

E. Polyester Velour: Napped fabric of 100 percent polyester weighing not less than 22 oz./linear yd. (683 g/linear m), with pile height approximately 75 mils (1.9 mm); inherently and permanently flame resistant; 54-inch (1372-mm) minimum width.
   1. Color/Texture/Pattern: As indicated by manufacturer's designations, Match Architect's samples or As selected by Architect from manufacturer's full range.

F. Muslin: Sheer, plain-woven fabric.

   1. Fabric: 100 percent cotton weighing not less than 16 oz./linear yd. (495 g/linear m); 100-inch (2540-mm) minimum width.
   2. Fabric: 100 percent polyester weighing not less than 11.75 oz./linear yd. (364 g/linear m); inherently and permanently flame resistant; 106-inch (2692-mm) minimum width.
   3. Color: White, Black, Gray Blue as directed.

G. Duvetyn: 100 percent cotton, short-napped fabric weighing not less than 8 oz./linear yd. (250 g/linear m) or 12 oz./linear yd. (370 g/linear m) as directed; twill weave with soft uniform texture; 54-inch (1372-mm) minimum width; black.

H. Duvetyn, Heavy Weight: 100 percent cotton, short-napped fabric weighing not less than 16 oz./linear yd. (495 g/linear m); twill weave with soft uniform texture; 54-inch (1372-mm) minimum width; black.

I. Repp, Atlas Oxford: 100 percent heavyweight cotton woven fabric; herringbone weave; 54-inch (1372-mm) minimum width.
   1. Color/Texture/Pattern: As indicated by manufacturer's designations, Match Architect's samples or as selected by Architect from manufacturer's full range.

J. Repp, Nassau Chevron: 100 percent heavyweight cotton or polyester woven fabric as directed; chevron weave; 54-inch (1372-mm) minimum width.
   1. Color/Texture/Pattern: As indicated by manufacturer's designations, Match Architect's samples or as selected by Architect from manufacturer's full range.

K. Synthetic Boucle: 100 percent synthetic blend with opaque vinyl backing; diagonal weave; inherently and permanently flame resistant; 48-inch (1219-mm) minimum width.

1. Color/Texture/Pattern: As indicated by manufacturer's designations, Match Architect's samples or as selected by Architect from manufacturer's full range.

L. Polyester: 100 percent polyester yarn woven fabric weighing not less than 13 oz./linear yd. (400 g/linear m); inherently and permanently or durably flame resistant; 72-inch (1829-mm) minimum width.
1. Color/Texture/Pattern: As indicated by manufacturer's designations, Match Architect's samples or as selected by Architect from manufacturer's full range.

M. Sharkstooth Scrim: Open-weave, seamless, lightweight gauze fabric.

1. Fabric: 100 percent cotton or 95 percent cotton/5 percent polyester weighing not less than 29 oz./linear yd. (899 g/linear m); 30-foot (9-m) or 35-foot (10.7-m) minimum width as directed.
2. Fabric: 100 percent cotton weighing not less than 32 oz./linear yd. (992 g/linear m); three-thread construction; 30-foot (9-m) or 35-foot (10.7-m) minimum width as directed.
3. Fabric: 100 percent polyester weighing not less than 37 oz./linear yd. (1147 g/linear m); inherently and permanently flame resistant; 35-foot (10.7-m) minimum width.
4. Fabric: 100 percent polyester/modacrylic blend weighing not less than 40 oz./linear yd. (1240 g/linear m); inherently and permanently flame resistant; three-thread construction; suitable for all weather applications; 36-foot (11-m) minimum width.
5. Color: White, Black, Gray or Blue.

2.4 LINING

A. Cotton Lining: Yarn-dyed denim cloth of 100 percent cotton; woven in a warp-faced twill; 54-inch (1372-mm) minimum width; black.

B. Ranger Lining: 100 percent cotton fabric weighing not less than 13 oz./linear yd. (400 g/linear m); 54-inch (1372-mm) minimum width; beige or black as directed.

C. Polyester Lining: 100 percent polyester fabric; inherently and permanently flame resistant; 54-inch (1372-mm) minimum width; beige or black as directed.

2.5 CURTAIN FABRICATION

A. General: Affix permanent label, stating compliance with requirements of authorities having jurisdiction, in accessible location on fabric not visible to audience. Provide vertical seams unless otherwise indicated. Arrange vertical seams so they do not fall on faces of pleats. Do not use fabric cuts less than one-half width.

B. Vertical and Top Hems: Machine sew hems as follows unless otherwise indicated:

1. Vertical Hems: Minimum 2 inches (50 mm) wide, with not less than a 1-inch (25-mm) tuck and with no selvage material visible from front of curtain. Sew open ends of hems closed.

2. Turnbacks: As directed Provide leading-edge or leading- and trailing-edge turnbacks for traveler curtains, formed by folding back not less than 12 inches (300 mm) of face fabric, with not less than a 1-inch (25-mm) tuck, and vertically secured by sewing.
3. Top Hems: Reinforced by double-stitching 3-1/2-inch- (89-mm-) wide, heavy, jute or laminated synthetic webbing to top edge on back side of curtain with not less than 2 inches (50 mm) of face fabric turned under.

C. Fullness:

1. Flat: Provide zero percent fullness in curtains.
2. 50 Percent Fullness: Provide fullness, exclusive of turnbacks and hems, by sewing additional material into 3-inch (75-mm) double-stitched, flat, box pleats or tying or hooking together adjacent grommets into round pleats spaced at 12 inches (300 mm) o.c. along top hem reinforcement as directed.
3. 100 Percent Fullness: Provide fullness, exclusive of turnbacks and hems, by sewing additional material into 6-inch (150-mm) double-stitched, flat, box pleats spaced at 12 inches (300 mm) o.c. or tying or hooking together adjacent grommets 6 inches (150 mm) apart into round pleats spaced at 6 inches (150 mm) o.c. along top hem reinforcement as directed.

D. Grommets: Brass, No. 3, or No. 4. For black curtains, provide brass or aluminum grommets with black finish.

E. Bottom Hems: Machine sew hems as follows unless otherwise indicated:

1. For flat curtains without fullness: 4-inch (100-mm) lined hem with pocket for sliding pipe or conduit weight and stiffener into bottom of curtain, and with a concealing flap of same fabric in front of pocket made 2 inches (50 mm) longer than bottom edge of pocket.
2. For curtains with fullness:

    a. Curtains That Do Not Hang to Floor: Hems not less than 3 inches (75 mm) deep, and with open ends of hems sewn closed.
    b. Floor-Length Curtains: Hems not less than 6 inches (150 mm) deep, with 1-inch (25-mm) weight tape sewn to top seam of the bottom hem, clear of the finished bottom edge, and with open ends of hems sewn closed.
    c. Floor-Length Curtains: Hems not less than 6 inches (150 mm) deep, with individual weights in individual closed pockets sewn above finished bottom edge of curtain, and with open ends of hems sewn closed.

2.6 SCRIMS AND DROPS

A. General: Affix permanent label, stating compliance with requirements of authorities having jurisdiction, in accessible location on fabric not visible to audience. Provide vertical seams unless otherwise indicated. Do not use fabric cuts less than one-half width.

B. Scrims: Scrim curtain fabric sewn flat. Provide with continuous 6-inch (150-mm) pipe pocket at bottom with 6-inch (150-mm) flap of same fabric in front of pocket. Double-stitch 3-1/2-inch (89-mm) jute or laminated synthetic webbing at top with not less than No. 2 brass grommets

spaced at 12 inches (300 mm) o.c. and 1 inch (25 mm) from corner of curtain. Provide not less than 2-inch (50-mm) double-folded side hem and 4-inch (100-mm) bottom hem.

C. Drops: Muslin fabric, sewn flat, with either horizontal or vertical seams and with selvage to the rear. Provide 6-inch (150-mm) pipe pocket at bottom with 6-inch (150-mm) flap of same fabric in front of pocket. Double-stitch 3-1/2-inch (89-mm) jute or laminated synthetic webbing at top with not less than No. 2 brass grommets spaced at 12 inches (300 mm) o.c. and 1 inch (25 mm) from corner of curtain. Provide not less than 2-inch (50-mm) double-folded side hem and 4-inch (100-mm) bottom hem.

2.7 ALUMINUM CURTAIN TRACK

A. Aluminum Track: Extruded aluminum, ASTM B221 (ASTM B221M); alloy and temper as recommended by manufacturer for strength and corrosion resistance; mill or black paint finish as directed; complete with necessary accessories for support and operation.
   1. Aluminum Thickness: 0.080 inch (2.03 mm), 0.125 inch (3.1 mm) or as recommended by manufacturer for loads and operation.

B. Curtain Rails: Provide end stops for track rails.

C. Curtain Carriers: Standard carriers, with a quantity of carriers sufficient for track length, to suit curtain fabrication. Include one master carrier for each leading curtain edge.

D. Clamp and Bracket Hangers: Steel clamps and brackets of sufficient strength required to support loads for attaching track to overhead support.

E. Track-Lap Clamp: Metal to match track channel for attaching two tracks at center overlap.

F. Manual Walk-Along Operation: Fabricate curtain track without cord, cable, pulleys, or floor pulley.

G. Manual Cord Operation: Fabricate curtain track with cord, pulleys, and floor pulley.

   1. Operating Line: 3/8-inch (9-mm) diameter, stretch-resistant operating cord consisting of braided synthetic-fiber jacket over solid, synthetic-fiber, linear filaments.
   2. End Pulleys: One single dead-end and one double live-end pulley. Provide sheave(s) with shielded ball bearing(s) housed in plated-steel body finished to match track. Provide with bracket for securing off-stage curtain end.
   3. Floor Pulley: Sheave with shielded ball bearing housed in plated-steel body, painted black. Spring-tensioned type. Adjustable type.

2.8 STEEL CURTAIN TRACK

A. Steel Track: Roll-formed, galvanized, commercial-quality, zinc-coated steel sheet, ASTM A653/A653M; G60 (Z180) coating designation; with continuous bottom slot and with each half of track in one continuous piece; black paint finish; complete with necessary accessories for support and operation.
   1. Steel Thickness: As recommended by manufacturer for loads and operation.

a. Heavy Duty: Minimum 0.079 inch (2.01 mm).
b. Medium Duty: Minimum 0.064 inch (1.63 mm).

B. Clamp and Bracket Hangers: Steel clamps and brackets of sufficient strength required to support loads for attaching track to overhead support.

C. Track-Lap Clamp: Metal to match track channel for attaching two tracks at center overlap.

D. Curtain Rails: Provide end stops for track rails.

E. Curtain Carriers: Standard carriers, with a quantity of curtain carriers sufficient for track length, to suit curtain fabrication. Include one master carrier for each leading curtain edge.

F. Manual Cord Operation: Provide with cord operating line, 3/8-inch- (9-mm-) diameter, stretch-resistant operating cord of braided synthetic-fiber jacket over solid, synthetic-fiber, linear filaments.

2.9 CURTAIN RIGGING

A. Battens: Fabricated from steel pipe with a minimum number of joints. Connect pipe at joints with a drive-fit pipe sleeve not less than 18 inches (450 mm) long, and secure with four flush rivets, plug welds, threaded couplings, or another equally strong method.

1. Steel Pipe: ASTM A53/A53M, Grade A, standard weight (Schedule 40), black, NPS 1-1/2 (DN 40) nominal diameter unless otherwise indicated.
2. Finish: Shop painted black, with a 1-inch- (25-mm-) wide yellow stripe at center of each batten.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install stage-curtain system according to curtain and track manufacturer's written instructions.

B. Battens: Install battens by suspending with supports spaced to support load, except do not exceed 10 feet (3 m) between supports.

3.2 TRACK INSTALLATION

A. Ceiling-Mounted Track: Drill track at intervals not greater than manufacturer's written instructions for spacing, fasten directly to structure.

B. Beam-Mounted Track: Install track by suspending from beam clamps securely mounted to I-beam structure at track-support spacing, according to manufacturer's written instructions.

C. Wall-Mounted Track: Install track by suspending from brackets securely mounted to wall construction at track-support spacing, according to manufacturer's written instructions.

D. Batten-Hung Track: Install track by suspending from pipe batten with manufacturer's track clamp hangers attached to batten pipe clamps at track-support spacing, according to manufacturer's written instructions.

E. Install track for center-parting curtains with not less than 24-inch (600-mm) overlap of track sections at center, supported by track lap clamps.

3.3 CURTAIN INSTALLATION

A. Track Hung: Secure curtains to track carriers with S-hooks or snap hooks as directed.

B. Batten Hung: Secure curtains to pipe battens with S-hooks or ties as directed.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain stage curtains and tracks as directed.

3.5 CURTAIN SCHEDULE

A. Stage Curtain: As indicated on Drawings and as follows:

1. Type: Proscenium, Grand drape, Tormentors, Intermediate, Traveler panels, Legs, Sides, Border, Valance, Scrim, Drop or Cyclorama as directed.
2. Horizontal Accessory Curtain: Teaser or Valance as directed.
3. Size and Arrangement: As indicated on Drawings.
4. Fabric: Heavyweight woven cotton velour, Medium-weight woven cotton velour, Lightweight woven cotton velour, Polyester velour, Duvetyn, Duvetyn, heavy weight, Repp, atlas oxford, Repp, Nassau chevron, Synthetic boucle, Polyester, Sharkstooth scrim or Muslin as directed.
5. Lining: Cotton, Ranger or Polyester as directed.
6. Fullness: Flat, 50 percent or 100 percent as directed.
7. Bottom Weights: None, Individual weights, Proof coil chain, Weight tape or Pipe or conduit weight and stiffener as directed.
8. Hanging Accessories: S-hooks, Tie lines or Snap hooks as directed.
9. Battens: Use existing, As indicated on Drawings or As recommended by manufacturer.
10. Track: Use existing, Aluminum, Medium-duty steel, Heavy-duty steel with single- or double-curtain capacity as directed.
11. Track Shape: Straight.
12. Operation: Manual walk-along or Manual cord (pulley rope) as directed.
13. Special Requirements: As directed.

END OF SECTION 116143

SECTION 116623 - GYMNASIUM EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Basketball equipment.
2. Volleyball equipment.
3. Badminton equipment.
4. Exercise equipment.
5. Safety pads.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference as directed.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: For gymnasium equipment.

1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power, signal, and control wiring.

D. Samples: For each exposed product and for each item and color specified.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Court layout plans, reflected ceiling plans, and other details, drawn to scale, and coordinated with ceiling-suspended gymnasium equipment, floor inserts, game lines, and markers applied to finished flooring, and coordinated with each other, using input from installers of the items involved.

B. Product Certificates: For each type of gymnasium equipment.

C. Sample warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Fabricator of products or an entity that employs installers and supervisors who are trained and approved by manufacturer.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of gymnasium equipment that fail in materials or workmanship within specified warranty period.

1. Warranty Period: As directed from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Basketball backstops and anchors shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

2.2 BASKETBALL EQUIPMENT

A. Standard Rules: Provide equipment according to the requirements as directed.

B. Connections: Manufacturer's standard connections or connections recommended in writing by manufacturer and complying with Section 055000 "Metal Fabrications" of size and type required to transfer loads to building structure.

C. Overhead-Supported, Wall-Braced Backstops:

1. Stationary Type: Manufacturer's standard assembly.
2. Folding Type: Manufacturer's standard assembly as directed for backstop, with hardware and fittings to permit folding.
3. Goal Height Adjuster: Adjustable from 8 to 10 feet (2.40 to 3.05 m) to top of ring with gear-drive mechanism, locking in any position within adjustment range, with visible height scale attached to side of framing.

a. Operation:

1) Manual operation with detachable crank handle.
2) Electrical: Electric operation with integral gear-drive motor, with limit switches preset to goal heights and the following:

D. Wall-Mounted Backstops: Complete assembly extending from wall, including support framing to building structure, bracing, cables, support chains, pulleys, fittings, hardware, pipe anchors, equipment pads, and fasteners.

1. Stationary Type: Manufacturer's standard assembly for stationary backstop.
2. Folding Type: Manufacturer's standard assembly for upward or side folding backstop.

3. Goal Height Adjuster: Adjustable from 8 to 10 feet (2.40 to 3.05 m) to top of ring with gear-drive mechanism, locking in any position within adjustment range, with visible height scale attached to side of framing.

    a. Operation:

        1) Manual operation with detachable crank handle.
        2) Electrical: Electric operation with integral gear-drive motor, with limit switches preset to goal heights, and one detachable electric control device(s).

E. Backstop Safety Device: Designed to limit free fall if support cable, chains, pulleys, fittings, winch, or related components fail.

F. Winch: Hoist consisting of heavy-duty, fully enclosed worm-gear; brake; cable drum; cable; and fittings, for mounting on wall with equipment-mounting board; designed to move and hold backboard in any raised or lowered position.

G. Backstop Electric Operator: Provide operating machine of size and capacity recommended in writing by manufacturer for equipment specified, with electric motor and factory-prewired motor controls, starter, gear-reduction unit, and remote controls. Coordinate wiring requirements and electrical characteristics with building electrical system.

1. Electrical Components, Devices, and Accessories: Listed and labeled according to NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Motor Electrical Characteristics:

    a. Horsepower: ½, ¾ or 1, as directed.
    b. Voltage: 115 V ac, single phase, 60 hertz.

3. Remote-Control Station(s): NEMA ICS 6, Type 1 enclosure for surface, recessed or flush mounting and momentary-contact, three-position, switch-operated control with up, down, and off functions.

    a. Keys: Provide keys as directed.

4. Limit Switches: Adjustable switches at each backstop, interlocked with motor controls and set to automatically stop backstop at fully retracted and fully lowered positions.

H. Basketball Backboards:

1. Shape and Size:

    a. Rectangular, 72 by 42 inches (1830 by 1070 mm) or 72 by 48 inches (1830 by 1220 mm) width by height, with rounded corners.
    b. Fan-shaped, 54-inch (1370-mm) maximum width by 35-inch (890-mm) or 39-inch (990-mm) maximum height.

2. Backboard Material: Provide with predrilled holes or preset inserts for mounting goals, and as follows:

a. Fiberglass: Minimum 1-1/2-inch (38-mm) thick.
b. Glass: Minimum 1/2-inch (13-mm) thick, transparent tempered glass according to ASTM C1048 Kind FT (fully tempered) and with impact-testing requirements in 16 CFR 1201 Category II or ANSI Z97.1 Class A for safety glazing. Provide glass and framing system manufactured according to FIBA Level 1 or Level 2 requirement that glass does not split off if broken or as directed.

1) Rim-Restraining Device: According to NCAA and NFHS rules and designed to ensure that basket remains attached if glass backboard breaks.

c. Steel: Single-piece, steel face sheet, minimum 0.1046-inch (2.7-mm) nominal thickness, with 1-1/2-inch (38-mm) deep, roll-edged perimeter flange and with steel-reinforced, welded frame welded to back side of backboard; with mounting slots for mounting backboard frame to backstop at standard mounting centers.
d. Hardwood or Particleboard: Minimum 1-1/2-inch (38-mm) thick.

3. Target Area and Border Markings: Permanently etched in white color, marked in pattern and stripe width according to referenced standard rules or manufacturer's standard pattern and stripe width, as directed.
4. Target Area and Border Markings: Marked as directed.
5. Finish: Manufacturer's standard factory-applied, white background.

I. Goal-Mounting Assembly: Compatible with goal, backboard, and backstop.

J. Basketball Goals: Basket ring complete with flanges, braces, attachment plate, and evenly spaced loops welded around underside of ring.

1. Single-rim basket ring competition goal.
2. Double-rim basket ring.
3. Type:

a. Fixed: Nonmovable.
b. Movable: pressure-release design with manufacturer's standard breakaway mechanism and rebound characteristics identical to those of fixed, nonmovable ring.

4. Finish: Manufacturer's standard or Polyester powder-coat finish, as directed.

K. Basketball Nets: 12-loop-mesh net, between 15 and 18 inches (380 to 460 mm) long, sized to fit ring diameter, and as follows:

1. Cord: Made from white cotton or nylon.

L. Backboard Safety Pads: Designed for backboard thickness and extending continuously along bottom and up sides of backboard and over backstop as required by referenced standard rules according to manufacturer's standard design and as directed.

1. Color: As directed.

2.3 VOLLEYBALL EQUIPMENT

A. Standard Rules: Provide equipment according to the requirements as directed.

B. Floor Insert: Solid-brass or Chrome-finished steel floor plate and steel pipe sleeve, concealed by floor plate, with capped bottom end, sized with ID to fit post standards, minimum 9 inches (230 mm) long or 12 inches (305 mm) long, as directed to securely anchor pipe sleeve in structural floor or below finished floor in concrete footing, as directed; with anchors designed for securing floor insert to floor substrate indicated; one per post standard, quantity as directed.

1. Flush Floor Plate: Self-locking or Lockable as directed, hinged access cover, designed to be flush with adjacent flooring. Provide one or two tool(s) for unlocking access covers.
2. Floor Plate: As directed.

C. Post Standards: Removable, fixed-height or adjustable-height, telescoping, paired volleyball post standards and a center post standard for multicourt play, as indicated on Drawings, designed for easy removal from permanently placed floor inserts.

1. Materials: As directed, pipe or tubing, with nonmarking plastic or rubber end cap or floor bumper to protect permanent flooring.
2. Nominal Pipe or Tubing Diameter: As directed, OD at base.
3. Finish: Manufacturer's standard factory-applied, polyester powder-coat finish or plated metal finish.
4. Net Height Adjuster: As directed, height adjustment, complete with fittings; designed for positioning net at heights indicated.

    a. Net Heights: As directed.

5. Height Markers: Clearly marked at regulation play heights as directed.

D. Net: 32 feet (9.75 m) long; one per pair of paired post standards or two per every center post standard; and as follows:

1. Width and Nylon Mesh: Competition volleyball net, 36 inches (910 mm) or 39 inches (990 mm) with 4-inch (102-mm) square knotless mesh made of black nylon string.
2. Dowels: Minimum 1/2-inch (13-mm) diameter fiberglass or 1-inch (25-mm) diameter wood. Provide two dowels per net threaded through each side hem sleeve for straightening net side edges.
3. Net Antennas: 3/8-inch (9.5-mm) diameter, high-tensile-strength, extruded-fiberglass or plastic rods, 72 inches (1830 mm) long, extending above top hem band of net, with alternating white and red bands according to referenced standard rules. Provide two antennas per net.
4. Boundary Tape Markers: 2-inch (50-mm) wide white strip with sleeve for securing net antenna, secured to net top and bottom with hook-and-loop attachment. Provide two tape markers per net for marking court boundaries.

E. Net-Tensioning System: Designed to adjust and hold tension of net. Fully enclosed, nonslip, manufacturer's standard-type winch with cable length and fittings for connecting to net lines, positive-release mechanism, and handle as directed.

F. Bottom Net Lock Tightener: Manufacturer's standard.

G. Judges' Stands: Manufacturer's standard, adjustable-height units designed as directed.

H. Safety Pads: Consisting of minimum 1-inch (25-mm) or 1-1/4-inch (32-mm) thick, multiple-impact-resistant polyurethane, crosslinked or closed-cell polyethylene, as directed foam filler covered by puncture- and tear-resistant fabric cover, minimum 14-oz./sq. yd. (475-g/sq. m) PVC-coated polyester, treated with fungicide for mildew resistance, minimum 14-oz./sq. yd. (475-g/sq. m) nylon-reinforced PVC, molded PVC, as directed; with fire-test-response characteristics indicated, and lined with fire-retardant liner. Provide pads with hook-and-loop closure or attachments for the following components:

1. Post Standards: Wraparound or three- or four-sided style pads, designed to totally enclose each standard to a minimum height of 66 inches (1680 mm) or 72 inches (1830 mm); one per post.
2. Net Lines: Four per net.
3. Judges' Stands: Pads designed to totally enclose front and sides.
4. Fabric Cover Flame-Resistance Ratings: Complies with NFPA 701 as directed.
5. Fabric Color: As directed.

I. Post Standard Transporter: Manufacturer's standard.

J. Wall Storage Rack: Manufacturer's standard.

K. Storage Cart: Manufacturer's standard.

2.4 BADMINTON EQUIPMENT

A. Standard Rules: Provide equipment according to the requirements of BWF's "Laws of Badminton."

B. Floor Insert: Solid-brass floor plate with hinged access cover and steel pipe sleeve with capped bottom end; sized with ID to fit post standards, minimum 5-1/4 inches (133 mm) long, as directed, to securely anchor pipe in structural floor or below finished floor in concrete footing, as directed; one per post standard or as directed.

C. Floor-Insert Adaptor: Pipe sleeve adaptor to convert volleyball floor-insert sleeve to fit badminton post standard; one per badminton post standard or as directed.

D. Post Standards: Paired badminton post standards and a center post standard for multicourt play, designed for easy removal from permanently placed floor inserts.

1. Material: Steel pipe or tubing, with plastic or rubber end cap or nonmarking floor bumper to protect permanent flooring.
2. Nominal Pipe or Tubing Diameter: 1-1/2-inch (38-mm) or 2-3/8-inch (60-mm) OD at base.
3. Finish: Manufacturer's standard factory-applied, polyester powder-coat finish.
4. Net Height Setting: By preset net hooks or adjustable mechanism.

E. Net: Competition badminton net, 20 feet (6.1 m) long and as follows; one per pair of paired post standards or two per every center post standard:

1. Width and Mesh: 30 inches (760 mm) with 3/4-inch (19-mm) square mesh made of purple, dark brown, or black nylon string.

F. Wall Storage Rack: Manufacturer's standard.

G. Storage Cart: Manufacturer's standard.

2.5 EXERCISE EQUIPMENT

A. Pull-up Bar: Wall mounted.

1. Fixed height.
2. Adjustable Height: In 6-inch (152-mm) increments within a range of 18 inches (460 mm) or 30 inches (760 mm).
3. Bar Length: Minimum 36 inches (910 mm) or 40 inches (1010 mm), as directed.
4. Bar: Minimum 1-1/16-inch (27-mm) diameter, round, plated solid-steel bar.
5. Bar Installation Height and Wall Clearance: Height as directed and minimum 12 inches (305 mm) from wall.

B. Stall Bars: Wall mounted in a continuous row; each vertical section with no fewer than 16 rungs.

1. Size: Each section 96 inches (2440 mm) high by 36 inches (910 mm) wide, as directed.
2. Rungs: Minimum 1-3/8-inch- (35-mm-) diameter, round rungs made from hardwood or maple firmly fixed to side rails to prevent rotating or other movement. Provide equipment with top rung extended 6 inches (152 mm) beyond other rungs.
3. Extended Top Rail: Manufacturer's standard.
4. Number of Sections: As directed, complete with intermediate uprights and terminal uprights without rung holes at finished ends.

C. Horizontal Ladder: Wall mounted, with 12 rungs.

1. Size: 12 feet (3.7 m) long by minimum 16 inches (400 mm) wide, as directed.
2. Rungs: Minimum 1-5/16-inch (33-mm) diameter round rungs made from hardwood or maple firmly fixed to side rails to prevent rotating or other movement.
3. Ladder Installation Height and Wall Clearance: Height as directed and 30 inches (760 mm) from wall.

D. Vertical Arm Ladder: Wall mounted, with five to seven horizontal rungs for hand and foot holds.

1. Size: 60 inches (1520 mm) long by minimum 22 inches (560 mm) wide, as directed.
2. Rungs: Minimum 1-1/16-inch (27-mm) OD, round pipe or tubing rungs firmly welded to side rails.
3. Ladder Installation Height: As directed.
4. Ladder Installation Method: Fixed to wall or Removable.

E. Pegged Board Vertical Climber: Wall-mounted board; size as indicated on Drawings; with two peg handholds per board.

F. Climbing Rope: 1-1/2-inch (38-mm) diameter rope, with top end securely clamped in fitting designed for attaching to supporting structure indicated on Drawings.

1. Description: As directed.
2. Length: As directed to allow 42 inches (1070 mm) of rope to lie on floor.
3. Rope Bottom End: As directed.
4. Rubber Balls: Securely fastened every 12 inches (305 mm) or 18 inches (460 mm) along length of rope.
5. Tambourine: 24-inch (610-mm) diameter; minimum 1/2-inch (13-mm) thick, painted plywood disk for restricting climbing and for exercise competition.
6. Safety Guard: 3/16-inch (5-mm) chain or 1/8-inch (3-mm) diameter cable, clamp, and fittings designed for attaching guard to supporting structure indicated on Drawings.
7. Pipe Beam: Ceiling or Wall and ceiling mounted.

G. Metal Finish: Manufacturer's standard factory-applied, polyester powder-coat finish.

H. Wood Finish: Manufacturer's standard transparent or opaque-painted finish.

2.6 SAFETY PADS

A. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less, as directed.
2. Smoke-Developed Index: 50 - 450 or less, as directed.

B. Pad Coverings: Provide safety pad fabric covering that is fabricated from puncture- and tear-resistant, PVC-coated polyester or nylon-reinforced PVC fabric, minimum 14-oz./sq. yd. (475-g/sq. m) and treated with fungicide for mildew resistance; with surface-burning characteristics indicated, lined with fire-retardant liner.

C. Wall Safety Pads: Padded wall wainscot panels designed to be attached in a continuous row; each panel section consisting of fill laminated to backer board, with visible surfaces fully covered by seamless fabric covering, free of sag and wrinkles and firmly attached to back of backer board.

1. Backer Board: Minimum 3/8-inch (9.5-mm) thick plywood, mat formed, or composite panel or fire-retardant-treated plywood by pressure process according to AWPA U1, Use Category UCFA Fire Retardant Interior.
2. Fill: Multiple-impact-resistant foam, as directed.
3. Fire-Resistive Fill: Multiple-impact-resistant foam minimum 1-1/2-inch (38-mm) thick, fire-resistive neoprene, 6.0-lb/cu. ft. (96-kg/cu. m) density or 2-inch (50-mm) thick, fire-resistive neoprene, 6.0-lb/cu. ft. (96-kg/cu. m) density.
4. Size: Each panel section 24 inches (610 mm) wide by minimum 60 inches (1520 mm) long or 24 inches (610 mm) wide by minimum 72 inches (1830 mm) long, as directed.
5. Number of Modular Panel Sections: As directed.
6. Installation Method: Manufacturer's standard.
7. Fabric Covering Color(s): As directed.

D. Corner Wall Safety Pads: Wall corner pad consisting of minimum 1-1/4-inch (32-mm) thick, multiple-impact-resistant, closed-cell, polyethylene-foam filler, covered on both sides and all edges by fabric covering with backer board and manufacturer's standard anchorage to wall or self-adhesive, hook-and-loop attachment to exposed face of wall.

1. Length: Each pad minimum 72 inches (1830 mm), as directed.
2. Fabric Covering Color(s): As directed.

E. Column Safety Pads: Pads covering exposed flange of columns to height indicated, consisting of minimum 1-1/4-inch (32-mm) thick, multiple-impact-resistant, closed-cell, polyethylene-foam filler, covered on both sides and all edges by fabric covering with backer board and manufacturer's standard anchorage to column or self-adhesive, hook-and-loop attachment to exposed face of column.

1. Length: Each pad minimum 72 inches (1830 mm), as directed.
2. Fabric Covering Color(s): As directed

F. Round Column Safety Pads: Wraparound pads fully or partially covering exposed round column to height indicated, consisting of minimum 2-inch (50-mm) thick, multiple-impact-resistant, bonded polyurethane-foam filler, 6.0-lb/cu. ft. (96-kg/cu. m) density, covered on both sides and all edges by fabric covering with hook-and-loop or cord lace and grommet attachment to column.

1. Length: Each pad minimum 72 inches (1830 mm), as directed.
2. Fabric Covering Color(s): As directed.

G. Cutout Trim: Manufacturer's standard flanged cutout trim kits for fitting pads around switches, receptacles, and other obstructions.

1. Color: Gray or Black.

2.7 MATERIALS

A. Support Cable: Manufacturer's standard galvanized-stranded-steel wire rope. Provide fittings according to the wire rope manufacturer's written instructions for size, number, and installation method.

B. Support Chain and Fittings: For chains used for overhead lifting, provide Grade 80 heat-treated alloy-steel chains, according to ASTM A391/A391M, with commercial-quality, hot-dip galvanized or zinc-plated steel connectors and hangars.

C. General-Purpose Chain: For chains not used for overhead lifting, provide carbon steel chain, according to ASTM A413/A413M (Grade 30 proof coil chain or higher grade recommended by gymnasium equipment manufacturer). Provide coating type, chain size, number, and installation method according to manufacturer's written instructions.

D. Castings and Hangers: Malleable iron, according to ASTM A47/A47M; grade as required for structural loading.

E. Softwood Plywood: DOC PS 1, exterior.

F. Particleboard: ANSI A208.1.

G. Equipment-Mounting Board: Wood, transparent or neutral-color-painted finish; size and quantity as required to mount gymnasium equipment according to manufacturer's written instructions.

H. Anchors, Fasteners, Fittings, and Hardware: Gymnasium equipment manufacturer's standard corrosion-resistant or noncorrodible units; concealed; tamperproof, vandal- and theft-resistant design.

I. Grout: Nonshrink, nonmetallic, premixed, factory-packaged, nonstaining, noncorrosive, nongaseous grout, according to ASTM C1107/C1107M, with minimum strength recommended in writing by gymnasium-equipment manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Comply with manufacturer's written installation instructions and competition rules for each type of gymnasium equipment.

B. Permanently Placed Gymnasium Equipment and Components: Install rigid, level, plumb, square, and true; anchored securely to supporting structure; positioned at locations and elevations indicated; in proper relationship to adjacent construction; and aligned with court layout.

C. Connections: Connect electric operators to building electrical system.

D. Removable Gymnasium-Equipment Components: Assemble in place to verify that equipment and components are complete and in proper working order. Disassemble removable gymnasium equipment after assembled configuration is approved by Architect or Owner, and store units in location indicated on Drawings.

E. Adjust movable components of gymnasium equipment to operate safely, smoothly, easily, and quietly; free from binding, warp, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range; and lubricate as recommended in writing by manufacturer.

3.2 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain gymnasium equipment.

END OF SECTION 116623

SECTION 116653 - GYMNASIUM DIVIDERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Walk-draw divider systems.
2. Fold-up divider systems.
3. Radius-fold divider systems.
4. Peak-fold divider systems.
5. Roll-up divider systems.
6. Top-roll divider systems.
7. Electric operators.
8. Divider curtains.
9. Divider system accessories.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at as directed.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For gymnasium dividers.

1. Include diagrams for power, signal, and control wiring.

C. Samples: For each exposed product and for each item and color specified.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans with divider-curtain layouts, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

B. Product Certificates: For each type of gymnasium divider.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Fabricator of products or an entity that employs installers and supervisors who are trained and approved by manufacturer.

PART 2 - PRODUCTS

2.1 WALK-DRAW DIVIDER SYSTEMS

A. Divider-Curtain System: Manually operated, cable-suspended or channel track system, and as follows:

1. Stacking: Stacks to one side or bi-parting with 36-inch (910-mm) overlap at opening as directed.
2. Top Hem: Double-thickness mesh or solid vinyl for grommets.
3. Outer Edge Hems: Double turned and or triple turned and double welded.
4. Bottom Pocket: Double thickness with proof coil chain in pocket.
5. Support Cable: Manufacturer's standard galvanized-stranded-steel wire rope and fittings.

2.2 FOLD-UP DIVIDER SYSTEMS

A. Divider-Curtain System: Electrically operated, upward folding, cable suspended, and as follows:

1. Top Hem: Double-thickness mesh or solid vinyl for continuous pipe batten.
2. Outer Edge Hems: Triple turned and welded.
3. Bottom Curtain Pocket: 6 inches (152 mm) with manufacturer's standard pipe batten with padding, as directed.
4. Support Cables: Galvanized-stranded-steel wire rope and fittings.
5. Support Chain and Fittings: Hardened alloy-steel chain rated for lifting loads indicated, with commercial-quality, corrosion-resistant steel connectors and hangers.
6. Curtain Battens and Drive Pipe: Steel pipe or tubing.

2.3 RADIUS-FOLD DIVIDER SYSTEMS

A. Divider-Curtain System: Electrically operated, upward folding, cable suspended, curved as indicated on Drawings, and as follows:

1. Top Hem: Double-thickness mesh or solid vinyl for pipe battens.
2. Outer Edge Hems: Triple turned and welded.
3. Bottom Curtain Pocket: 6 inches (152 mm) with manufacturer's standard pipe batten with padding, as directed.
4. Support Cable: Galvanized-stranded-steel wire rope and fittings.
5. Support Chain and Fittings: Hardened alloy-steel chain rated for lifting loads indicated, with commercial-quality, corrosion-resistant steel connectors and hangers.
6. Curtain Battens and Drive Pipe: Steel pipe or tubing.

a. Provide segmented or universal-joint-coupled pipe and hoist system design, allowing divider to follow radius indicated.

2.4 PEAK-FOLD DIVIDER SYSTEMS

A. Divider-Curtain System: Electrically operated, upward folding, cable suspended, and as follows:

1. Top Hem: Double-thickness mesh or solid vinyl for pipe battens.
2. Outer Edge Hems: Triple turned and welded.
3. Bottom Curtain Pocket: 6 inches (152 mm) with manufacturer's standard pipe batten with padding as directed.
4. Support Cable: Galvanized-stranded-steel wire rope and fittings.
5. Support Chain and Fittings: Hardened alloy-steel chain rated for lifting loads indicated, with commercial-quality, corrosion-resistant steel connectors and hangers.
6. Curtain Battens: Steel pipe or tubing.
7. Provide drums of varying diameters to evenly retract curtains to sloped ceiling, and hinged piping to fit to changes in ceiling slope. Provide sheave assemblies or idler pulleys to guide cables, and other system components required to follow ceiling contour.

2.5 ROLL-UP DIVIDER SYSTEMS

A. Divider-Curtain System: Electrically operated with roll-up drive pipe, and as follows:

1. Top Hem: Double-thickness mesh or solid vinyl for continuous pipe batten.
2. Outer Edge Hems: Double turned and welded.
3. Belts: Manufacturer's standard width polyester or polyurethane webbing or fabric belts.
4. Support Chain and Fittings: Hardened alloy-steel chain rated for lifting loads indicated, with commercial-quality, corrosion-resistant steel connectors and hangers.
5. Curtain Battens and Drive Pipe: Steel pipe or tubing.

2.6 TOP-ROLL DIVIDER SYSTEMS

A. Divider-Curtain System: Electrically operated, top-roll drive pipe, and as follows:

1. Outer Edge Hems: Double turned and welded.
2. Supports and Fittings: Corrosion-resistant steel clamps and hangers.
3. Drive Pipe and Curtain Battens: Steel pipe or tubing.

2.7 ELECTRIC OPERATORS

A. Provide factory-assembled electric operation system of size and capacity recommended in writing and provided by gymnasium divider manufacturer for gymnasium dividers specified, with electric motors and factory-prewired motor controls, control devices, and accessories required for proper operation.

1. Include wiring from control stations to motors and between synchronizer and dual motors for long curtains. Coordinate operator wiring requirements and electrical characteristics with building electrical system.

B. Electrical Components, Devices, and Accessories: Listed and labeled according to NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Motor Electrical Characteristics:

1. Horsepower: ¾ - 1hp, as directed.
2. Voltage: 115 V ac single phase, 60 hertz, as directed

D. Limit Switches: Adjustable switches at each divider curtain, interlocked with motor controls and set to automatically stop divider curtain at fully extended and fully retracted positions.

E. Control System:

1. Key-Switch Operation: NEMA ICS 6, Type 1 enclosure, momentary-contact, three-position switch-operated control with up, down, and off functions.

a. Keys: Provide one - two key(s) per station, as directed.

2.8 DIVIDER CURTAINS

A. Curtain, Mesh: Woven mesh of polyester yarn coated with vinyl, weighing as directed.

1. Mesh Color: As directed. As directed.

B. Upper Curtain, Mesh: Woven mesh of polyester yarn coated with vinyl, weighing as directed.

1. Mesh Color: As directed.

C. Lower Curtain, Solid: Woven polyester fabric coated with vinyl, 18 oz./sq. yd. (610 g/sq. m) or 22 oz./sq. yd. (745 g/sq. m) and 8-foot (2.4-m) or 10-foot (3.0-m) height above floor.

1. Fabric Color(s): As directed.

D. Hems: Folded and electronically welded.

E. Seams: Electronically welded.

F. Overall Curtain Height: Floor to ceiling, within installation clearances required, as directed.

G. Bottom of Curtain: Approximately 2 inches (50 mm) above finished floor.

H. Divider-Curtain Flame-Resistance Rating passes NFPA 701 Test 2, as directed.

2.9 DIVIDER SYSTEM ACCESSORIES

A. Safety Lock: Locks drive system when speed exceeds 1-1/2 fps (0.3 m/s) or manufacturer's recommended speed, as directed.

B. Audible Motion Alarm: Provide alarm with intermittent warning tone when curtain is raised or lowered.

2.10 SUPPORT MATERIALS AND FASTENERS

A. Support Chain and Fittings: For chains used for overhead lifting, provide Grade 80, heat-treated alloy-steel chains, according to ASTM A391/A391M, with commercial-quality, hot-dip galvanized or zinc-plated steel connectors and hangers.

B. General-Purpose Chain: For chains not used for overhead lifting, provide carbon steel chain, according to ASTM A413/A413M, Grade 30 proof coil chain or higher grade recommended by gymnasium divider manufacturer. Provide coating type, chain size, number, and installation method according to manufacturer's written instructions.

C. Anchors, Fasteners, Fittings, and Hardware: Manufacturer's standard corrosion-resistant or noncorrodible units; concealed.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Comply with manufacturer's written installation instructions.

B. Install gymnasium dividers level, plumb, square, and true; anchored securely to supporting structure; positioned at locations and elevations indicated; in proper relation to adjacent construction; and aligned with sport-court layout.

C. Connections: Connect electric operators to building electrical system.

D. Adjust movable components of gymnasium dividers to operate safely, smoothly, easily, and quietly, free from binding, warp, distortion, uneven tension, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range; and lubricate as recommended in writing by manufacturer.

E. Limit Switch Adjustment: Set and adjust upper and lower limit controls.

3.2 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain gymnasium dividers.

END OF SECTION 116653

SECTION 116800 - PLAY FIELD EQUIPMENT AND STRUCTURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes playground equipment as follows:

1. Freestanding playground equipment.
2. Composite playground equipment.

1.2 DEFINITIONS

A. Definitions in ASTM F1487 apply to Work of this Section.

B. IPEMA: International Play Equipment Manufacturers Association.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at as directed.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: For each type of playground equipment.

1. Include plans, elevations, sections, and attachment details.
2. Include fall heights and use zones for playground equipment, coordinated with the critical-height values of protective surfacing specified in Section 321816.13 "Playground Protective Surfacing."

D. Samples: For each exposed product and for each color and texture specified.

1.5 INFORMATIONAL SUBMITTALS

A. Product certificates.

B. Material certificates.

C. Field quality-control reports.

D. Sample warranty.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.8 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of playground equipment that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Years from date of Substantial Completion, as directed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Safety Standard: Provide playground equipment according to ASTM F1487, as directed.

B. Playground equipment and components shall have the IPEMA Certification Seal.

C. The following playground equipment and components shall have the IPEMA Certification Seal:

1. As directed.

2.2 FREESTANDING PLAYGROUND EQUIPMENT

A. Swing Set providing upright support, as directed.

1. Metal Frame: Galvanized-steel or Aluminum pipe or tubing.

a. Leg Upright(s): As directed.
b. Overhead Beam: As directed.
c. Color: As directed.

2. Wood Frame: Leg upright(s) and overhead beam, as directed.
3. Overhead Beam Height: 96 inches (2440 mm) or 10 ft. (3 m), as directed from pivot point to protective surfacing below.
4. Suspension Members: As directed.

a. Color: As directed.

5. Swing Connector: S-hook or Double clevis and bolt link, as directed.

6. Swing Hanger: Galvanized stamped steel clamp and ductile-iron pivot or heavy-duty ductile iron, as directed.
7. Swing Seats: As directed.

    a. Color: As directed.

8. Capacity: As directed.
9. Age Appropriateness: Two through five years or Five through 12 years, as directed.

B. Slide: As directed.
1. Plan Configuration: As directed.
2. Access: As directed.
3. Sit-Down Entrance: As directed.
4. Frame: As directed.
5. Sliding Surface: As directed.
6. Sliding Surface Construction: As directed.
7. Colors: As directed.
8. Age Appropriateness: Two through five years or Five through 12 years, as directed.

2.3 COMPOSITE PLAYGROUND EQUIPMENT

A. Composite Play Structure: Integral play assembly that provides more than one play activity; manufactured as a system or assembled from manufacturer's standard modular-sized units.
1. Metal Frame: Galvanized-steel or Aluminum pipe or tubing connected with bolts or clamps.

    a. Main Frame Posts: As directed.
    b. Color: As directed.

2. Wood Frame: Frame components connected with bolts.

    a. Main Frame Posts: As directed.
    b. Color: As directed.

3. Platforms: As directed.

    a. Color: As directed.

4. Roofs: As directed.

    a. Color: As directed.

5. Play Structure Access Component(s): As directed.

    a. Handholds: As directed.

6. Equipment: Include the following play event components:

    a. Activity panel.
    b. Balance beam.
    c. Bridge.

d. Climber: As directed.
e. Log roll.
f. Slide.
g. Track ride.
h. Tunnel.
i. Colors: As directed.

7. Arrangement: As directed.
8. Capacity: 10 - 20 users.
9. Age Appropriateness: Two through five years or Five through 12 years, as directed.

2.4 MATERIALS

A. Aluminum: Material, alloy, and temper recommended by manufacturer for type of use and finish indicated.

B. Steel: Hot-dip galvanized.

C. Stainless-Steel Sheet: Type 304; finished on exposed faces with No. 2B finish.

D. Wood: As directed, surfaced smooth on all sides and all edges rounded.

E. Plywood: PS 1, Exterior grade; smooth surfaced with rounded edges; preservative treated after fabrication.

F. Opaque Plastics: Color impregnated, UV stabilized, and mold resistant.

G. Transparent Plastic: Abrasion-resistant, UV-stabilized polycarbonate sheet; clear or colorless; not less than 3/16 inch (5 mm) thick.

H. Suspension Chain and Fittings: Hot-dip galvanized, Zinc-plated or PVC-coated chain, steel connectors, and swing or ring hangers.

I. Suspension Cable: Hot-dip galvanized, Zinc-plated or PVC-coated cable, steel connectors, and swing or ring hangers.

J. Iron Castings and Hangers: Malleable iron, ASTM A47/A47M, Grade 32510, hot-dip galvanized.

K. Post Caps: Cast aluminum or color-impregnated, UV-stabilized, mold-resistant polyethylene or polypropylene; color to match posts.

L. Platform Clamps and Hangers: Cast aluminum or zinc-plated steel, not less than 0.105-inch-(2.7-mm-) nominal thickness.

M. Hardware: Manufacturer's standard; commercial-quality; corrosion-resistant; hot-dip galvanized steel and iron, stainless steel, or aluminum; of a vandal-resistant design.

N. Fasteners: Manufacturer's standard; corrosion-resistant; hot-dip galvanized or zinc-plated steel and iron, or stainless steel; permanently capped; and theft resistant.

2.5 WOOD-PRESERVATIVE-TREATED MATERIALS

A. Preservative Treatment: Pressure-treat wood products according to AWPA U1 and the following:

1. Use preservative chemicals acceptable to authorities having jurisdiction and containing no arsenic or chromium. Use chemical formulations that do not bleed through or otherwise adversely affect finishes. Do not use colorants to distinguish treated materials from untreated materials.
2. Kiln-dry lumber and plywood after treatment to a maximum moisture content, respectively, of 19 and 15 percent. Do not use materials that are warped or do not comply with requirements for untreated materials.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with manufacturer's written installation instructions for each equipment type unless more stringent requirements are indicated. Anchor playground equipment securely, positioned at locations and elevations indicated.

1. Maximum Equipment Height: Coordinate installed fall heights of equipment with finished elevations and critical-height values of protective surfacing. Set equipment so fall heights and elevation requirements for age group use and accessibility are within required limits. Verify that playground equipment elevations comply with requirements for each type and component of equipment.

3.2 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage or Engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative.

1. Perform inspection and testing for each type of installed playground equipment according to ASTM F1487, as directed.

C. Playground equipment items will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION 116800

SECTION 117300 - PATIENT CARE EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Intravenous (IV) tracks, carriers, and bottle holders.
2. Patient-bed locators.
3. Patient-bed service walls.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include plans, elevations, sections, and details.
2. Include details of components. Indicate location and size of each field connection.
3. Include diagrams for service connections and power, signal, and control wiring.

C. Samples: For each exposed product and for each color and texture specified.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 IV TRACKS, CARRIERS, AND BOTTLE HOLDERS

A. IV Tracks: Extruded aluminum, not less than 1-1/4 inches wide by ¾-inch high (32 mm wide by 19 mm high).

1. Track Minimum Wall Thickness: 0.058 inch (1.47 mm), 0.062 inch (1.57 mm) or Manufacturer's standard.
2. Curved Track: Factory-fabricated, 12-inch- (305-mm-) radius bends.
3. Finish: Clear anodized, Satin anodized, Baked enamel, acrylic, or epoxy as directed.

B. IV Carriers: Four nylon rollers and nylon, steel or stainless-steel axles with hanger loop fabricated from 1/4-inch (6-mm) diameter, stainless steel as directed.

1. Provide carriers with ball bearings.

C. Stationary IV Bottle Holders: 24-inch (610-mm), 30-inch (762-mm), 36-inch (914-mm), 42-inch (1067-mm) or 48-inch (1219-mm) fixed height with stainless-steel shaft as directed.

1. Arms: As directed Four or Eight 1/4-inch (6-mm) stainless-steel arms with loops.

a. Type: Folding or Nonfolding as directed.
b. Bottom Loop: Stainless steel.
c. Top Loop: Stainless steel, coated for nonconductivity or uncoated as directed.

D. Telescoping IV Bottle Holders: As directed 28-inch (711-mm), 39-inch (991-mm), 45-inch (1143-mm), 51-inch (1295-mm) or 57-inch (1448-mm) overall height with a 3/4-inch (19-mm) stainless-steel main shaft and a 3/8-inch (9.5-mm) stainless-steel inner shaft, minimum vertical adjustment of 16 inches (406 mm).

1. Arms: As directed Four or Eight 1/4-inch (6-mm) stainless-steel arms with loops.

a. Type: Folding or Nonfolding as directed.
b. Bottom Loop: Stainless steel.
c. Top Loop: Stainless steel, coated for nonconductivity or uncoated as directed.

2. Adjustment Control: Push button or Release ring as directed.

2.2 PATIENT-BED LOCATORS

A. Patient-Bed Locator: Surface-mounted docking station with conduit raceway provisions for eight power-service connections, four on each side, that is UL listed and labeled and complying with NFPA 70, and that ensures proper positioning of patient beds and protects wall surfaces from impact and abrasion damage caused by contact with patient bed.

1. Enclosure: Manufacturer's standard high-impact plastic, one or two piece(s) as directed.

a. Color and Pattern: As selected by Architect from manufacturer's full range.
b. Height: 22-1/2 inches (572 mm), nominal.
c. Width: 50 inches (1270 mm), nominal.
d. Overall Depth: 4-5/8 inches (118 mm), nominal.

2. Power Services:

a. Normal power.
b. Critical power.
c. Low-voltage power and communication.

3. Accessories:

a. Direct and indirect lighting fixture.

2.3 PATIENT-BED SERVICE WALLS

A. Patient-Bed Service Wall: Headwall system; UL listed and labeled; complying with NFPA 70 and NFPA 99; with integrated raceways that provide single-area connection for power services and communication wiring and single connection for hard-piped and brazed medical gas piping.

1. Type: Horizontal, Vertical or Panel as directed.

    a. Unit Overall Length: As indicated on Drawings.
    b. Unit Overall Width: As indicated on Drawings.
    c. Panel Sizes: As indicated on Drawings.

2. Fascia Panels: Removable for installation and maintenance of services, high-pressure plastic or high-pressure laminate as directed.

    a. Color and Pattern: As selected by Architect from manufacturer's full range.

3. Fascia Panel Reveals: 3/8-inch (9.5-mm) flush concave, 3/8-inch (9.5-mm) protruding or Manufacturer's standard.

    a. Reveal Finish: Black or Aluminum as directed.

4. Enclosure/Frame: Anodized aluminum or Galvanized steel as directed.
5. Mounting: Surface, Recessed, single sided or Recessed, double sided as directed.

    a. Unit Depth: As indicated on Drawings, 5 inches (127 mm), nominal or As required by wall construction indicated on Drawings.

6. Accessory Rails: Two, Four or As indicated on Drawings
7. Medical Gas Services:

    a. Oxygen.
    b. Medical air.

8. Medical Vacuum Services: ASME B16.22 copper vacuum-service tubes.
9. Gas Manifold: Machined aluminum block with CGA V-5 diameter, indexed safety system, gas-specific check valves.
10. Power Services:

    a. Normal power.
    b. Critical power.
    c. Low-voltage power.

11. Isolated Power Systems Equipment: UL 1047.
12. Metallic Outlet Boxes: UL 514A.
13. Accessories:

    a. Arm light, compact fluorescent.
    b. Bottle slide.
    c. Blood-pressure gage mount.

d. Charting shelf.
e. Glove-box mount.
f. Light, utility track mounted.
g. Integrated diagnostic system mount.
h. ISS transfer pole with mount.
i. IV resuscitator hook, dual.
j. Ophthalmoscope mount.
k. Post-type utility mount.
l. Resuscitator bag holder.
m. Sharps-container mount.
n. Shelf, mayo or swivel as directed.
o. Speculum mount.
p. Universal charting light with mount.
q. Universal holder.
r. Universal light mount.
s. Universal pole holder, C-clamp.
t. Utility hook.
u. Utility otoscope mount.
v. Utility shelf.
w. Utility slide mount.

PART 3 - EXECUTION

3.1 IV TRACKS, CARRIERS, AND BOTTLE HOLDERS

A. Install tracks level and plumb, according to manufacturer's written instructions.

B. For tracks up to 20 feet (6.0 m) in length, provide track fabricated from single, continuous length.

C. Surface-Track Mounting: Fasten tracks to ceilings at intervals recommended by manufacturer. Fasten tracks to structure at each splice and tangent point of each corner. Center fasteners in track to ensure unencumbered carrier operation. Attach track to ceiling as follows:

1. Mechanically fasten directly to bottom of concrete deck with post-installed anchors.
2. Mechanically fasten directly to finished ceiling with toggle bolts.
3. Mechanically fasten to furring through suspended ceiling with screw and tube spacer.
4. Mechanically fasten to suspended ceiling grid with screws.
5. Attach track to suspended ceiling grid with manufacturer's proprietary clip.

D. Track Accessories: Install splices, end caps, connectors, end stops, coupling and joining sleeves, and other accessories as required for a secure and operational installation.

E. IV Bottle Holders: Unless otherwise indicated, install one IV hook on each IV track and hang one IV hanger.

3.2 PATIENT-BED LOCATORS

A. Install bed locators, level and plumb, according to manufacturer's written instructions.

B. Accurately fit, align, securely fasten, and install bed locators free from distortion or defects.

3.3 PATIENT-BED SERVICE WALLS

A. Install service walls level and plumb, according to manufacturer's written instructions.

B. Accurately fit, align, securely fasten, and install service walls free from distortion or defects.

END OF SECTION 117300

SECTION 118226 - FACILITY WASTE COMPACTORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes facility waste compactors.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For each waste compactor and for special components not dimensioned or detailed in manufacturer's product data.

1. Dimension chute and diverter locations that interface with waste compactors.
2. Include location and installation details of automatic sprinkler in hopper of each chute-fed compactor.
3. Indicate equipment access points and required space for equipment service and operation.

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of waste compactor.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

PART 2 - PRODUCTS

2.1 FACILITY WASTE COMPACTORS

A. Waste Compactor: As directed Manufacturer's standard stationary-horizontal, self-contained horizontal, compactor-container (combination-container), vertical or pivoting-ram-type stationary compactor, complying with requirements; liquidtight; and with components, options, and accessories needed to provide a complete, functional system.
   1. Waste-Compactor Standards: ANSI Z245.21 including appendices and NFPA 82.
   2. Waste-Container Standards: ANSI Z245.30 and ANSI Z245.60.
   3. Rated Size (Volume): Minimum 0.14 cu. yd. (0.11 cu. m), 1.00 cu. yd. (0.77 cu. m), 1.50 cu. yd. (1.15 cu. m), 2.00 cu. yd. (1.53 cu. m), 3.50 cu. yd. (2.68 cu. m), 5.00 cu. yd. (3.82 cu. m), 7.50 cu. yd. (5.73 cu. m) or 10.00 cu. yd. (7.65 cu. m) as directed.
   4. Clear Top Opening (Length by Width): Minimum 20 by 28 inches (508 by 711 mm), 24 by 36 inches (610 by 914 mm), 30 by 48 inches (762 by 1219 mm), 60 by 48 inches (1524 by 1219 mm) or 108 by 72 inches (2743 by 1829 mm) as directed.
   5. Scale Weight: Maximum 2500 lb (1134 kg), 6000 lb (2722 kg), 12,000 lb (5443 kg) or 20,000 lb (9072 kg) as directed.
   6. Electrical Characteristics:
      a. Horsepower: 3, 10, 15, 20, 30 or 50 hp as directed.
      b. Voltage: 115 V ac single phase, 60 Hertz, 230 V ac, single phase, 60 Hertz, 208 V ac, three phase, 60 Hertz, 230 V ac, three phase, 60 Hertz or 460 V ac three phase, 60 Hertz as directed.
   7. Finish: Manufacturer's standard or Manufacturer's standard primer for field painting.
      a. Color: White, Black, Gray, Dark green, Yellow or As selected by Architect from manufacturer's full range.

B. Number of Extra Storage Containers: One or Two as directed.

PART 3 - EXECUTION

3.1 INSTALLATION OF FACILITY WASTE COMPACTORS

A. Install each waste compactor according to manufacturer's written instructions, ANSI Z245.2, and ANSI Z245.21, including appendices.

B. Install automatic sprinkler in hopper of each chute-fed compactor according to NFPA 82.

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. Perform installation and startup checks according to manufacturer's written instructions.

2. Test and adjust controls, alarms, and safeties. Replace damaged and malfunctioning controls and equipment.

B. A waste compactor will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.3 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain waste compactors according to manufacturer's written instructions and ANSI Z245.2.

END OF SECTION 118226

SECTION 122113 - HORIZONTAL LOUVER BLINDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Horizontal louver blinds with slats as directed.
2. Motorized operators.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For horizontal louver blinds, include fabrication and installation details.

1. Motorized Operators: Include details of installation in headrails and include diagrams for power, signal, and control wiring.

C. Samples: For each exposed product and for each color and texture specified, 12 inches (300 mm) long.

1.3 INFORMATIONAL SUBMITTALS

A. Product test reports.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance data.

PART 2 - PRODUCTS

2.1 HORIZONTAL LOUVER BLINDS, ALUMINUM SLATS

A. Slats: Aluminum; alloy and temper recommended by producer for type of use and finish indicated; with crowned profile and radius corners.

1. Width: As directed
2. Thickness: Not less than 0.006 inch (0.15 mm) or Not less than 0.008 inch (0.20 mm) as directed.
3. Features:

a. Lift-Cord Rout Holes: Minimum size required for lift cord and located near back (outside) edge of slat to maximize slat overlap and minimize light gaps between slats.
b. Perforated Slats: Openness factor of 6 to 7 percent.

B. Headrail: Formed steel or extruded aluminum; long edges returned or rolled. Headrails fully enclose operating mechanisms on three sides.

1. Motorized Operating Mechanisms: Coordinate headrail with motorized operator requirements. Provide headrail acceptable to blind and motorized operator manufacturers and suitable for applications indicated.
2. Manual Lift Mechanism:

a. Lift-Cord Lock: Variable; stops lift cord at user-selected position within blind full operating range or Top locking; stops lift cord when blind is in fully opened or fully closed positions only; equipped with ring pull not more than 4 inches (100 mm) long as directed.
b. Operator: Extension of lift cord(s) through lift-cord lock mechanism to form cord pull.

3. Manual Tilt Mechanism: Enclosed worm-gear mechanism and linkage rod that adjusts ladders.

a. Tilt: Full.
b. Tilt: One or Two-direction as directed, positive stop or lockout limited at an angle as directed degrees from horizontal, both directions.
c. Operator: As directed.

4. Manual Lift-Operator and Tilt-Operator Lengths: As directed.
5. Manual Lift-Operator and Tilt-Operator Locations: As directed.

C. Bottom Rail: Formed-steel or extruded-aluminum tube that secures and protects ends of ladders and lift cords and has plastic- or metal-capped ends.

1. Type: As directed.

D. Ladders: As directed.

E. Valance: Two slats or PVC strip as directed.

F. Mounting Brackets: With spacers and shims required for blind placement and alignment indicated.

G. Hold-Down Brackets and Hooks or Pins: Manufacturer's standard.

H. Side Channels and Perimeter Light Gap Seals: Manufacturer's standard.

I. Colors, Textures, Patterns, and Gloss:

1. Slats: As directed.

2. Components: Provide rails, cords, ladders, and materials exposed to view matching or coordinating with slat color unless otherwise indicated.

2.2 HORIZONTAL LOUVER BLINDS, WOOD SLATS

A. Slats: Hardwood as directed.

1. Width: As directed.
2. Thickness: 0.115 inch (2.9 mm) or 0.125 inch (3.2 mm) as directed.
3. Profile: As directed.
4. Corners: Square or Radius as directed.
5. Features:

    a. Lift-Cord Rout Holes: Minimum size required for lift cord and located near back (outside) edge of slat to maximize slat overlap and minimize light gaps between slats or None as directed.

B. Headrail: Formed steel or extruded aluminum; long edges returned or rolled. Headrails fully enclose operating mechanisms on three sides and ends.

1. Motorized Operating Mechanisms: Coordinate headrail with motorized operator requirements. Provide headrail acceptable to blind and motorized operator manufacturers and suitable for applications indicated.
2. Manual Lift Mechanism:

    a. Lift-Cord Lock: Variable; stops lift cord at user-selected position within full operating range or Top locking; stops lift cord when blind is in fully opened or fully closed positions only; equipped with ring pull not more than 4 inches (100 mm) long as directed.
    b. Operator: Extension of lift cord(s) through lift-cord lock mechanism to form cord pull.

3. Manual Tilt Mechanism: Enclosed worm-gear mechanism and linkage rod that adjusts ladders.

    a. Tilt: Full.
    b. Tilt: One or Two-direction as directed, positive stop or lockout limited at an angle directed degrees from horizontal, both directions.
    c. Operator: As directed.

4. Manual Lift-Operator and Tilt-Operator Lengths: As directed
5. Manual Lift-Operator and Tilt-Operator Locations: As directed

C. Bottom Rail: Hardwood, finished to match slats, that secures and protects ends of ladders and lift cords.

1. Type: With trapezoid-shaped bottom angled to minimize light gaps as directed.

D. Ladders: Braided cord or Cloth tape, manufacturer's standard width as directed.

E. Valance: Manufacturer's standard.

F. Tassels: Hardwood finished to match slats, manufacturer's standard.

G. Mounting Brackets: With spacers and shims required for blind placement and alignment indicated.

H. Hold-Down Brackets and Hooks or Pins: Manufacturer's standard.

I. Colors, Finishes, and Gloss:

1. Slats: As directed.
2. Components: Provide rails, cords, ladders, and materials exposed to view matching or coordinating with slat color unless otherwise indicated.

2.3 HORIZONTAL LOUVER BLINDS, POLYMER SLATS

A. Flame-Resistance Rating: Comply with NFPA 701; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

B. Slats: Polymers that are lead-free, UV stabilized, integrally colored, opaque, and will not crack or yellow; antistatic, dust-repellent treated.

1. Width: As directed.
2. Thickness: As directed.
3. Features:

a. Lift-Cord Rout Holes: Minimum size required for lift cord and located near back (outside) edge of slat to maximize slat overlap and minimize light gaps between slats or None as directed.
b. Perforated Slats: Openness factor of 6 to 7 percent.

C. Headrail: Formed steel or extruded aluminum; long edges returned or rolled. Headrail fully encloses operating mechanisms on three sides and ends.

1. Motorized Operating Mechanisms: Coordinate headrail with motorized operator requirements. Provide headrail acceptable to blind and motorized operator manufacturers and suitable for applications indicated.
2. Manual Lift Mechanism:

a. Lift-Cord Lock: Variable; stops lift cord at user-selected position within full operating range or Top locking; stops lift cord when blind is in fully opened or fully closed positions only; equipped with ring pull not more than 4 inches (100 mm) long as directed.
b. Operator: Extension of lift cord(s) through lift-cord lock mechanism to form cord pull.

3. Manual Tilt Mechanism: Enclosed worm-gear mechanism and linkage rod that adjusts ladders.

a. Tilt: Full.

b. Tilt: One or Two-direction as directed, positive stop or lockout limited at an angle as directed degrees from horizontal, both directions.
c. Operator: As directed.

4. Manual Lift-Operator and Tilt-Operator Lengths: As directed.
5. Manual Lift-Operator and Tilt-Operator Locations: As directed

D. Bottom Rail: Secures and protects ends of ladders and lift cords.

1. Type: As directed.

E. Ladders: Braided cord or Cloth tape, manufacturer's standard width as directed.

F. Valance: Manufacturer's standard.

G. Mounting Brackets: With spacers and shims required for blind placement and alignment indicated.

H. Hold-Down Brackets and Hooks or Pins: Manufacturer's standard.

I. Colors, Textures, Patterns, and Gloss:

1. Slats: As directed.
2. Components: Provide rails, cords, ladders, and materials exposed to view matching or coordinating with slat color unless otherwise indicated.

2.4 HORIZONTAL LOUVER BLIND FABRICATION

A. Product Safety Standard: Fabricate horizontal louver blinds to comply with WCMA A 100.1 including requirements for corded, flexible, looped devices; lead content of components; and warning labels.

B. Unit Sizes: Fabricate units in sizes to fill window and other openings as follows, measured at 74 deg F (23 deg C):

1. Between (Inside) Jamb Installation: Width equal to jamb-to-jamb dimension of opening in which blind is installed less 1/4 inch (6 mm) per side or 1/2 inch (13 mm) total, plus or minus 1/8 inch (3.1 mm). Length equal to head-to-sill dimension of opening in which blind is installed less 1/4 inch (6 mm), plus or minus 1/8 inch (3.1 mm).
2. Outside of Jamb Installation: Width and length as indicated, with terminations between blinds of end-to-end installations at centerlines of mullion or other defined vertical separations between openings.

2.5 MOTORIZED OPERATORS

A. Function: Lift and tilt.

B. Electric Motors: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 110513 "Common Motor Requirements for Equipment."

1. Electrical Characteristics: Single phase as directed.

C. Remote Controls: Control stations as directed.

D. Limit Switches: Adjustable switches, interlocked with motor controls and set to stop blind automatically at fully raised and fully lowered positions.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install horizontal louver blinds level and plumb, aligned and centered on openings, and aligned with adjacent units according to manufacturer's written instructions.

1. Locate so exterior slat edges are not closer than 1 inch (25 mm) or 2 inches (51 mm) as directed from interior faces of glass and not closer than 1/2 inch (13 mm) or 1-1/2 inches (38 mm) from interior faces of glazing frames through full operating ranges of blinds.
2. Install mounting and intermediate brackets to prevent deflection of headrails.
3. Install with clearances that prevent interference with adjacent blinds, adjacent construction, and operating hardware of glazed openings, other window treatments, and similar building components and furnishings.

B. Electrical Connections: Connect motorized operators to building electrical system.

C. Adjust horizontal louver blinds to operate free of binding or malfunction through full operating ranges.

D. Clean horizontal louver blind surfaces after installation according to manufacturer's written instructions.

END OF SECTION 122113

SECTION 122116 - VERTICAL LOUVER BLINDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Vertical louver blinds with vanes as directed.
2. Motorized operators.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For vertical louver blinds and motorized operators, include fabrication and installation details.

1. Motorized Operators: Include details of installation and diagrams for power, signal, and control wiring.

C. Samples: For each exposed product and for each color and texture specified, 12 inches (300 mm) long.

1.3 INFORMATIONAL SUBMITTALS

A. Product test reports.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance data.

PART 2 - PRODUCTS

2.1 VERTICAL LOUVER BLINDS, PVC VANES

A. Vanes: Lead-free, UV-stabilized, integrally colored, opaque, permanently flexible, extruded PVC that will not crack or yellow; with not less than 3/8-inch (9.5-mm) overlap when vanes are rotated fully closed.

1. Width: 2 inches (51 mm) or 3-1/2 inches (89 mm) as directed.
2. Profile: As directed.
3. Perforated Vanes: Openness factor percent as directed.

4. Flame-Resistance Rating: Comply with NFPA 701; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
5. Features:

    a. Bottom chain.

B. Headrail: Channel, formed steel or extruded aluminum with long edges returned or rolled and ends capped. Headrail encloses operating mechanisms including carrier-spacing mechanism that provides uniform vane spacing when blinds are traversed fully across headrail (closed).

1. Motorized Operator Control: Coordinate headrail with motorized operator requirements. Provide headrail acceptable to blind and motorized operator manufacturers and suitable for applications indicated.
2. Manual Traverse Control: As directed.
3. Manual Rotation Control: As directed.
4. Manual Control Locations: Right or Left as directed.
5. Draw and Stack: As directed.
6. Cord-Tensioner Mounting: As directed.

C. Carriers: Allow vane removal and replacement.

D. Valance: As directed.

E. Mounting Brackets: With spacers and shims required for blind placement and alignment indicated.

F. Colors, Textures, and Patterns:

1. Vanes: As directed.
2. Components: Provide materials exposed to view matching or coordinating with vanes unless otherwise indicated.

2.2 VERTICAL LOUVER BLINDS, PVC VANES WITH FABRIC VANE INSERTS

A. Vanes: Lead-free, UV-stabilized, permanently flexible, extruded PVC that will not crack or yellow; with not less than 3/8-inch (9.5-mm) overlap when vanes are rotated fully closed. Provide integrally colored, opaque vane with clear grooves for holding fabric insert.

1. Width: 3-1/2 inches (89 mm).
2. Fabric Insert: Stain and fade resistant.

B. Headrail: Channel, formed steel or extruded aluminum with long edges returned or rolled and ends capped. Headrail encloses operating mechanisms including carrier-spacing mechanism that provides uniform vane spacing when blinds are traversed fully across headrail (closed).

1. Motorized Operator Control: Coordinate headrail with motorized operator requirements. Provide headrail acceptable to blind and motorized operator manufacturers and suitable for applications indicated.
2. Manual Traverse Control: As directed.

3. Manual Rotation Control: As directed.
4. Manual Control Locations: Right or Left as directed.
5. Draw and Stack: As directed.
6. Cord-Tensioner Mounting: As directed.

C. Carriers: Allow vane removal and replacement.

D. Valance: As directed.

E. Mounting Brackets: With spacers and shims required for blind placement and alignment indicated.

F. Colors, Textures, and Patterns:

1. Vanes:

a. PVC: As directed.
b. Fabric Inserts: As directed.

2. Components: Provide materials exposed to view matching or coordinating with PVC vanes unless otherwise indicated.

2.3 VERTICAL LOUVER BLINDS, FABRIC VANES

A. Vanes: PVC-coated fiberglass mesh or PVC-coated polyester mesh free-hanging fabric with hemmed, non-raveling edges as directed; stain and fade resistant; with not less than 3/8-inch (9.5-mm) overlap when vanes are rotated fully closed.

1. Width: As directed.
2. Flame-Resistance Rating: Comply with NFPA 701; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
3. Features:

a. Weight, sewn in at bottom of vanes.
b. Bottom chain.

B. Headrail: Channel, formed steel or extruded aluminum with long edges returned or rolled and ends capped. Headrail encloses operating mechanisms including carrier-spacing mechanism that provides uniform vane spacing when blinds are traversed fully across headrail (closed).

1. Motorized Operator Control: Coordinate headrail with motorized operator requirements. Provide headrail acceptable to blind and motorized operator manufacturers and suitable for applications indicated.
2. Manual Traverse Control: As directed.
3. Manual Rotation Control: As directed.
4. Manual Control Locations: Right or Left as directed.
5. Draw and Stack: As directed.
6. Cord-Tensioner Mounting: As directed.

C. Carriers: Allow vane removal and replacement.

D. Valance: As directed.

E. Mounting Brackets: With spacers and shims required for blind placement and alignment indicated.

F. Colors, Textures, and Patterns:

1. Vanes: As directed.
2. Components: Provide materials exposed to view matching or coordinating with vanes unless otherwise indicated.

2.4 VERTICAL LOUVER BLIND FABRICATION

A. Product Safety Standard: Fabricate vertical louver blinds to comply with WCMA A 100.1 including requirements for corded, flexible, looped devices; lead content of components; and warning labels.

B. Unit Sizes: Fabricate units in sizes to cover window and other openings as follows, measured at 74 deg F (23 deg C):

1. Between (Inside) Jamb Installation: Width equal to jamb-to-jamb dimension of opening in which blind is installed less 1/4 inch (6 mm) per side or 1/2 inch (13 mm) total, plus or minus 1/8 inch (3.1 mm). Length equal to head-to-sill or -floor dimension of opening in which blind is installed less 1/4 inch (6 mm), plus or minus 1/8 inch (3.1 mm).
2. Outside of Jamb Installation: Width and length as indicated, with terminations between blinds of end-to-end installations at centerlines of mullion or other defined vertical separations between openings.

2.5 MOTORIZED OPERATORS

A. Function: Rotation and traverse.

B. Electric Motors: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 110513 "Common Motor Requirements for Equipment."

1. Electrical Characteristics: Single phase, as directed.

C. Remote Controls: As directed.

D. Limit Switches: Adjustable switches interlocked with motor controls and set to stop blind automatically at vanes fully traversed across headrail and rotated closed and vanes stacked and rotated open.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install vertical louver blinds level and plumb, aligned and centered on openings, and aligned with adjacent units according to manufacturer's written instructions.

1. Locate so exterior vane edges are not closer than 2 inches (51 mm) from interior faces of glass and not closer than 1-1/2 inches (38 mm) from interior faces of glazing frames through full operating ranges of blinds.
2. Install mounting and intermediate brackets to prevent deflection of headrails.
3. Install with clearances that prevent interference with adjacent blinds, adjacent construction, and operating hardware of glazed openings, other window treatments, and similar building components and furnishings.

B. Electrical Connections: Connect motorized operators to building electrical system.

C. Adjust vertical louver blinds to operate free of binding or malfunction through full operating ranges.

D. Clean vertical louver blind surfaces after installation according to manufacturer's written instructions.

END OF SECTION 122116

SECTION 122200 - CURTAINS AND DRAPES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Drapes.
2. Drapery tracks.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Drapery Tracks: Include maximum weights of drapes that can be supported.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings:

1. Drapery Tracks: Show installation and anchorage details and locations of controls.
2. Drapes: Show sizes, locations, and details of installation.

D. Samples: As follows:

1. Drapery Tracks: 18 inches (450 mm) long, with carriers, controls, and accessories.
2. Drapery Fabrics: For each color and pattern indicated, full width by 36 inches (1000 mm) long, from dye lot to be used for the Work and with specified textile treatments applied. Show complete pattern repeat if any. Mark top and face of fabric.
3. Textile Trims: For each color and pattern indicated, 18 inches (450 mm) long.
4. Drape Fabrication: For each heading, fabric, color, and pattern indicated, a complete full-size panel to verify details of fabrication and thread colors.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: For drapery track installation; reflected ceiling plans drawn to scale and coordinating track installation with openings and ceiling-mounted items.

B. Product certificates.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: For drapes and drapery tracks, fabricator of drapes.

PART 2 - PRODUCTS

2.1 DRAPERY TRACKS

A. Manually Operated Track:
   1. Construction: Extruded aluminum, slotted for mounting at interval of not more than 24 inches (610 mm) o.c., and bendable to radii indicated.

      a. Lengths and Configurations: As directed.
      b. Support Capability: Weight of drape indicated as directed, mounted on track length indicated as directed.
      c. Finish: White baked enamel or Clear anodic coating as directed.

   2. Mounting Brackets: Aluminum, of type suitable for fastening track to surface indicated and designed to support weight of track assembly and drape plus force applied to operate track.

      a. Size: Adjustable.

   3. Installation Fasteners: Sized to support track assembly and drape, and fabricated from metal compatible with track, brackets, and supporting construction. Provide two fasteners to fasten each bracket to supporting construction.
   4. Operation: As directed.

      a. Pulley Mounting Location: As directed.
      b. Draw: As directed.
      c. Operating Hardware Location: As directed.

   5. Carriers: As directed.

      a. Master Carriers: Butt or Overlap as directed.

   6. End Stops: Manufacturer's standard with track end cap.
   7. Pulleys: Standard or Heavy duty as directed.
   8. Accessories: As directed.

2.2 DRAPES

A. Source Limitations: Obtain each color and pattern of drapery fabric and trim from one dye lot.

B. Fire-Test-Response Characteristics: For fabrics treated with fire retardants, provide products that pass NFPA 701 as determined by testing of fabrics that were treated using treatment-application method intended for use for this Project by a testing and inspecting agency acceptable to authorities having jurisdiction.

C. Drape:

1. Heading:

a. Pinch (French) Pleats: Percent fullness as directed; Fold (fingers) each pleat as directed.
b. Stack Pleats: Percent fullness as directed.
c. Roll Pleats: Percent fullness as directed.
d. Accordion Pleats: Percent fullness as directed.
e. Pleat Spacing: As directed.
f. Heading Accessories:

1) Nonwoven buckram.
2) Woven snap tape, 7/8 inch (22 mm) wide, with nickel-plated snaps at 4 inches (102 mm) o.c.
3) Hooks.

2. Drapery Fabric: As directed

3. Fiber Content: As directed.
4. Orientation: Run right (up the bolt).
5. Width: As directed.
6. Pattern Repeat Distance: Vertically as directed; horizontally as directed.
7. Textile Treatments: As directed.
8. Lining Fabric:

a. Lining Type: As directed.
b. Product: As directed.
c. Color: As directed.
d. Fiber Content: As directed.
e. Width: As directed.
f. Textile Treatments: As directed.

9. Textile Trim: As directed.
10. Tiebacks: As directed.
11. Hem Weights: 1-inch- (25-mm-) square lead weights or Tape type (string weights) as directed.

2.3 DRAPE FABRICATION

A. Fabricate drapes in heading styles and fullnesses indicated. Fabricate headings to stand erect. If less than a full width of fabric is required to produce panel of specified fullness, use equal widths of not less than one-half width of fabric located at ends of panel.

1. One-Way-Stacking Drapes: Add 5 inches (127 mm) to overall width for returns.
2. Center-Opening Drapes: Add 10 inches (254 mm) to overall width for overlap.

B. Seams: Sew vertical seams with twin-needle sewing machine with selvage trimmed and overlocked. Join widths so that patterns match and vertical seams lay flat and straight without puckering. Horizontal seams are unacceptable.

C. Side Hems: Double-turned, 1-1/2-inch- (38-mm-) wide hems consisting of three layers of fabric, and blindstitched so that stitches are invisible on face of drape.

D. Bottom Hems: Double-turned, 4-inch- (102-mm-) wide hems consisting of three layers of fabric, and weighted and blindstitched so that weights and stitches are invisible on face of drape.

1. Sew in square lead weights at each seam and at panel corners.

E. Linings: Equal to widths of drapery fabric and joined to drapery fabric at top by inside invisible seam, and hand stitched at side hems and shadowed with 1-1/2-inch (38-mm) return of face fabric.

1. Bottom Hem: Hem separately from or Blind stitch to drapery fabric as directed.

PART 3 - EXECUTION

3.1 DRAPERY TRACK INSTALLATION

A. Install track systems according to manufacturer's written instructions, level and plumb, and at height and location in relation to adjoining openings as indicated on Drawings.

B. Isolate metal parts of tracks and brackets from concrete, masonry, and mortar to prevent galvanic action. Use tape or another method recommended in writing by track manufacturer.

3.2 DRAPE INSTALLATION

A. Where drapes abut overhead construction, hang drapes so that clearance between headings and overhead construction is 1/4 inch (6.4 mm).

B. Where drapes extend to floor, install so that bottom hems clear finished floor by not more than 1 inch (25 mm) and not less than 1/2 inch (13 mm).

C. Where drapes extend to windowsill, install so that bottom hems hang above sill line and clear sill line by not more than 1/2 inch (13 mm).

D. After hanging drapes, do the following:

1. Test and adjust each drapery track to produce unencumbered, smooth operation.
2. Steam and dress down drapes as required to produce crease- and wrinkle-free installation.
3. Remove and replace drapes that are stained or soiled.

END OF SECTION 122200

SECTION 122413 - ROLLER WINDOW SHADES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Manually operated roller shades with single rollers.
2. Manually operated roller shades for skylights.
3. Motor-operated roller shades with single rollers.
4. Motor-operated roller shades for skylights.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Show fabrication and installation details for roller shades, including shadeband materials, their orientation to rollers, and their seam and batten locations.

1. Motor-Operated Shades: Include details of installation and diagrams for power, signal, and control wiring.

C. Samples: For each exposed product and for each color and texture specified.

1.3 INFORMATIONAL SUBMITTALS

A. Product certificates.

B. Product test reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Fabricator of products.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain roller shades from single source from single manufacturer.

2.2 MANUALLY OPERATED SHADES WITH SINGLE ROLLERS

A. Chain-and-Clutch Operating Mechanisms: With continuous-loop bead chain and clutch that stops shade movement when bead chain is released; permanently adjusted and lubricated.

1. Chain-Retainer Type: As directed.
2. Spring Lift-Assist Mechanisms: Provide for shadebands that weigh more than 10 lb (4.5 kg) or for shades as recommended by manufacturer, whichever criterion is more stringent.

B. Crank-and-Gear Operating Mechanisms: Sealed gearbox drive system controlled by detachable or permanently mounted crank handle as directed.

C. Rollers: Corrosion-resistant steel or extruded-aluminum tubes of diameters and wall thicknesses required to accommodate operating mechanisms and weights and widths of shadebands indicated without deflection. Provide with permanently lubricated drive-end assemblies and idle-end assemblies designed to facilitate removal of shadebands for service.

1. Roller Drive-End Location: Right side of interior face of shade or Left side of interior face of shade as directed.
2. Direction of Shadeband Roll: Regular, from back (exterior face) of roller or Reverse, from front (interior face) of roller as directed.

D. Mounting Hardware: Brackets or endcaps, corrosion resistant and compatible with roller assembly, operating mechanism, installation accessories, and mounting location and conditions indicated.

E. Roller-Coupling Assemblies: Coordinated with operating mechanism and designed to join up to three inline rollers into a multiband shade that is operated by one roller drive-end assembly.

F. Shadebands:

1. Shadeband Material: Light-filtering fabric or Light-blocking fabric as directed.
2. Shadeband Bottom (Hem) Bar: Steel or extruded aluminum.

    a. Type: As directed.
    b. Color and Finish: As directed.

G. Installation Accessories:

1. Front Fascia: Aluminum extrusion that conceals front and underside of roller and operating mechanism and attaches to roller endcaps without exposed fasteners.
2. Exposed Headbox: Rectangular, extruded-aluminum enclosure including front fascia, top and back covers, endcaps, and removable bottom closure.

3. Endcap Covers: To cover exposed endcaps.
4. Recessed Shade Pocket: Rectangular, extruded-aluminum enclosure designed for recessed ceiling installation; with front, top, and back formed as one piece, end plates, and removable bottom closure panel.
5. Closure Panel and Wall Clip: Removable aluminum panel designed for installation at bottom of site-constructed ceiling recess or pocket and for snap-in attachment to wall clip without fasteners.
6. Side Channels: With light seals and designed to eliminate light gaps at sides of shades as shades are drawn down. Provide side channels with shadeband guides or other means of aligning shadebands with channels at tops.
7. Bottom (Sill) Channel or Angle: With light seals and designed to eliminate light gaps at bottoms of shades when shades are closed.
8. Installation Accessories Color and Finish: As directed

2.3 MANUALLY OPERATED SKYLIGHT ROLLER SHADES

A. Manual Operating Mechanisms: Manufacturer's complete system and accessories suitable for conditions indicated, recommended by manufacturer for use with shade indicated, and as required for reliable operation without malfunction.

1. Chain-and-Clutch Operating Mechanisms: Double or Single-roller system as directed with continuous-loop bead chain and clutch in drive roller that stops shade movement when bead chain is released; permanently adjusted and lubricated.

    a. Chain-Retainer Type: As directed.

2. Crank-and-Gear Operating Mechanisms: Double-roller systems with sealed gearbox drive systems controlled by detachable crank handles in drive rollers and with springs in opposing rollers to hold shadebands taught.

B. Rollers: Corrosion-resistant steel or extruded-aluminum tubes of diameters and wall thicknesses required to accommodate operating mechanisms and weights and widths of shadebands indicated without deflection. Provide with permanently lubricated drive-end assemblies and idle-end assemblies designed to facilitate removal of shadebands for service.

1. Roller Drive-End Location: Right side of interior face of shade or Left side of interior face of shade as directed.
2. Direction of Shadeband Roll: Regular, from back (exterior face) of roller or Reverse, from front (interior face) of roller.

C. Shadeband Retention System: Manufacturer's standard system for guiding shadeband through range of travel and holding shadeband taut with edges of shadeband supported by side channels or angles.

D. Mounting Hardware: Corrosion resistant and compatible with operating mechanism, installation accessories, and mounting location and conditions indicated.

E. Shadebands:

1. Shadeband Material: Light-filtering fabric or Light-blocking fabric as directed.

2. Shadeband Bottom (Hem) Bar: Manufacturer's standard for operating mechanism indicated.

    a. Color and Finish of Exposed Bottom Bar: As directed.

F. Installation Accessories:

1. Exposed Headboxes and Bottom Boxes: Rectangular, extruded-aluminum enclosure including front fasciae, top and back covers, endcaps, and removable closures.
2. Channels or Angles: Manufacturer's standard design for operating mechanism indicated and shadeband take-up and support.
3. Installation Accessories Color and Finish: As directed.

2.4 MOTOR-OPERATED, SINGLE-ROLLER SHADES

A. Motorized Operating System: Provide factory-assembled, shade-operator system of size and capacity and with features, characteristics, and accessories suitable for conditions indicated. Coordinate operator wiring requirements and electrical characteristics with building electrical system.

1. Electrical Components: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Electric Motor: Tubular, enclosed in roller as directed.

    a. Electrical Characteristics: As directed.
    b. Maximum Total Shade Width: As directed.
    c. Maximum Shade Drop: As directed.
    d. Maximum Weight Capacity: As directed.

3. Remote Control: Control station as directed.
4. Crank-Operator Override: Crank and gearbox operate shades in event of power outage or motor failure.
5. Limit Switches: Adjustable switches interlocked with motor controls and set to stop shades automatically at fully raised and fully lowered positions.

B. Rollers: Corrosion-resistant steel or extruded-aluminum tubes of diameters and wall thicknesses required to accommodate operating mechanisms and weights and widths of shadebands indicated without deflection. Provide with permanently lubricated drive-end assemblies and idle-end assemblies designed to facilitate removal of shadebands for service.

1. Roller Drive-End Location: Right side of interior face of shade or Left side of interior face of shade as directed.
2. Direction of Shadeband Roll: Regular, from back (exterior face) of roller or Reverse, from front (interior face) of roller as directed.

C. Mounting Hardware: Brackets or endcaps, corrosion resistant and compatible with roller assembly, operating mechanism, installation accessories, and mounting location and conditions indicated.

D. Roller-Coupling Assemblies: Coordinated with operating mechanism and designed to join up to three inline rollers that are operated by one roller drive-end assembly.

E. Shadebands:

1. Shadeband Material: Light-filtering fabric or Light-blocking fabric.
2. Shadeband Bottom (Hem) Bar: Steel or extruded aluminum.

    a. Type: As directed.
    b. Color and Finish: As directed.

F. Installation Accessories:

1. Front Fascia: Aluminum extrusion that conceals front and underside of roller and operating mechanism and attaches to roller endcaps without exposed fasteners.
2. Exposed Headbox: Rectangular, extruded-aluminum enclosure including front fascia, top and back covers, endcaps, and removable bottom closure.
3. Endcap Covers: To cover exposed endcaps.
4. Recessed Shade Pocket: Rectangular, extruded-aluminum enclosure designed for recessed ceiling installation; with front, top, and back formed as one piece, end plates, and removable bottom closure panel.
5. Closure Panel and Wall Clip: Removable aluminum panel designed for installation at bottom of site-constructed ceiling recess or pocket and for snap-in attachment to wall clip without fasteners.
6. Side Channels: With light seals and designed to eliminate light gaps at sides of shades as shades are drawn down. Provide side channels with shadeband guides or other means of aligning shadebands with channels at tops.
7. Bottom (Sill) Channel or Angle: With light seals and designed to eliminate light gaps at bottoms of shades when shades are closed.
8. Installation Accessories Color and Finish: As directed.

2.5 MOTOR-OPERATED, SKYLIGHT ROLLER SHADES

A. Motorized Operating System: Provide factory-assembled, shade-operator system of size and capacity and with features, characteristics, and accessories suitable for conditions indicated. Coordinate operator wiring requirements and electrical characteristics with building electrical system.

1. System Type: As directed.
2. Electrical Components: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Electric Motor: Tubular, enclosed in roller as directed.

    a. Electrical Characteristics: As directed.
    b. Maximum Total Shade Width: As directed.
    c. Maximum Shade Length: As directed.
    d. Maximum Weight Capacity: As directed.

4. Remote Control: Control station as directed.

5. Crank-Operator Override: Crank and gearbox operate shades in event of power outage or motor failure.
6. Limit Switches: Adjustable switches, interlocked with motor controls and set to stop shade movement automatically at fully raised and fully lowered positions.

B. Rollers: Corrosion-resistant steel or extruded-aluminum tubes of diameters and wall thicknesses required to accommodate operating mechanisms and weights and widths of shadebands indicated without deflection. Provide with permanently lubricated drive-end assemblies and idle-end assemblies designed to facilitate removal of shadebands for service.

1. Drive-End Location: Right side of interior face of shade orLeft side of interior face of shade as directed.
2. Direction of Shadeband Roll: Regular, from back (exterior face) of roller or Reverse, from front (interior face) of roller as directed.

C. Shadeband Retention System: Manufacturer's standard system for guiding shadeband through range of travel and holding shadeband taut with edges of shadeband supported by side channels or angles.

D. Mounting Hardware: Corrosion resistant and compatible with operating mechanism, installation accessories, and mounting location and conditions indicated.

E. Shadebands:

1. Shadeband Material: Light-filtering fabric or Light-blocking fabric as directed.
2. Shadeband Bottom (Hem) Bar: Manufacturer's standard for operating mechanism indicated.

a. Color and Finish of Exposed Bottom Bar: As directed.

F. Installation Accessories:

1. Exposed Headboxes and Bottom Boxes: Rectangular, extruded-aluminum enclosure including front fasciae, top and back covers, endcaps, and removable closures.
2. Channels or Angles: Manufacturer's standard design for operating mechanism indicated and shadeband take-up and support.
3. Installation Accessories Color and Finish: As directed.

2.6 SHADEBAND MATERIALS

A. Shadeband Material Flame-Resistance Rating: Comply with NFPA 701. Testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

B. Light-Filtering Fabric: Woven fabric, stain and fade resistant.

1. Source: Roller shade manufacturer.
2. Type: As directed.
3. Weave: Mesh or Basketweave as directed.
4. Thickness: As directed.
5. Weight: As directed.

6. Roll Width: As directed.
7. Orientation on Shadeband: Up the bolt or Railroaded as directed.
8. Openness Factor: Percent as directed.
9. Color: As directed.

C. Light-Blocking Fabric: Opaque fabric, stain and fade resistant.

1. Source: As directed.
2. Type: As directed.
3. Thickness: As directed.
4. Weight: As directed.
5. Roll Width: As directed.
6. Orientation on Shadeband: Up the bolt or Railroaded as directed.
7. Features: Washable or Antistatic treatment.
8. Color: As directed.

2.7 ROLLER SHADE FABRICATION

A. Product Safety Standard: Fabricate roller shades to comply with WCMA A 100.1

B. Unit Sizes: Fabricate units in sizes to fill window and other openings as follows, measured at 74 deg F (23 deg C):

1. Between (Inside) Jamb Installation: Width equal to jamb-to-jamb dimension of opening in which shade is installed less 1/4 inch (6 mm) per side or 1/2-inch (13-mm) total, plus or minus 1/8 inch (3.1 mm). Length equal to head-to-sill or -floor dimension of opening in which shade is installed less 1/4 inch (6 mm), plus or minus 1/8 inch (3.1 mm).
2. Outside of Jamb Installation: Width and length as indicated, with terminations between shades of end-to-end installations at centerlines of mullion or other defined vertical separations between openings.

C. Shadeband Fabrication: Fabricate shadebands without battens or seams to extent possible, except as follows:

1. Vertical Shades: Where width-to-length ratio of shadeband is equal to or greater than 1:4, provide battens and seams at uniform spacings along shadeband length to ensure shadeband tracking and alignment through its full range of movement without distortion of the material.
2. Skylight Shades: Provide battens and seams at uniform spacings along shadeband as required to ensure shadeband tracking and alignment through its full range of movement without distortion or sag of material.
3. Railroaded Materials: Railroad material where material roll width is less than the required width of shadeband and where indicated. Provide battens and seams as required by railroaded material to produce shadebands with full roll-width panel(s) plus, if required, one partial roll-width panel located at top of shadeband.

PART 3 - EXECUTION

3.1 ROLLER SHADE INSTALLATION

A. Install roller shades level, plumb, and aligned with adjacent units according to manufacturer's written instructions.

1. Opaque Shadebands: Located so shadeband is not closer than 2 inches (51 mm) to interior face of glass. Allow clearances for window operation hardware.

B. Electrical Connections: Connect motor-operated roller shades to building electrical system.

C. Adjust and balance roller shades to operate smoothly, easily, safely, and free from binding or malfunction throughout entire operational range.

D. Clean roller shade surfaces, after installation, according to manufacturer's written instructions.

E. Replace damaged roller shades that cannot be repaired, in a manner approved by Architect, before time of Substantial Completion.

END OF SECTION 122413

SECTION 122416 - PLEATED WINDOW SHADES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Z-pleated shades.
2. Cellular pleated shades.
3. Motorized operators.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Show fabrication and installation details for pleated shades.

1. Motorized Operators: Include details of installation and diagrams for power, signal, and control wiring.

C. Samples: For each exposed product and for each color and texture specified.

1.3 INFORMATIONAL SUBMITTALS

A. Product certificates.

B. Product test reports.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Fabricator of products.

PART 2 - PRODUCTS

2.1 Z-PLEATED SHADES

A. Z-Pleated Shades: Permanently creased, horizontally folded shades that maintain uniform spacing between folds (pleats).

B. Source Limitations: Obtain Z-pleated shades from single source from single manufacturer.

C. Nominal Pleat Width: 1 inch (25 mm) or 2 inches (51 mm) as directed.

D. Shade Fabric: Stain and fade resistant.

1. Flame-Resistance Rating: Comply with NFPA 701; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
2. Type: As directed.
3. Pattern: As directed.
4. Style: As directed.
5. Colors: As directed.

E. Headrail: Extruded aluminum. Headrails fully enclose operating mechanisms on three sides and have capped ends.

1. Capacity: One shade or Two shades as directed per headrail unless otherwise indicated.
2. Motorized Operating Mechanisms: Coordinate headrail with motorized-operator requirements. Provide headrail acceptable to shade and motorized-operator manufacturers and suitable for applications indicated.
3. Manual Operating Mechanisms: Manufacturer's standard system as directed.

a. Control Location: Right side of headrail or Left side of headrail unless otherwise indicated.
b. Cord Tensioner: For continuous-looped cord; locate as directed.

F. Bottom Rail: Formed-steel or extruded-aluminum tube that secures end of shade fabric and has capped ends.

G. Mounting Brackets: With spacers and shims required for shade placement and alignment indicated.

1. Intermediate Support: Provide intermediate support brackets to produce support spacing recommended by shade manufacturer for weight and size of shade.

H. Hold-Down Brackets: Manufacturer's standard.

I. Valance: As directed.

J. Component Colors: Provide rails, cords, and other materials exposed to view in colors, as directed.

2.2 CELLULAR PLEATED SHADES

A. Cellular Pleated Shades: Horizontally folded shades with multiple fabric layers that form accordion folds that enclose airspaces or cells between the fabric layers.

B. Source Limitations: Obtain cellular pleated shades from single source from single manufacturer.

C. Cellular Pleated-Shade Construction: Fabric thicknesses as directed.

D. Shade Face Fabric: Stain and fade resistant.

1. Flame-Resistance Rating: Comply with NFPA 701; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
2. Type: As directed.
3. Pattern: As directed.
4. Style: As directed.
5. Color: As directed.

E. Shade Backup Fabric: Stain and fade resistant.

1. Flame-Resistance Rating: Comply with NFPA 701; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
2. Type: As directed.
3. Fabric Width: Matching face fabric.
4. Color: As directed.

F. Headrail: Extruded aluminum. Headrails fully enclose operating mechanisms on three sides and have capped ends.

1. Capacity: One shade or Two shades as directed per headrail unless otherwise indicated.
2. Motorized Operating Mechanisms: Coordinate headrail with motorized-operator requirements. Provide headrail acceptable to shade and motorized-operator manufacturers and suitable for applications indicated.
3. Manual Operating Mechanisms: Manufacturer's standard system as directed.

    a. Control Location: Right side of headrail or Left side of headrail unless otherwise indicated.
    b. Cord Tensioner: For continuous-looped cord; locate as directed.

G. Bottom Rail: Formed-steel or extruded-aluminum tube that secures end of shade fabric and has capped ends.

H. Mounting Brackets: With spacers and shims required for shade placement and alignment indicated.

1. Intermediate Support: Provide intermediate support brackets to produce support spacing recommended by shade manufacturer for weight and size of shade.

I. Hold-Down Brackets: Manufacturer's standard.

J. Valance: As directed.

K. Component Colors: Provide rails, cords, and other materials exposed to view in colors as directed.

2.3 PLEATED-SHADE FABRICATION

A. Product Safety Standard: Fabricate pleated shades to comply with WCMA A 100.1.

B. Unit Sizes: Fabricate units in sizes to cover window and other openings as follows, measured at 74 deg F (23 deg C):

1. Between (Inside) Jamb Installation: Width equal to jamb-to-jamb dimension of opening in which shade is installed less 1/4 inch (6 mm) per side or 1/2-inch (13-mm) total, plus or minus 1/8 inch (3.1 mm). Length equal to head-to-sill or -floor dimension of opening in which shade is installed less 1/4 inch (6 mm), plus or minus 1/8 inch (3.1 mm).
2. Outside of Jamb Installation: Width and length as indicated, with terminations between shades of end-to-end installations at centerlines of mullion or other defined vertical separations between openings.

C. Fabric Shades: Fabricate from full widths of fabric, with fabric length as it comes off the roll oriented vertically on shades, and without seams.

2.4 MOTORIZED OPERATORS

A. Description: Provide factory-assembled, shade-operator systems of size and capacity and with features, characteristics, and accessories suitable for conditions indicated and recommended by shade and motorized-operator manufacturers for use with shades indicated. Coordinate operator wiring requirements and electrical characteristics with building electrical system.

1. Electrical Components: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Electric Motors: As directed for operating pleated shades.

1. Electrical Characteristics: As directed.

C. Remote Controls: Control stations as directed.

D. Limit Switches: Adjustable switches interlocked with motor controls and set to stop shades automatically at fully raised and fully lowered positions.

PART 3 - EXECUTION

3.1 PLEATED-SHADE INSTALLATION

A. Install pleated shades level and plumb, aligned and centered on openings, and aligned with adjacent units according to manufacturer's written instructions.

1. Locate so exterior shade edges are not closer than 2 inches (51 mm) from interior faces of glass and not closer than 1-1/2 inches (38 mm) from interior faces of glazing frames through full operating ranges of shades.
2. Install mounting and intermediate brackets to prevent deflection of headrails.
3. Install with clearances that prevent interference with adjacent shades, adjacent construction, and operating hardware of glazed openings, other window treatments, and similar building components and furnishings.

B. Electrical Connections: Connect motorized operators to building electrical system.

C. Adjust and balance pleated shades to operate smoothly, easily, safely, and free from binding or malfunction through entire operational range.

D. Clean pleated-shade surfaces after installation, according to manufacturer's written instructions.

E. Replace damaged pleated shades that cannot be repaired, in a manner approved by Architect, before time of Substantial Completion.

END OF SECTION 122416

SECTION 123213 - MANUFACTURED WOOD-VENEER-FACED CASEWORK

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Wood-veneer-faced casework.
2. Casework hardware and accessories.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: For wood-veneer-faced casework.

D. Samples: For casework and hardware finishes.

1.4 INFORMATIONAL SUBMITTALS

A. Quality Standard Compliance Certificates: AWI Quality Certification Program or WI Certified Compliance Program as directed.

B. Sample warranty.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: As directed.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of casework that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 GENERAL REQUIREMENTS FOR CASEWORK

A. Quality Standard: Unless otherwise indicated, comply with the AWI/AWMAC/WI's "Architectural Woodwork Standards" for grades of casework indicated for construction, finishes, installation, and other requirements.

1. Grade: As directed.
2. Provide inspections of casework fabrication and installation together with labels and certificates from AWI or WI certification program as directed indicating that casework complies with requirements of grades specified.

B. Product Designations by Manufacturer Reference: Drawings indicate sizes, configurations, and finish materials of manufactured wood-veneer-faced casework by referencing designated manufacturer's catalog numbers. Other manufacturers' casework of similar sizes and door and drawer configurations, of same finish materials, and complying with the Specifications may be considered. See Section 016000 "Product Requirements."

C. Product Designations by AWI/AWMAC/WI Reference: Drawings indicate configurations of manufactured wood-veneer-faced casework by referencing designations of Casework Design Series numbering system in the Appendix of the AWI/AWMAC/WI's "Architectural Woodwork Standards."

2.3 WOOD-VENEER-FACED CABINETS

A. Design: Face-frame or Frameless cabinet construction as directed with the following door and drawer-front style:

1. Lipped overlay with radiused wood edges and full-width, recessed finger pulls machined into faces of doors and drawers.
2. Reveal overlay with recessed finger pulls machined into faces of doors and drawers.
3. Flush overlay.

B. Wood Species: As directed.

1. Wood Stain Colors and Finishes: As directed.

C. Face Veneer Cut: As directed.

D. Grain Direction:

1. Doors: Vertical with continuous vertical matching.
2. Drawer Fronts: Vertical with continuous vertical matching or Horizontal as directed.
3. Face Frame Members: Lengthwise.
4. End Panels: Vertical.
5. Bottoms and Tops of Units: Side to side.

6. Knee Space Panels: Vertical.
7. Aprons: Horizontal.

E. Exposed Materials:

1. Plywood: Hardwood plywood with face veneer of species indicated, selected for compatible color and grain. Provide backs of same species as faces.
2. Solid Wood: Clear hardwood lumber of species indicated and selected for grain and color compatible with exposed plywood.
3. Edgebanding: As directed.

    a. PVC Edgebanding Color: As directed.

F. Semi-exposed Materials:

1. Wood: Provide solid wood or hardwood plywood for semi-exposed surfaces unless otherwise indicated.

    a. Solid Wood: Sound hardwood lumber, selected to eliminate appearance defects, of species similar in color and grain to or same species as exposed wood as directed.
    b. Plywood: Hardwood plywood of species similar in color and grain to or same species as exposed wood as directed. Provide backs of same species as faces.

2. Thermoset Decorative Panels: Provide thermoset decorative panels for semi-exposed surfaces, except provide solid wood or hardwood plywood for interior faces of doors and drawer fronts and other locations where opposite side of component is exposed.

    a. Colors and Patterns: As directed.

3. Hardboard: Use only for cabinet backs where exterior side of back is not exposed.
4. Metal for Steel Drawer Pans: Cold-rolled, carbon-steel sheet complying with ASTM A1008/A1008M; matte finish; suitable for exposed applications.

G. Concealed Materials:

1. Solid Wood: With no defects affecting strength or utility.
2. Plywood: Hardwood plywood. Provide backs of same species as faces.
3. Particleboard.
4. MDF.
5. Hardboard.

2.4 MATERIALS

A. Maximum Moisture Content for Lumber: 7 percent for hardwood and 12 percent for softwood.

B. Hardwood Plywood: HPVA HP-1, particleboard core except where veneer core is indicated.

C. Softwood Plywood: DOC PS 1.

D. Particleboard: ANSI A208.1, Grade M-2.

E. MDF: Medium-density fiberboard, ANSI A208.2, Grade 130.

F. Hardboard: ANSI A135.4, Class 1 tempered.

G. PVC Edgebanding for Wood: Rigid PVC extrusions, through color with satin finish, 0.12 inch (3 mm) thick at doors and drawer fronts, 0.04 inch (1 mm) thick elsewhere.

H. Thermoset Decorative Panels: Particleboard or MDF finished with thermally fused, melamine-impregnated decorative paper and complying with requirements of NEMA LD 3, Grade VGL, for Test Methods 3.3, 3.4, 3.6, 3.8, and 3.10.

1. Edgebanding for Thermoset Decorative Panels: PVC or polyester edgebanding matching thermoset decorative panels.

I. Float Glass for Glazed Doors: Clear float glass complying with ASTM C1036, Type I, Class 1, Quality-Q3; not less than as directed thickness.

J. Tempered Glass for Glazed Doors: Clear tempered glass complying with ASTM C1048, Kind FT, Condition A, Type I, Class 1, Quality-Q3; not less than 5.0 mm thick.

K. Laminated Glass for Glazed Doors: Clear laminated annealed glass complying with ASTM C1172, Kind LA, Condition A, Type I, Class I, Quality-Q3; with two plies not less than 3.0 mm thick and with clear, polyvinyl butyral interlayer.

2.5 FINISH

A. Stain: Provide uniform color and to match approved Samples.

B. Finish: Manufacturer's standard, baked, clear finish consisting of a thermosetting catalyzed sealer and a thermosetting catalyzed conversion varnish.

2.6 CASEWORK HARDWARE AND ACCESSORIES

A. Hardware, General: Unless otherwise indicated, provide manufacturer's standard, commercial-quality, heavy-duty hardware as directed.

1. Use threaded metal or plastic inserts with machine screws for fastening to particleboard except where hardware is through-bolted from back side.

B. Butt Hinges: Semi-concealed, five-knuckle hinges complying with BHMA A156.9, Grade 1, with antifriction bearings and rounded tips as directed.

C. Frameless Concealed Hinges (European Type): BHMA A156.9, Type B01602, self-closing.

D. Wire Pulls: Solid wire pulls as directed, fastened from back with two screws.

1. For sliding doors, provide recessed stainless-steel or chrome-plated flush pulls.

E. Semi-recessed Pulls: Plastic. For sliding doors, provide recessed plastic flush-pulls.

F. Door Catches: As directed.

G. Door and Drawer Bumpers: Self-adhering, clear silicone rubber.

H. Drawer Slides: BHMA A156.9, Type B05091.

I. Drawer and Hinged-Door Locks: Cylindrical (cam) or Mortise type as directed, five-pin tumbler, brass with chrome-plated finish, and complying with BHMA A156.11, Grade 1.

1. Provide a minimum of two keys per lock and six master keys.
2. Provide locks where indicated or on every door and drawer as directed.

a. Masterkey for up to 500 key changes.

J. Sliding-Door Hardware Sets: Manufacturer's standard, to suit type and size of sliding-door unit.

K. Adjustable Shelf Supports: Two-pin-locking plastic shelf rests complying with BHMA A156.9, Type B04013 or Single-pin metal shelf rests complying with BHMA A156.9, Type B04013 as directed.

L. Adjustable Shelf Supports: Mortise-type, zinc-plated or powder-coated steel standards as directed and shelf rests complying with BHMA A156.9, Type B04071 and Type B04091.

PART 3 - EXECUTION

3.1 INSTALLATION OF WOOD-VENEER-FACED CASEWORK

A. Grade: Install casework to comply with same quality standard grade as item to be installed.

B. Install casework level, plumb, and true in line; shim as required using concealed shims. Where casework abuts other finished work, apply filler strips and scribe for accurate fit, with fasteners concealed where practical.

C. Base Cabinets: Set cabinets straight, level, and plumb. Adjust subtops within 1/16 inch (1.5 mm) of a single plane. Align similar adjoining doors and drawers to a tolerance of 1/16 inch (1.5 mm). Bolt adjacent cabinets together with joints flush, tight, and uniform.

D. Wall Cabinets: Hang cabinets straight, level, and plumb. Adjust fronts and bottoms within 1/16 inch (1.5 mm) of a single plane. Fasten cabinets to hanging strips, masonry, framing, wood blocking, or reinforcements in walls and partitions. Align similar adjoining doors to a tolerance of 1/16 inch (1.5 mm).

E. Fasten casework to adjacent units and to masonry, framing, wood blocking, or reinforcements in walls and partitions to comply with the AWI/AWMAC/WI's "Architectural Woodwork Standards."

F. Install hardware uniformly and precisely. Set hinges snug and flat in mortises unless otherwise indicated. Adjust and align hardware so moving parts operate freely and contact points meet accurately. Allow for final adjustment after installation.

G. Adjust operating hardware so doors and drawers operate smoothly without warp or bind. Lubricate operating hardware as recommended by manufacturer.

H. Clean finished surfaces, touch up as required, and remove or refinish damaged or soiled areas to match original factory finish, as approved by Architect.

END OF SECTION 123213

SECTION 123216 - MANUFACTURED PLASTIC-LAMINATE-CLAD CASEWORK

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Plastic-laminate-clad casework.
2. Casework hardware and accessories.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: For plastic-laminate-clad casework.

D. Samples: For casework and hardware finishes.

1.4 INFORMATIONAL SUBMITTALS

A. Quality Standard Compliance Certificates: AWI Quality Certification Program or WI Certified Compliance Program as directed.

B. Sample warranty.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: As directed.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of casework that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 GENERAL REQUIREMENTS FOR CASEWORK

A. Quality Standard: Unless otherwise indicated, comply with the AWI/AWMAC/WI's "Architectural Woodwork Standards" for grades of casework indicated for construction, finishes, installation, and other requirements.

1. Grade: As directed.
2. Provide inspections of casework fabrication and installation together with labels and certificates from AWI or WI certification program as directed indicating that casework complies with requirements of grades specified.

B. Product Designations: Drawings indicate sizes, configurations, and finish materials of manufactured plastic-laminate-clad casework by referencing designated manufacturer's catalog numbers. Other manufacturers' casework of similar sizes and door and drawer configurations, of same finish materials, and complying with the Specifications may be considered. See Section 016000 "Product Requirements."

C. Product Designations: Drawings indicate configurations of manufactured plastic-laminate-clad casework by referencing designations of Casework Design Series numbering system in the Appendix of the AWI/AWMAC/WI's "Architectural Woodwork Standards."

2.3 PLASTIC-LAMINATED-FACED CABINETS

A. Design: Face-frame or Frameless cabinet construction as directed with the following door and drawer-front style:

1. Lipped overlay with radiused wood edges and full-width, recessed finger pulls machined into faces of doors and drawers.
2. Reveal overlay with recessed finger pulls machined into faces of doors and drawers.
3. Flush overlay.

B. Grain Direction for Wood-Grain Plastic Laminate:

1. Doors: Vertical with continuous vertical matching.
2. Drawer Fronts: Vertical with continuous vertical matching or Horizontal as directed.
3. Face Frame Members: Lengthwise.
4. End Panels: Vertical.
5. Bottoms and Tops of Units: Side to side.
6. Knee Space Panels: Vertical.
7. Aprons: Horizontal.

C. Exposed Materials:

1. Plastic-Laminate Grade: As directed.

a. Colors and Patterns: As directed.

2. Edgebanding: Plastic laminate matching adjacent surfaces or PVC as directed.

a. PVC Edgebanding Color: As directed.

3. Solid Wood: Clear hardwood lumber of species indicated, selected for compatible grain and color.

a. Wood Species: As directed.
b. Wood Finish: As directed.

D. Semi-exposed Materials:

1. Plastic Laminate: Grade VGS or Grade CLS unless otherwise indicated. Provide plastic laminate for semi-exposed surfaces unless otherwise indicated.

a. Colors and Patterns: As directed.
b. Provide plastic laminate of same grade as exposed surfaces for interior faces of doors and drawer fronts and other locations where opposite side of component is exposed.

2. Thermoset Decorative Panels: Provide thermoset decorative panels for semi-exposed surfaces unless otherwise indicated.

a. Colors and Patterns: As directed.
b. Provide plastic laminate of same grade as exposed surfaces for interior faces of doors and drawer fronts and other locations where opposite side of component is exposed.

3. Hardboard: Use only for cabinet backs where exterior side of back is not exposed.
4. Metal for Steel Drawer Pans: Cold-rolled, carbon-steel sheet complying with ASTM A1008/A1008M; matte finish; suitable for exposed applications.
5. Unless otherwise indicated, provide specified edgebanding on all semi-exposed edges.

E. Concealed Materials:

1. Solid Wood: With no defects affecting strength or utility.
2. Plywood: Hardwood plywood.
3. Plastic Laminate: Grade BKL.
4. Particleboard.
5. MDF.
6. Hardboard.

2.4 MATERIALS

A. Maximum Moisture Content for Lumber: 7 percent for hardwood and 12 percent for softwood.

B. Hardwood Plywood: HPVA HP-1, particleboard core except where veneer core is indicated.

C. Softwood Plywood: DOC PS 1.

D. Particleboard: ANSI A208.1, Grade M-2.

E. MDF: Medium-density fiberboard, ANSI A208.2, Grade 130.

F. Hardboard: ANSI A135.4, Class 1 tempered.

G. Plastic Laminate: High-pressure decorative laminate complying with NEMA LD 3.

H. PVC Edgebanding for Plastic Laminate: Rigid PVC extrusions, through color with satin finish, 0.12 inch (3 mm) thick at doors and drawer fronts, 0.04 inch (1 mm) thick elsewhere.

I. Thermoset Decorative Panels: Particleboard or MDF finished with thermally fused, melamine-impregnated decorative paper and complying with requirements of NEMA LD 3, Grade VGL, for Test Methods 3.3, 3.4, 3.6, 3.8, and 3.10.

1. Edgebanding for Thermoset Decorative Panels: PVC or polyester edgebanding matching thermoset decorative panels.

J. Glass for Glazed Doors: Clear float glass complying with ASTM C1036, Type I, Class 1, Quality-Q3; not less than as directed thickness.

K. Glass for Glazed Doors: Clear tempered glass complying with ASTM C1048, Kind FT, Condition A, Type I, Class 1, Quality-Q3; not less than 5.0 mm thick.

L. Glass for Glazed Doors: Clear laminated annealed glass complying with ASTM C1172, Kind LA, Condition A, Type I, Class I, Quality-Q3; with two plies not less than 3.0 mm thick and with clear, polyvinyl butyral interlayer.

2.5 CASEWORK HARDWARE AND ACCESSORIES

A. Hardware, General: Unless otherwise indicated, provide manufacturer's standard, commercial-quality, heavy-duty hardware.

1. Use threaded metal or plastic inserts with machine screws for fastening to particleboard except where hardware is through-bolted from back side.

B. Butt Hinges: As directed, semi-concealed, five-knuckle hinges complying with BHMA A156.9, Grade 1, with antifriction bearings and rounded tips.

C. Frameless Concealed Hinges (European Type): BHMA A156.9, Type B01602, self-closing.

D. Wire Pulls: Solid wire pulls as directed, fastened from back with two screws.

1. For sliding doors, provide recessed stainless-steel or chrome-plated flush pulls.

E. Semi-recessed Pulls: Plastic. For sliding doors, provide recessed plastic flush-pulls.

F. Door Catches: As directed.

G. Door and Drawer Bumpers: Self-adhering, clear silicone rubber.

H. Drawer Slides: BHMA A156.9, Type B05091.

I. Drawer and Hinged-Door Locks: Cylindrical (cam) or Mortise as directed type, five-pin tumbler, brass with chrome-plated finish, and complying with BHMA A156.11, Grade 1.

1. Provide a minimum of two keys per lock and six master keys.
2. Provide locks where indicated or on every door and drawer as directed.

a. Masterkey for up to 500 key changes.

J. Sliding-Door Hardware Sets: Manufacturer's standard, to suit type and size of sliding-door unit.

K. Adjustable Shelf Supports: Two-pin-locking plastic shelf rests complying with BHMA A156.9, Type B04013 or Single-pin metal shelf rests complying with BHMA A156.9, Type B04013 as directed.

L. Adjustable Shelf Supports: Mortise-type, zinc-plated or powder-coated steel standards as directed and shelf rests complying with BHMA A156.9, Type B04071 and Type B04091.

PART 3 - EXECUTION

3.1 INSTALLATION OF PLASTIC-LAMINATE-CLAD CASEWORK

A. Grade: Install casework to comply with same quality standard grade as item to be installed.

B. Install casework level, plumb, and true in line; shim as required using concealed shims. Where casework abuts other finished work, apply filler strips and scribe for accurate fit, with fasteners concealed where practical.

C. Base Cabinets: Set cabinets straight, level, and plumb. Adjust subtops within 1/16 inch (1.5 mm) of a single plane. Align similar adjoining doors and drawers to a tolerance of 1/16 inch (1.5 mm). Bolt adjacent cabinets together with joints flush, tight, and uniform.

D. Wall Cabinets: Hang cabinets straight, level, and plumb. Adjust fronts and bottoms within 1/16 inch (1.5 mm) of a single plane. Fasten cabinets to hanging strips, masonry, framing, wood blocking, or reinforcements in walls and partitions. Align similar adjoining doors to a tolerance of 1/16 inch (1.5 mm).

E. Fasten casework to adjacent units and to masonry, framing, wood blocking, or reinforcements in walls and partitions to comply with the AWI/AWMAC/WI's "Architectural Woodwork Standards."

F. Install hardware uniformly and precisely. Set hinges snug and flat in mortises unless otherwise indicated. Adjust and align hardware so moving parts operate freely and contact points meet accurately. Allow for final adjustment after installation.

G. Adjust operating hardware so doors and drawers operate smoothly without warp or bind. Lubricate operating hardware as recommended by manufacturer.

H. Clean finished surfaces, touch up as required, and remove or refinish damaged or soiled areas to match original factory finish, as approved by Architect.

END OF SECTION 123216

SECTION 123530 - RESIDENTIAL CASEWORK

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes kitchen and vanity cabinets.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

C. Shop Drawings: For residential casework. Include plans, elevations, details, and attachments to other work.

D. Samples: For casework and hardware finishes.

1.3 INFORMATIONAL SUBMITTALS

A. Product Certificates: For casework.

PART 2 - PRODUCTS

2.1 CABINETS

A. Quality Standard: Provide cabinets that comply with KCMA A161.1.

1. KCMA Certification: Provide cabinets with KCMA's "Certified Cabinet" seal affixed in a semi-exposed location of each unit and showing compliance with KCMA A161.1.

B. Door and Drawer Face Style: As directed.

1. Door and Drawer Fronts: Solid-wood stiles and rails, 5/8 inch (16 mm) thick, with 3/4-inch (19-mm) thick, solid-wood center panels.
2. Door and Drawer Fronts: Solid-wood stiles and rails, 3/4 inch (19 mm) thick, with 1/4-inch (6.4-mm) thick, veneer-faced plywood center panels.
3. Door and Drawer Fronts: 1/2-inch (13-mm) thick, veneer-faced plywood.
4. Door and Drawer Fronts: 1/2-inch (13-mm) thick, plastic-laminate-faced particleboard, with continuous solid-wood pulls on one edge or with PVC edgebanding as directed.
5. Door and Drawer Fronts: 1/2-inch (13-mm) thick, thermoset decorative panels, with continuous solid-wood pulls on one edge as directed.

6. Door and Drawer Fronts: 1/2-inch (13-mm) thick, thermoformed-vinyl-faced panels with vinyl overlay on faces and edges and with thermoset decorative panel backs or faces, backs, and edges as directed.

C. Cabinet Style: Face frame or Frameless as directed.

1. Face Frames: 3/4-by-1-5/8-inch (19-by-41-mm) solid wood with glued mortise and tenon or doweled joints.
2. Face Frames: 5/8-inch (16-mm) thick particleboard with plastic laminate on exposed and semi-exposed surfaces.
3. Face Frames: 5/8-inch (16-mm) thick, thermoset decorative panel material.
4. Face Frames: 1/2-inch (13-mm) thick, thermoformed-vinyl-faced panels with vinyl overlay on exposed and semi-exposed surfaces.

D. Exposed Cabinet End Finish: As directed.

2.2 CABINET MATERIALS

A. Hardwood Lumber: Kiln dried to 7 percent moisture content.

B. Softwood Lumber: Kiln dried to 10 percent moisture content.

C. Hardwood Plywood: HPVA HP-1.

D. Particleboard: ANSI A208.1, Grade M-2.

E. Particleboard: Straw-based particleboard complying with requirements in ANSI A208.1, Grade M-2, except for density.

F. MDF: Medium-density fiberboard, ANSI A208.2, Grade MD.

G. Hardboard: ANSI A135.4, Class 1 tempered.

H. Exposed Materials:

1. Exposed Wood Species: As directed.

   a. Select materials for compatible color and grain. Do not use two adjacent exposed surfaces that are noticeably dissimilar in color, grain, figure, or natural character markings.
   b. Staining and Finish: As directed.

2. Solid Wood: Clear hardwood lumber of species indicated, free of defects.
3. Plywood: Hardwood plywood with face veneer of species indicated, with Grade A faces and Grade C backs of same species as faces.

   a. Edge band exposed edges with a minimum of 1/8-inch (3-mm) thick, solid-wood or veneer edging of same species as face veneer as directed.

4. Plastic Laminate: Particleboard faced with high-pressure decorative laminate complying with NEMA LD 3, Grade VGS or Grade HGL and edgebanded as directed.

a. Colors, Textures, and Patterns: As directed.
b. Plastic-Laminate Edgebanding: Of same grade, pattern, color, and texture of plastic laminate as for faces.
c. PVC Edgebanding: Rigid PVC extrusions, through color with satin finish, 3 mm thick at doors and drawer fronts, and 1 mm thick elsewhere or 1 mm thick as directed.

1) Color: As directed.

5. Thermoset Decorative Panels: Particleboard or MDF finished with thermally fused, melamine-impregnated decorative paper.

a. Provide material finished on both sides for doors and drawer fronts.
b. Provide PVC or polyester edgebanding or PVC edge molding on components with exposed or semi-exposed edges as directed.
c. Colors: As directed.

6. Thermoformed-Vinyl-Faced Panels: MDF, milled to required shapes, with a thermoformed vinyl overlay applied in a vacuum or membrane press.

a. Color: As directed.

I. Semi-exposed Materials: Unless otherwise indicated, provide the following:

1. Solid Wood: Sound hardwood lumber, selected to eliminate appearance defects. Same species as exposed surfaces or stained to be compatible with exposed surfaces.
2. Plywood: Hardwood plywood with Grade C faces and not less than Grade 3 backs of same species as faces. Face veneers of same species as exposed surfaces or stained to be compatible with exposed surfaces.
3. Plastic Laminate: Particleboard faced with high-pressure decorative laminate complying with NEMA LD 3, Grade VGS or Grade CLS as directed.

a. For backs of doors and drawer fronts faced with plastic laminate, provide same grade, pattern, color, and texture of plastic laminate as for faces.
b. For face frames faced with plastic laminate, provide plastic-laminate edges of same grade, pattern, color, and texture of plastic laminate as for faces.
c. For shelves faced with plastic laminate, provide plastic-laminate edges of same grade, pattern, color, and texture of plastic laminate as for faces or PVC edge molding, 1 mm thick as directed.
d. Colors, Textures, and Patterns: As directed.

4. Thermoset Decorative Panels: Particleboard or MDF finished with thermally fused, melamine-impregnated decorative paper.

a. Provide material finished on both sides for shelves, dividers, drawer bodies, and other components with two semi-exposed surfaces.
b. Provide PVC or polyester edgebanding or PVC edge molding as directed on components with semi-exposed edges.
c. Colors: As directed.

5. Vinyl-Faced Particleboard: MDF with embossed, wood-grain-patterned vinyl film adhesively bonded to particleboard.

    a. Provide vinyl film on both sides of shelves, dividers, drawer bodies, and other components with two semi-exposed surfaces and on semi-exposed edges.
    b. Colors, Textures, and Patterns: As directed.

J. Concealed Materials: Solid wood or plywood, of any hardwood or softwood species, with no defects affecting strength or utility; particleboard; MDF; or hardboard.

2.3 CABINET HARDWARE

A. General: Manufacturer's standard units complying with BHMA A156.9, of type, size, style, material, and finish as directed.

B. Pulls: As directed.

C. Hinges: As directed.

D. Drawer Guides: Epoxy-coated-metal, self-closing drawer guides; designed to prevent rebound when drawers are closed; with nylon-tired, ball-bearing rollers; and complying with BHMA A156.9, Type B05011 or Type B05091.

E. Door and Drawer Bumpers: Self-adhering, clear silicone rubber.

1. Doors: Provide one bumper at top and bottom of closing edge of each swinging door.
2. Drawers: Provide one bumper on back side of drawer front at each corner.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install casework with no variations in adjoining surfaces; use concealed shims. Where casework abuts other finished work, scribe and cut for accurate fit. Provide filler strips, scribe strips, and moldings in finish to match casework.

B. Install casework without distortion so doors and drawers fit the openings, are aligned, and are uniformly spaced. Complete installation of hardware and accessories as indicated.

C. Install casework level and plumb to a tolerance of 1/8 inch in 8 feet (3 mm in 2.4 m).

D. Fasten casework to adjacent units and to backing.

1. Fasten wall cabinets through back, near top and bottom, and at ends not more than 16 inches (400 mm) o.c.

    a. Fasteners: As directed.

E. Adjust hardware so doors and drawers are centered in openings and operate smoothly without warp or bind. Lubricate operating hardware as recommended by manufacturer.

F. Clean casework on exposed and semi-exposed surfaces. Touch up as required to restore damaged or soiled areas to match original factory finish, as approved by Architect.

END OF SECTION 123530

SECTION 123553.13 - METAL LABORATORY CASEWORK

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal laboratory casework.
2. Utility-space framing at backs of base cabinets.
3. Filler and closure panels.
4. Laboratory countertops.
5. Tables.
6. Shelves.
7. Laboratory sinks and troughs.
8. Laboratory accessories.
9. Water, laboratory gas, and electrical service fittings.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: For laboratory casework. Include plans, elevations, sections, and attachments to other work including blocking and reinforcements required for installation.

D. Samples: For casework finishes and materials requiring color selection.

E. Delegated-Design Submittal: For laboratory casework indicated to comply with seismic performance requirements, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.4 INFORMATIONAL SUBMITTALS

A. Product test reports.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Product Designations: Drawings indicate sizes and configurations of laboratory casework by referencing designated manufacturer's catalog numbers. Other manufacturers' laboratory casework of similar sizes and similar door and drawer configurations and complying with Specifications may be considered. See Section 016000 "Product Requirements."

2.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design laboratory casework installation.

B. Seismic Performance: Laboratory casework installation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. Design earthquake spectral response acceleration, short period (Sds) for Project as directed.
2. Component Importance Factor: 1.0 or 1.5 as directed.
3. Base Cabinet Load (Including Countertop and Load on Countertop): 320 lb/ft. (480 kg/m).
4. Wall Cabinet (Upper Cabinet) Load: 160 lb/ft. (240 kg/m).

2.3 CASEWORK, GENERAL

A. Casework Product Standard: Comply with SEFA 8 M, "Laboratory Grade Metal Casework."

B. Flammable Liquid Storage: Where cabinets are indicated for solvent or flammable liquid storage, provide units that are listed and labeled as complying with requirements in NFPA 30 by a testing and inspecting agency acceptable to authorities having jurisdiction or FM Approvals as directed.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.4 METAL CASEWORK MATERIALS

A. Steel Sheet: Cold-rolled, commercial steel (CS) sheet, complying with ASTM A1008/A1008M; matte finish; suitable for exposed applications.

2.5 AUXILIARY CABINET MATERIALS

A. Acid Storage-Cabinet Lining: 1/4-inch- (6-mm-) thick, as directed.

B. Glass for Glazed Doors: Clear float glass complying with ASTM C1036, Type I, Class 1, Quality-Q3; thickness not less than as directed.

C. Glass for Glazed Doors: Clear tempered glass complying with ASTM C1048, Kind FT, Condition A, Type I, Class 1, Quality-Q3; not less than 5.0 mm thick.

D. Glass for Glazed Doors: Clear laminated annealed glass complying with ASTM C1172, Kind LA, Condition A, Type I, Class I, Quality-Q3; with two plies not less than 3.0 mm thick and with clear, polyvinyl butyral interlayer.

2.6 CABINET HARDWARE

A. General: Provide laboratory casework manufacturer's standard, commercial-quality, heavy-duty hardware complying with requirements indicated for each type.

B. Hinges: Stainless or Epoxy-coated-steel as directed, five-knuckle hinges complying with BHMA A156.9, Grade 1, with antifriction bearings and rounded tips.

C. Hinged-Door and Drawer Pulls: Solid-aluminum, stainless-steel, or chrome-plated-brass or Epoxy-coated-steel as directed, back-mounted pulls.

D. Sliding-Door Pulls: Stainless-steel or chrome-plated or Epoxy-coated-steel recessed flush pulls as directed.

E. Door Catches: Nylon-roller spring or Dual, self-aligning, permanent magnet catches as directed. Provide two catches on doors more than 48 inches (1200 mm) high.

F. Drawer Slides: Manufacturer's standard.

G. Locks: Cam or half-mortise type, brass with chrome-plated finish; complying with BHMA A156.11, Type E07281, Type E07261, Type E07111, or Type E07021.

1. Tumbler: Disc or Five pin as directed.
2. Lock Locations: Provide where indicated or on drawers and doors as directed.
3. Keying: As directed.

    a. Masterkey for up to 225 or 500 key changes as directed.

4. Key Quantity: Minimum of two keys per lock.
5. Master Key System: Key locks to be operable by master key.

    a. Master Keys: Provide two.

H. Sliding-Door Hardware Sets: Laboratory casework manufacturer's standard, to suit type and size of sliding-door units.

2.7 COUNTERTOP TABLETOP, SHELF, TROUGH AND SINK MATERIALS

A. Plastic Laminate: High-pressure decorative laminate complying with NEMA LD 3.

1. Colors, Patterns, and Finishes: As directed.

B. Chemical-Resistant Plastic Laminate:

1. High-pressure decorative laminate, complying with NEMA LD 3, that has the following ratings when tested with indicated reagents according to NEMA LD 3, Test Procedure 3.4.5:

    a. No Effect: Acetic acid (98 percent), acetone, ammonium hydroxide (28 percent), amyl acetate, benzene, butyl alcohol, carbon tetrachloride, chloroform, dimethyl formamide, dioxane, ethyl acetate, ethyl alcohol, ethyl ether, formaldehyde (37 percent), gasoline, gentian violet, hydrogen peroxide (3 percent), methyl alcohol, methyl ethyl ketone, methylene chloride, mono chlorobenzene, naphthalene, toluene, trichloroethylene, xylene, zinc chloride (saturated).
    b. Slight Effect: Cresol, tincture of iodine, sodium sulfide (15 percent), phenol (90 percent), sodium hydroxide (20 percent), and methyl red.
    c. Moderate Effect: Hydrochloric acid (37 percent), nitric acid (30 percent), phosphoric acid (75 percent), silver nitrate (saturated), and sulfuric acid (77 percent).

2. Color: As directed.

C. Core Materials for Plastic Laminate:
1. Particleboard: ANSI A208.1, Grade M-2.

2. Exterior-Glue Particleboard: ANSI A208.1, Grade M-2, Exterior glue.

3. Exterior Plywood: DOC PS 1, Exterior A-C or Exterior B-C with fully sanded face as directed.

D. Adhesive for Bonding Plastic Laminate: As directed.

E. Epoxy: Factory-molded, modified epoxy-resin formulation with smooth, nonspecular finish.
1. Physical Properties:

    a. Flexural Strength: Not less than 10,000 psi (70 MPa).
    b. Modulus of Elasticity: Not less than 2,000,000 psi (1400 MPa).
    c. Hardness (Rockwell M): Not less than 100.
    d. Water Absorption (24 Hours): Not more than 0.02 percent.
    e. Heat Distortion Point: Not less than 260 deg F (127 deg C).

2. Chemical Resistance: Epoxy-resin material has the following ratings when tested with indicated reagents according to NEMA LD 3, Test Procedure 3.4.5:

    a. No Effect: Acetic acid (98 percent), acetone, ammonium hydroxide (28 percent), benzene, carbon tetrachloride, dimethyl formamide, ethyl acetate, ethyl alcohol, ethyl ether, methyl alcohol, nitric acid (70 percent), phenol, sulfuric acid (60 percent), and toluene.
    b. Slight Effect: Chromic acid (60 percent) and sodium hydroxide (50 percent).

3. Color: As directed.

F. Phenolic Composite: Solid, high-pressure decorative laminate, complying with NEMA LD 3, Grade CGS.

1. Chemical Resistance: Composite countertop material has the following ratings when tested with indicated reagents according to NEMA LD 3, Test Procedure 3.4.5:

    a. No Effect: Acetic acid (98 percent), acetone, ammonium hydroxide (28 percent), ethyl acetate, ethyl alcohol, formaldehyde (37 percent), furfural, phosphoric acid (85 percent), sulfuric acid (33 percent), and toluene.

2. Color: As directed.

G. Stainless-Steel Sheet: ASTM A240/A240M, Type 304 or Type 316L as directed.

2.8 METAL CABINETS AND TABLES

A. Fabrication: Assemble and finish units at point of manufacture. Use precision dies for interchangeability of like-size drawers, doors, and similar parts. Perform assembly on precision jigs to provide units that are square. Reinforce units with angles, gussets, and channels. Except where otherwise specified, integrally frame and weld cabinet bodies to form dirt- and vermin-resistant enclosures. Where applicable, reinforce base cabinets for sink support. Maintain uniform clearance around door and drawer fronts of 1/16 to 3/32 inch (1.5 to 2.4 mm).

B. Flush Doors: Outer and inner pans that nest into box formation, with full-height channel reinforcements at center of door. Fill doors with noncombustible, sound-deadening material.

C. Glazed Doors: Hollow-metal stiles and rails of similar construction as flush doors, with glass held in resilient channels or gasket material.

D. Hinged Doors: Mortise for hinges and reinforce with angles welded inside inner pans at hinge edge.

E. Drawers: Fronts made from outer and inner pans that nest into box formation, without raw metal edges at top. Sides, back, and bottom fabricated in one piece with rolled or formed top of sides for stiffening and comfortable grasp for drawer removal. Provide drawers with rubber bumpers, polymer roller slides, and positive stops to prevent metal-to-metal contact or accidental removal.

F. Adjustable Shelves: Front, back, and ends formed down, with edges returned horizontally at front and back to form reinforcing channels.

G. Toe Space: Fully enclosed, 4 inches (100 mm) high by 3 inches (75 mm) deep, with no open gaps or pockets.

H. Tables: Welded tubing legs, not less than 2 inches (50 mm) square with channel stretchers as needed to comply with product standard. Weld or bolt stretchers to legs and cross-stretchers, and bolt legs to table aprons. Provide leveling device welded to bottom of each leg.

    1. Leg Shoes: Black vinyl or rubber or Satin-finished, stainless-steel, open-bottom, slip-on type as directed.

I. Utilities: Provide space, cutouts, and holes for pipes, conduits, and fittings in cabinet bodies to accommodate utility services and their support-strut assemblies.

1. Provide base cabinets with removable backs for access to utility space.

J. Utility-Space Framing: Steel framing units consisting of two steel slotted channels complying with MFMA-4, not less than 1-5/8 inches (41 mm) square by 0.105-inch (2.66-mm) nominal thickness, that are connected at top and bottom by U-shaped brackets made from 1-1/4-by-1/4-inch (32-by-6-mm) steel flat bars. Framing units may be made by welding channel material into rectangular frames instead of using U-shaped brackets.

K. Filler and Closure Panels: Provide where indicated and as needed to close spaces between casework and walls, ceilings, and equipment. Fabricate from same material and with same finish as casework and with hemmed or flanged edges unless otherwise indicated.

2.9 METAL CABINET FINISH

A. Chemical-Resistant Finish: Finish complies with acceptance levels of cabinet surface finish tests in SEFA 8 M. Acceptance level for chemical spot test shall be no more than for Level 3 conditions.

1. Colors for Metal Laboratory Casework Finish: As directed.

2.10 COUNTERTOPS, TABLETOPS, SHELVES, TROUGHS, AND SINKS

A. Countertops, General: Provide units with smooth surfaces in uniform plane, free of defects. Make exposed edges and corners straight and uniformly beveled. Provide front and end overhang of 1 inch (25 mm).

B. Sinks, General: Provide sizes indicated or laboratory casework manufacturer's closest standard size of equal or greater volume, as approved by Architect.

1. Outlets: Provide with strainers and tailpieces, NPS 1-1/2 (DN 40), unless otherwise indicated.
2. Overflows: For each sink except cup sinks, where indicated, provide overflow of standard beehive or open-top design with separate strainer. Height 2 inches (50 mm) less than sink depth. Provide in same material as strainer.

C. Plastic-Laminate Countertops, Tabletops and Shelves:

1. Countertops: Plastic or Chemical-resistant plastic laminate shop bonded to top surface and exposed edges of core with plastic-laminate backing bonded to bottom surface. Sand surfaces to which plastic laminate is to be bonded.

a. Top Core Thickness: As directed
b. Backsplash Core Thickness: 3/4 inch (19 mm) or 1 inch (25 mm) as directed.
c. Countertop Core: As directed
d. Countertop Core for Counters Containing Sinks: Exterior-glue particleboard or exterior plywood.

e. Flat Configuration: With square edges, flat backsplashes, and flat end splashes. Finish faces and exposed edges of splashes with same plastic laminate as top.
f. Postformed Configuration: With raised, rolled edge and integral coved backsplash with rolled top edge. Construct top and backsplash from one piece of plastic laminate. Where indicated, provide separate end splashes of same material as top and fitted to top.
g. Plastic-Laminate Grade: As directed.

2. Tabletops: Plastic or Chemical-resistant plastic laminate shop bonded to top surface and exposed edges of core with plastic-laminate backing bonded to bottom surface. Sand surfaces to which plastic laminate is to be bonded.

a. Tabletop Core: Particleboard or exterior plywood.
b. Core Thickness: As directed.
c. Plastic-Laminate Grade: As directed.

3. Plastic-Laminate Shelves: Plastic or Chemical-resistant plastic laminate shop bonded to both faces and edges of core as directed. Sand surfaces to which plastic laminate is to be bonded.

a. Shelf Core: As directed
b. Core Thickness: 3/4 inch (19 mm) or 1 inch (25 mm) as directed.
c. Plastic-Laminate Grade: As directed.

D. Epoxy Countertops Tabletops and Sinks:

1. Countertop Fabrication: Fabricate with factory cutouts for sinks, holes for service fittings and accessories, and butt joints assembled with epoxy adhesive and concealed metal splines.

a. Flat Configuration: as directed 5/8 inch (16 mm), 3/4 inch (19 mm) or 1 inch (25 mm) thick with continuous drip groove on underside 1/2 inch (13 mm) from overhang edge.

1) Edges and Corners: Beveled or Rounded as directed.
2) Backsplash: Integral coved or Applied as directed.

b. Marine-Edge Configuration: As directed 5/8-inch (16-mm), 3/4-inch (19-mm) or 1-inch (25-mm) minimum thickness, with integral or applied raised edge.

1) Edges and Corners: Beveled or Rounded as directed.
2) Backsplash: Integral coved or Applied as directed.

c. Construction: Uniform throughout full thickness or Epoxy composition not less than 1/4 inch (6 mm) thick, laminated to backing as directed.

2. Tabletop Fabrication:

a. Flat Configuration: As directed 5/8 inch (16 mm), 3/4 inch (19 mm) or 1 inch (25 mm) thick with continuous drip groove on underside at perimeter.

1) Edges and Corners: Beveled or Rounded as directed.

b. Marine-Edge Configuration: As directed 5/8-inch (16-mm), 3/4-inch (19-mm) or 1-inch (25-mm) minimum thickness with integral or applied raised edge.

1) Edges and Corners: Beveled or Rounded as directed.

c. Tabletop Construction: Uniform throughout full thickness or Epoxy composition not less than 1/4 inch (6 mm) thick, laminated to backing as directed.

3. Sink Fabrication: Molded in one piece with smooth surfaces, coved corners, and bottom sloped to outlet; 1/2-inch (13-mm) minimum thickness.

a. Provide with polypropylene strainers and tailpieces.
b. Provide integral sinks in epoxy countertops, bonded to countertops with invisible joint line.
c. Provide sinks for drop-in installation in phenolic-composite countertops with 1/4-inch- (6-mm-) thick lip around perimeter of sink.
d. Provide sinks for underside installation with manufacturer's recommended adjustable support system for table- and cabinet-type installations.

E. Phenolic-Composite Countertops, Tabletops and Shelves As Directed:

1. Countertop Fabrication: Fabricate with cutouts for sinks, holes for service fittings and accessories, and butt joints assembled with epoxy adhesive and concealed metal splines.

a. Flat Configuration: As directed 1/2 inch (13 mm), 5/8 inch (16 mm), 3/4 inch (19 mm) or 1 inch (25 mm) thick with continuous drip groove on underside 1/2 inch (13 mm) from overhang edge and integral coved backsplash.

1) Edges and Corners: Beveled or Rounded as directed.

b. Marine-Edge Configuration: As directed 1/2-inch (13-mm), 5/8-inch (16-mm), 3/4-inch (19-mm) or 1-inch (25-mm) minimum thickness, with raised edge and integral coved backsplash.

1) Edges and Corners: Beveled or Rounded as directed.

2. Tabletop Fabrication:

a. Flat Configuration: As directed 1/2 inch (13 mm), 5/8 inch (16 mm), 3/4 inch (19 mm) or 1 inch (25 mm) thick with continuous drip groove on underside at perimeter.

1) Edges and Corners: Beveled or Rounded as directed.

b. Marine-Edge Configuration: As directed 5/8-inch (16-mm), 3/4-inch (19-mm) or 1-inch (25-mm) minimum thickness with integral or applied raised edge.

1) Edges and Corners: Beveled or Rounded as directed.

3. Shelf Configuration: Flat, 5/8 inch (16 mm) or 3/4 inch (19 mm) thick as directed.

    a. Edges and Corners: Beveled or Rounded as directed.

F. Stainless-Steel Countertops: Made from stainless-steel sheet, not less than 0.062-inch (1.59-mm) nominal thickness, with No. 4 satin finish.

1. Extend top down 1 inch (25 mm) at edges with a 1/2-inch (13-mm) return flange under frame. Apply heavy coating of heat-resistant, sound-deadening mastic to undersurface.
2. Form backsplash coved to and integral with top surface.
3. Provide raised (marine) edge around perimeter of countertops containing sinks and where indicated.
4. Pitch countertops that contain sinks two ways to sink, where indicated, without channeling or grooving.
5. Factory punch holes for service fittings.
6. Reinforce underside of countertop with channels, or thicker metal sheet where necessary to ensure rigidity without deflection.
7. Weld shop-made joints.
8. Where field-made joints are required, provide hairline butt joints mechanically bolted through continuous channels welded to underside at edges of joined ends. Keep field jointing to a minimum.
9. Where stainless-steel sinks and cup sinks occur in stainless-steel countertops, factory weld into one integral unit.
10. After fabricating and welding, grind surfaces smooth and polish to produce uniform, directionally textured finish with no cross scratches or evidence of welds. Passivate and rinse surfaces; remove embedded foreign matter and leave surfaces clean.

G. Stainless-Steel Shelves: Made from stainless-steel sheet, not less than 0.050-inch (1.27-mm) nominal thickness, with No. 4 satin finish. Weld shop-made joints. Fold down or up, front edge 3/4 inch (19 mm); fold up back edge 3 inches (75 mm) as directed.

1. Provide integral stiffening brackets, formed by folding up ends 3/4 inch (19 mm) and welding to upturned back edge or front and back edges as directed.
2. After fabricating, grind welds smooth and polish to produce uniform, directionally textured finish with no cross scratches or evidence of welds. Passivate and rinse surfaces; remove embedded foreign matter and leave surfaces clean.

H. Stainless-Steel Sinks: Made from stainless-steel sheet, not less than 0.050-inch (1.27-mm) nominal thickness. Fabricate with corners rounded and coved to at least 5/8-inch (16-mm) radius. Slope sink bottoms to outlet. Provide continuous butt-welded joints.

1. Provide double-wall construction for sink partitions with top edge rounded to at least 1/2-inch (13-mm) diameter.
2. After fabricating and welding, grind surfaces smooth and polish to produce uniform finish with no cross scratches or evidence of welds. Passivate and rinse surfaces; remove embedded foreign matter and leave surfaces clean.
3. Factory punch holes for fittings.
4. Provide with stainless-steel strainers and tailpieces.
5. Provide with integral rims except where located in stainless-steel countertops.

6. Apply 1/8-inch- (3-mm-) thick coating of heat-resistant, sound-deadening mastic to undersink surfaces.

I. Cup Sinks: Provide in material indicated, 3-by-6-inch (75-by-150-mm) oval, 3-by-9-inch (75-by-228-mm) oval, 5-inch (127-mm) diameter or as indicated on Drawings.

1. Epoxy Cup Sinks: Provide with polypropylene strainers and integral tailpieces.
2. Polypropylene Cup Sinks: Provide with polypropylene strainers and integral tailpieces.
3. Stainless-Steel Cup Sinks: Provide with stainless-steel strainers and integral tailpieces.

J. Troughs: Provide in material indicated and pitch to drains not less than 1/8 inch/foot (10 mm/m). Except where troughs empty into sinks, provide NPS 1-1/2 (DN 40) outlets with strainers and tailpieces.

1. Epoxy Troughs: Molded in one piece with smooth surfaces and coved corners; As directed 1/2-inch (13-mm), 5/8-inch (16-mm) or 3/4-inch (19-mm) minimum thickness. Provide polypropylene strainers and tailpieces.
2. Stainless-Steel Troughs: Made from stainless-steel sheet, as directed not less than 0.050-inch (1.27-mm) or 0.062-inch (1.59-mm) nominal thickness. Fabricate with corners rounded and coved to at least 5/8-inch (16-mm) radius. Provide continuous butt-welded joints. After fabricating and welding, grind surfaces smooth and polish to produce uniform finish with no cross scratches or evidence of welds. Passivate and rinse surfaces; remove embedded foreign matter and leave surfaces clean. Provide stainless-steel strainers and tailpieces.

2.11 LABORATORY ACCESSORIES

A. Reagent Shelves: Provide as indicated, fabricated from same material as adjacent countertop unless otherwise indicated.

B. Burette Rods: Aluminum or stainless-steel rods, 1/2 inch (13 mm) in diameter and 18 inches (450 mm) long, threaded on one end to fit tapered plug adapter for flush socket receptacle. Provide with tapered plug adapter and receptacle.

C. Upright Rod Assembly and Metal Crossbar: Aluminum or stainless steel. Two vertical rods and one horizontal crossbar, 3/4 inch (19 mm) in diameter and 36 inches (900 mm) long unless otherwise indicated; two flush socket receptacles and two crossbar clamps. Ends of vertical rods are tapered to fit receptacles; other rod ends are rounded.

D. Greenlaw Arm Assembly: Aluminum or stainless-steel vertical rod, tapered on one end to fit flush socket receptacle. Adjustable crossbar of hardwood with black, acid-resistant finish, secured to upright with adjustable clamp. Provide with receptacle.

E. Lattice Assembly: Aluminum or stainless-steel, vertical and horizontal rod lattice assembly with 3/4-inch- (19-mm-) diameter rods at approximately 12 inches (300 mm) o.c. with two flush socket receptacles for mounting.

1. Size: As directed 36 inches (900 mm) or 48 inches (1200 mm) wide by 24 inches (600 mm) or 36 inches (900 mm) high.

F. Pegboards: Polypropylene, epoxy, or phenolic-composite pegboards with removable polypropylene pegs and stainless-steel drip troughs with drain outlet.

G. Pegboards: Stainless-steel pegboards with removable polypropylene pegs and stainless-steel drip troughs with drain outlet.

2.12 WATER AND LABORATORY GAS SERVICE FITTINGS

A. Service Fittings: Provide units that comply with SEFA 7, "Recommended Practices for Fixtures." Provide fittings complete with washers, locknuts, nipples, and other installation accessories. Include wall and deck flanges, escutcheons, handle extension rods, and similar items.

1. Provide units that comply with "Vandal-Resistant Faucets and Fixtures" recommendations in SEFA 7.

B. Materials: Fabricated from cast or forged red brass unless otherwise indicated.

1. Reagent-Grade Water Service Fittings: Polypropylene, PVC, or PVDF for parts in contact with water.

C. Finish: As directed.

1. Provide chemical-resistant powder coating in laboratory casework manufacturer's standard metallic brown, aluminum, white, or other color as approved by Architect.

D. Water Valves and Faucets: Provide units complying with ASME A112.18.1, with renewable seats, designed for working pressure up to 80 psig (550 kPa).

1. Vacuum Breakers: Provide ASSE 1035 vacuum breakers on water fittings with serrated outlets.
2. Aerators: Provide aerators on water fittings that do not have serrated outlets.
3. Self-Closing Valves: Provide self-closing valves where indicated.

E. Ball Valves: Chrome-plated ball and PTFE seals. Handle requires no more than 5 lbf (22 N) to operate. Provide units designed for working pressure up to 75 psig (520 kPa), with serrated outlets.

1. Locking Safety Handles: Where ball valves are indicated for fuel-gas use, provide handles that must be pushed in or pulled up before being turned on.

F. Ground-Key Cocks: Tapered core and handle of one-piece forged brass, ground and lapped, and held in place under constant spring pressure. Provide units designed for working pressure up to 40 psig (280 kPa), with serrated outlets.

G. Steam Valves: Stainless-steel seat and PTFE seat disc. Provide units designed for steam working pressure up to 20 psig (140 kPa), with serrated outlets.

H. Needle Valves: Provide units with renewable, self-centering, floating cones and renewable seats of stainless steel or Monel metal, with removable serrated outlets.

1. Provide units designed for working pressure up to 60 psig (410 kPa), 100 psig (690 kPa) or 125 psig (860 kPa) as directed.

I. Hand of Fittings: Furnish right-hand fittings unless fitting designation is followed by "L."

J. Remote-Control Valves: Provide needle valves, straight-through or angle type as indicated for fume hoods and where indicated.

K. Handles: Provide three- or four-arm, forged-brass or three- or four-wing, molded-plastic or powder-coated-metal handles for valves unless otherwise indicated.

1. Provide lever-type handles for ground-key cocks. Lever handle aligns with outlet when valve is closed and is perpendicular to outlet when valve is fully open.
2. Provide lever-type handles for ball valves unless otherwise indicated. Lever handle aligns with outlet when valve is closed and is perpendicular to outlet when valve is fully open.
3. Provide heat-resistant plastic handles for steam valves.
4. Provide knurled, molded-plastic handles for needle valves.

L. Service-Outlet Identification: Provide color-coded plastic discs with embossed identification, secured to each service-fitting handle to be tamper resistant. Comply with SEFA 7 for colors and embossed identification.

2.13 ELECTRICAL AND COMMUNICATION SERVICE FITTINGS

A. Service Fittings, General: Provide units complete with metal housings, receptacles, switches, pilot lights, data communication outlets, cover plates, accessories, and gaskets required for mounting on laboratory casework.

B. Electrical Wiring Devices: Comply with requirements in Section 262726 "Wiring Devices" for receptacles, switches, pilot lights, cover plates, and accessories.

C. Twisted-Pair Copper Data Outlets: Comply with requirements in Section 271513 "Communications Copper Horizontal Cabling."

D. Optical-Fiber Data Outlets: Comply with requirements Section 271523 "Communications Optical Fiber Horizontal Cabling."

E. Electrical Receptacles: Hospital or General grade as directed. 125 V, 20 A; NEMA WD 6, Configuration 5-20R unless otherwise indicated.

1. GFCI Receptacles: Feed or Non-feed-through type with integral LED indicator light as directed.
2. SPD Receptacles: With LED indicator light and integral SPD in line to ground, line to neutral, and neutral to ground.
3. Color of Receptacles: Brown or Ivory unless otherwise indicated or required by NFPA 70.

F. USB Charger Receptacles: As directed Single, Dual, Quad, Type A, color matching electrical receptacles.

1. Type: As directed Hospital grade, Standard grade, Tamper resistant.

G. Switches: Comply with NEMA WD 1, UL 20, and FS W-S-896.

1. Color of Switches: Brown or Ivory unless otherwise indicated or required by NFPA 70.

H. Data Communication Outlets: Two RJ-45 jacks for terminating 100-ohm, balanced, four-pair twisted-pair cabling complying with TIA-568-C.1; complying with Category 5e or Category 6 as directed. Comply with UL 1863.

I. Cover Plates: Provide satin-finish, chrome-plated or Type 304, stainless-steel cover plates with formed, beveled edges as directed.

J. Cover-Plate Identification: Use 1/4-inch- (6-mm-) high letters unless otherwise indicated. For stainless steel or chrome-plated metal, stamp or etch plate and fill in letters with black enamel.

1. Provide at every cover plate or at the following locations:

a. Receptacles other than standard 125-V duplex, grounding type.
b. Switches and thermal-overload switches.
c. Pilot lights when located remotely from associated equipment or switch, where function is not obvious.
d. Receptacles, switches, and other locations indicated.

2. Provide the following information:

a. Voltage and phase for receptacles other than standard 125-V duplex, grounding type.
b. Indicate equipment being controlled by switches and thermal-overload switches.
c. Indicate equipment being controlled for pilot lights when located remotely from associated equipment or switch, where function is not obvious.
d. Number of the breaker in panelboard that controls device.

K. Pedestal-Type Fittings: Cast-aluminum housings with sloped single face or two faces, as indicated, with neoprene gasket under base and with concealed mounting holes in base for attaching to laboratory casework. Provide holes tapped for conduits.

L. Line-Type Fittings: Provide with cast-metal boxes with threaded holes for mounting on rigid steel conduit. Provide cover plates same size as boxes.

M. Recessed-Type Fittings: Provide with galvanized-steel boxes.

N. Finishes for Service-Fitting Components: Provide housings or boxes for pedestal- and line-type fittings with manufacturer's standard baked-on, chemical-resistant enamel in color as selected by Architect from manufacturer's full range.

PART 3 - EXECUTION

3.1 INSTALLATION OF CABINETS

A. Comply with installation requirements in SEFA 2. Install level, plumb, and true in line; shim as required using concealed shims. Where laboratory casework abuts other finished work, apply filler strips and scribe for accurate fit, with fasteners concealed where practical.

B. Utility-Space Framing: Secure to floor with two fasteners at each frame. Fasten to partition framing, wood blocking, or metal reinforcements in partitions and to base cabinets.

C. Base Cabinets: Fasten cabinets to utility-space framing, partition framing, wood blocking, or reinforcements in partitions, with fasteners spaced not more than 16 inches (400 mm) o.c. Bolt adjacent cabinets together with joints flush, tight, and uniform.

1. Where base cabinets are installed away from walls, fasten to floor at toe space at not more than 24 inches (600 mm) o.c. and at sides of cabinets with not less than two fasteners per side.

D. Wall Cabinets: Fasten to hanging strips, masonry, partition framing, blocking, or reinforcements in partitions. Fasten each cabinet through back, near top, at not less than 16 inches (400 mm) o.c.

E. Install hardware uniformly and precisely.

F. Adjust operating hardware so doors and drawers align and operate smoothly without warp or bind and contact points meet accurately. Lubricate operating hardware as recommended by manufacturer.

3.2 INSTALLATION OF COUNTERTOPS

A. Comply with installation requirements in SEFA 2. Abut top and edge surfaces true in plane with flush hairline joints and with internal supports placed to prevent deflection. Locate joints where indicated on Shop Drawings.

B. Field Jointing: Where possible, make in same manner as shop-made joints, using dowels, splines, fasteners, adhesives, and sealants recommended by manufacturer. Shop prepare edges for field-made joints.

1. Plastic-Laminate Countertops: Secure field-made joints using concealed clamping devices located within 6 inches (150 mm) of front and back edges and at intervals not exceeding 24 inches (600 mm). Tighten according to manufacturer's written instructions to exert a uniform heavy pressure at joints.

C. Fastening:

1. Secure countertops, except for epoxy countertops, to cabinets with Z-type fasteners or equivalent, using two or more fasteners at each cabinet front, end, and back.
2. Secure epoxy countertops to cabinets with epoxy cement, applied at each corner and along perimeter edges at not more than 48 inches (1200 mm) o.c.

3. Where necessary to penetrate countertops with fasteners, countersink heads approximately 1/8 inch (3 mm) and plug hole flush with material equal to countertop in chemical resistance, hardness, and appearance.

D. Provide holes and cutouts required for service fittings.

E. Seal unfinished edges and cutouts in plastic-laminate countertops with heavy coat of polyurethane varnish.

F. Provide scribe moldings for closures at junctures of countertop, curb, and splash with walls as recommended by manufacturer for materials involved. Match materials and finish to adjacent laboratory casework. Use chemical-resistant, permanently elastic sealing compound where recommended by manufacturer.

G. Dress joints smooth, remove surface scratches, and clean entire surface.

3.3 INSTALLATION OF SINKS

A. Comply with installation requirements in SEFA 2.

B. Drop-in Installation of Epoxy Sinks: Rout groove in countertop to receive sink rim if not shop prepared. Set sink in adhesive and fill remainder of groove with sealant or adhesive. Use procedures and products recommended by sink and countertop manufacturers. Remove excess adhesive and sealant while still wet and finish joint for neat appearance.

C. Underside Installation of Epoxy Sinks: Use laboratory casework manufacturer's recommended adjustable support system for table- and cabinet-type installations. Set top edge of sink unit in sink and countertop manufacturers' recommended chemical-resistant sealing compound or adhesive, and firmly secure to produce a tight and fully leakproof joint. Adjust sink and securely support to prevent movement. Remove excess sealant or adhesive while still wet and finish joint for neat appearance.

D. Semi-flush Installation of Stainless-Steel Sinks: Before setting, apply sink and countertop manufacturers' recommended sealant under rim lip and along top. Remove excess sealant while still wet and finish joint for neat appearance.

E. Drop-in Installation of Epoxy and Polypropylene Cup Sinks: Rout groove in countertop to receive sink rim if not shop prepared. Set sink in adhesive and fill remainder of groove with sealant or adhesive. Use procedures and products recommended by sink and countertop manufacturers. Remove excess adhesive and sealant while still wet and finish joint for neat appearance.

F. Surface Installation of Epoxy and Polypropylene Cup Sinks: Set sink in sealant or adhesive. Use procedures and products recommended by sink and countertop manufacturers. Remove excess sealant or adhesive while still wet and finish joint for neat appearance.

3.4 INSTALLATION OF LABORATORY ACCESSORIES

A. Install accessories according to Shop Drawings, installation requirements in SEFA 2, and manufacturer's written instructions.

B. Securely fasten adjustable shelving supports, stainless-steel shelves, and pegboards to partition framing, wood blocking, or reinforcements in partitions.

C. Install shelf standards plumb and at heights to align shelf brackets for level shelves. Install shelving level and straight, closely fitted to other work where indicated.

D. Securely fasten pegboards to partition framing, wood blocking, or reinforcements in partitions.

3.5 INSTALLATION OF SERVICE FITTINGS

A. Comply with requirements in other Sections for installing water and laboratory gas service fittings and electrical devices.

B. Install fittings according to Shop Drawings, installation requirements in SEFA 2, and manufacturer's written instructions. Set bases and flanges of sink- and countertop-mounted fittings in sealant recommended by manufacturer of sink or countertop material. Securely anchor fittings to laboratory casework unless otherwise indicated.

3.6 CLEANING AND PROTECTING

A. Clean finished surfaces, touch up as required, and remove or refinish damaged or soiled areas to match original factory finish, as approved by Architect.

B. Protect countertop surfaces during construction with 6-mil (0.15-mm) plastic or other suitable water-resistant covering. Tape to underside of countertop at a minimum of 48 inches (1200 mm) o.c.

3.7 SERVICE-FITTING SCHEDULE

A. Water Service Fitting, Type WF-#:

1. Fitting Type: As directed Swing-spout mixing faucet, Rigid, gooseneck mixing faucet, Rigid, gooseneck, single-service faucet, Remote-control, rigid, gooseneck, single-service faucet or Single-service hose bib.
2. Outlet: Aerator or Vacuum breaker and removable serrated outlet as directed.
3. Mounting: As directed Wall, Deck or Line mounted.
4. Additional Requirements: As directed Self-closing valves or for reagent-grade water.

B. Laboratory Steam Service Fitting, Type SF-#:

1. Fitting Type: As directed Turret, Line mounted, Flange type, Remote-control turret or Remote-control flange type.
2. Outlets: As directed One, Two, at 90 degrees, Two, at 180 degrees, Three or Four.
3. Outlet Type: As directed Straight or Angled.

C. Laboratory Gas Service Fitting, Type GF-#:

1. Service: As directed Air, Gas (fuel gas) or Vacuum.
2. Fitting Type: As directed Turret, Line mounted, Flange type, Remote-control turret or Remote-control flange type.
3. Outlets: As directed One, Two, at 90 degrees, Two, at 180 degrees, Three or Four.
4. Outlet Type: As directed Straight or Angled.
5. Valve Type: As directed Ground-key cock, Ball valve or Needle valve.

D. Electrical Service Fitting, Type EF-#:

1. Fitting Type: As directed Pedestal, single faced, Pedestal, double faced, Recessed or Line mounted.
2. Device: As directed One duplex receptacle, Two duplex receptacles, Four duplex receptacles, One switched receptacle or One duplex receptacle, switch, and pilot light.
3. Additional Requirements: As directed GFCI or SPD receptacles.

E. Communication Service Fitting, Type CF-#:

1. Fitting Type: As directed Pedestal, single faced, Pedestal, double faced, Recessed or Line mounted.
2. Device: As directed One duplex communication receptacle or Two duplex receptacles.

F. Electrical and Communication Service Fitting, Type ECF-#:

1. Fitting Type: As directed Pedestal, single faced, Pedestal, double faced, Recessed or Line mounted.
2. Device: As directed One duplex receptacle and one duplex communication receptacle, Two duplex receptacles and two duplex communication receptacles or One switched receptacle and one duplex communication receptacle.
3. Additional Requirements: As directed GFCI or SPD receptacles.

END OF SECTION 123553.13

SECTION 123553.16 - PLASTIC-LAMINATE-CLAD LABORATORY CASEWORK

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Plastic-laminate-clad laboratory casework.
2. Utility-space framing at backs of base cabinets.
3. Filler and closure panels.
4. Laboratory countertops.
5. Shelves.
6. Laboratory sinks and troughs.
7. Laboratory accessories.
8. Water, laboratory gas, and electrical service fittings.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

C. Shop Drawings: For laboratory casework. Include plans, elevations, sections, and attachments to other work including blocking and reinforcements required for installation.

D. Samples: For plastic laminate and other materials requiring color selection.

E. Delegated-Design Submittal: For laboratory casework indicated to comply with seismic performance requirements, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.4 INFORMATIONAL SUBMITTALS

A. Product test reports.

PART 2 - PRODUCTS

2.1 CASEWORK MANUFACTURERS

A. Product Designations: Drawings indicate sizes and configurations of laboratory casework by referencing designated manufacturer's catalog numbers. Other manufacturers' laboratory casework of similar sizes and similar door and drawer configurations and complying with the Specifications may be considered. See Section 016000 "Product Requirements."

2.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design laboratory casework installation.

B. Seismic Performance: Laboratory casework installation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. Design earthquake spectral response acceleration, short period (Sds) for Project as directed.
2. Component Importance Factor: 1.0 or 1.5 as directed.
3. Base Cabinet Load (Including Countertop and Load on Countertop): 200 lb/ft. (300 kg/m).
4. Wall Cabinet (Upper Cabinet) Load: 100 lb/ft. (150 kg/m).

2.3 CASEWORK, GENERAL

A. Casework Product Standard: Comply with SEFA 8 PL, "Recommended Practices for Plastic Laminate Laboratory Grade Furniture, Casework, Shelving and Tables."

B. Flammable Liquid Storage: Where cabinets are indicated for solvent or flammable liquid storage, provide units that are listed and labeled as complying with requirements in NFPA 30 by a testing and inspecting agency acceptable to authorities having jurisdiction or FM Approvals as directed.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.4 PLASTIC-LAMINATE CABINETS

A. Design:

1. Reveal overlay with recessed finger pulls machined into faces of doors and drawers.
2. Flush overlay.

B. Exposed Materials:

1. Plastic-Laminate Grade: As directed.

a. Colors and Patterns: As directed.

2. Edgebanding: Plastic laminate matching adjacent surfaces or PVC as directed.

a. PVC Edgebanding Color: As directed.

C. Semi-exposed Materials:

1. Plastic Laminate: Grade VGS or Grade CLS unless otherwise indicated. Provide plastic laminate for semi-exposed surfaces unless otherwise indicated.

a. Colors and Patterns: As directed.
b. Provide plastic laminate of same grade as exposed surfaces for interior faces of doors and drawer fronts and other locations where opposite side of component is exposed.

2. Thermoset Decorative Panels: Provide thermoset decorative panels for semi-exposed surfaces unless otherwise indicated.

a. Colors and Patterns: As directed.
b. Provide plastic laminate of same grade as exposed surfaces for interior faces of doors and drawer fronts and other locations where opposite side of component is exposed.

2.5 PLASTIC-LAMINATE CABINET MATERIALS

A. Hardwood Plywood: HPVA HP-1, particleboard core except where veneer core is indicated.

B. MDF: Medium-density fiberboard, ANSI A208.2, Grade 130.

C. Particleboard: ANSI A208.1, Grade M-2.

D. Plastic Laminate: High-pressure decorative laminate complying with NEMA LD 3.

E. PVC Edgebanding for Plastic Laminate: Rigid PVC extrusions, through color with satin finish, 0.12 inch (3 mm) thick at doors and drawer fronts, 0.04 inch (1 mm) thick elsewhere.

F. Thermoset Decorative Panels: Particleboard or MDF finished with thermally fused, melamine-impregnated decorative paper and complying with requirements of NEMA LD 3, Grade VGL, for Test Methods 3.3, 3.4, 3.6, 3.8, and 3.10.

1. Edgebanding for Thermoset Decorative Panels: PVC or polyester edgebanding matching thermoset decorative panels.

2.6 AUXILIARY CABINET MATERIALS

A. Acid Storage-Cabinet Lining: 1/4-inch- (6-mm-) thick, as directed.

B. Glass for Glazed Doors: Clear float glass complying with ASTM C1036, Type I, Class 1, Quality-Q3; as directed thick.

C. Glass for Glazed Doors: Clear tempered glass complying with ASTM C1048, Kind FT, Condition A, Type I, Class 1, Quality-Q3; not less than 5.0 mm thick.

D. Glass for Glazed Doors: Clear laminated annealed glass complying with ASTM C1172, Kind LA, Condition A, Type I, Class I, Quality-Q3; with two plies not less than 3.0 mm thick and with clear, polyvinyl butyral interlayer.

2.7 CABINET HARDWARE

A. General: Provide laboratory casework manufacturer's standard, commercial-quality, heavy-duty hardware complying with requirements indicated for each type.

B. Butt Hinges: Stainless or Epoxy-coated-steel as directed, five-knuckle hinges complying with BHMA A156.9, Grade 1, with antifriction bearings and rounded tips.

C. Frameless Concealed Hinges (European Type): BHMA A156.9, Type B01602, self-closing.

1. Degrees of Opening: As directed.

D. Hinged-Door and Drawer Pulls: Solid-aluminum, stainless-steel, or chrome-plated-brass or Epoxy-coated-steel, back-mounted pulls as directed.

E. Sliding-Door Pulls: Stainless-steel or chrome-plated or Epoxy-coated-steel recessed flush pulls as directed.

F. Door Catches: Nylon-roller spring or Dual, self-aligning, permanent magnet catches as directed. Provide two catches on doors more than 48 inches (1200 mm) high.

G. Drawer Slides: Manufacturer's standard.

H. Locks: Cam type, brass with chrome-plated finish; complying with BHMA A156.11, Type E07281 or Type E07261.

1. Tumbler: Disc or Five pin as directed.
2. Lock Locations: Provide where indicated or on drawers and doors as directed.
3. Keying: Key as directed.

    a. Masterkey for up to 225 or 500 key changes as directed.

4. Key Quantity: Minimum of two keys per lock.
5. Master Key System: Key locks to be operable by master key.

    a. Master Keys: Provide two.

I. Sliding-Door Hardware Sets: Laboratory casework manufacturer's standard, to suit type and size of sliding-door units.

J. Adjustable Shelf Supports: BHMA A156.9, powder-coated steel shelf rests, Type B04013 or standards, mortise type, and shelf rests, Type B04071 and Type B04091 as directed.

2.8 COUNTERTOP SHELF TROUGH AND SINK MATERIALS

A. Plastic Laminate: High-pressure decorative laminate complying with NEMA LD 3.

1. Colors, Patterns, and Finishes: As directed.

B. Chemical-Resistant Plastic Laminate:

1. High-pressure decorative laminate, complying with NEMA LD 3, that has the following ratings when tested with indicated reagents according to NEMA LD 3, Test Procedure 3.4.5:

   a. No Effect: Acetic acid (98 percent), acetone, ammonium hydroxide (28 percent), amyl acetate, benzene, butyl alcohol, carbon tetrachloride, chloroform, dimethyl formamide, dioxane, ethyl acetate, ethyl alcohol, ethyl ether, formaldehyde (37 percent), gasoline, gentian violet, hydrogen peroxide (3 percent), methyl alcohol, methyl ethyl ketone, methylene chloride, mono chlorobenzene, naphthalene, toluene, trichloroethylene, xylene, and zinc chloride (saturated).
   b. Slight Effect: Cresol, tincture of iodine, sodium sulfide (15 percent), phenol (90 percent), sodium hydroxide (20 percent), and methyl red.
   c. Moderate Effect: Hydrochloric acid (37 percent), nitric acid (30 percent), phosphoric acid (75 percent), silver nitrate (saturated), and sulfuric acid (77 percent).

2. Color: Black as directed.

C. Core Materials for Plastic Laminate:

1. Particleboard: ANSI A208.1, Grade M-2.

2. Exterior-Glue Particleboard: ANSI A208.1, Grade M-2, exterior glue.

3. Exterior Plywood: DOC PS 1, Exterior A-C or Exterior B-C with fully sanded face as directed.

D. Adhesive for Bonding Plastic Laminate: As directed.

E. Epoxy: Factory-molded, modified epoxy-resin formulation with smooth, nonspecular finish.

1. Physical Properties:

   a. Flexural Strength: Not less than 10,000 psi (70 MPa).
   b. Modulus of Elasticity: Not less than 2,000,000 psi (1400 MPa).
   c. Hardness (Rockwell M): Not less than 100.
   d. Water Absorption (24 Hours): Not more than 0.02 percent.
   e. Heat Distortion Point: Not less than 260 deg F (127 deg C).

2. Chemical Resistance: Epoxy-resin material has the following ratings when tested with indicated reagents according to NEMA LD 3, Test Procedure 3.4.5:

a. No Effect: Acetic acid (98 percent), acetone, ammonium hydroxide (28 percent), benzene, carbon tetrachloride, dimethyl formamide, ethyl acetate, ethyl alcohol, ethyl ether, methyl alcohol, nitric acid (70 percent), phenol, sulfuric acid (60 percent), and toluene.
b. Slight Effect: Chromic acid (60 percent) and sodium hydroxide (50 percent).

3. Color: As directed.

F. Phenolic Composite: Solid, high-pressure decorative laminate, complying with NEMA LD 3, Grade CGS.
1. Chemical Resistance: Composite countertop material has the following ratings when tested with indicated reagents according to NEMA LD 3, Test Procedure 3.4.5:

a. No Effect: Acetic acid (98 percent), acetone, ammonium hydroxide (28 percent), ethyl acetate, ethyl alcohol, formaldehyde (37 percent), furfural, phosphoric acid (85 percent), sulfuric acid (33 percent), and toluene.

2. Color: As directed.

G. Stainless-Steel Sheet: ASTM A240/A240M, Type 304 or Type 316L as directed.

2.9 CABINET FABRICATION

A. Utility-Space Framing: Steel framing units consisting of two steel slotted channels complying with MFMA-4, not less than 1-5/8 inches (41 mm) square by 0.105-inch (2.66-mm) nominal thickness, that are connected at top and bottom by U-shaped brackets made from 1-1/4-by-1/4-inch (32-by-6-mm) steel flat bars. Framing units may be made by welding channel material into rectangular frames instead of using U-shaped brackets.

B. Removable Backs: Provide backs that can be removed from within cabinets at utility spaces.

C. Filler and Closure Panels: Provide where indicated and as needed to close spaces between casework and walls, ceilings, and equipment. Fabricate from same material and with same finish as adjacent exposed casework surfaces unless otherwise indicated.

2.10 COUNTERTOPS, SHELVES, TROUGHS, AND SINKS

A. Countertops, General: Provide units with smooth surfaces in uniform plane, free of defects. Make exposed edges and corners straight and uniformly beveled. Provide front and end overhang of 1 inch (25 mm).

B. Sinks, General: Provide sizes indicated or laboratory casework manufacturer's closest standard size of equal or greater volume, as approved by Architect.

1. Outlets: Provide with strainers and tailpieces, NPS 1-1/2 (DN 40), unless otherwise indicated.
2. Overflows: For each sink except cup sinks, where indicated, provide overflow of standard beehive or open-top design with separate strainer. Height 2 inches (50 mm) less than sink depth. Provide in same material as strainer.

C. Plastic-Laminate Countertops and Shelves:

1. Countertops: Plastic or Chemical-resistant plastic laminate shop bonded to top surface and exposed edges of core with plastic-laminate backing bonded to bottom surface as directed. Sand surfaces to which plastic laminate is to be bonded.

    a. Top Core Thickness: As directed.
    b. Backsplash Core Thickness: 3/4 inch (19 mm) or 1 inch (25 mm) as directed.
    c. Countertop Core: Particleboard, exterior-glue particleboard or exterior plywood as directed.
    d. Countertop Core for Counters Containing Sinks: Exterior-glue particleboard or exterior plywood as directed.
    e. Flat Configuration: With square edges, flat backsplashes, and flat end splashes. Finish faces and exposed edges of splashes with same plastic laminate as top.
    f. Postformed Configuration: With raised, rolled edge and integral coved backsplash with rolled top edge. Construct top and backsplash from one piece of plastic laminate. Where indicated, provide separate end splashes of same material as top and fitted to top.
    g. Exposed Plastic-Laminate Grade: As directed.
    h. Plastic-Laminate Backing Grade: BKL.

2. Plastic-Laminate Shelves: As directed Plastic or Chemical-resistant plastic laminate shop bonded to both faces and edges of core. Sand surfaces to which plastic laminate is to be bonded.

    a. Shelf Core: Particleboard, exterior-glue particleboard or exterior plywood as directed.
    b. Core Thickness: 3/4 inch (19 mm) or 1 inch (25 mm) as directed.
    c. Plastic-Laminate Grade: As directed.

D. Epoxy Countertops and Sinks:

1. Countertop Fabrication: Fabricate with factory cutouts for sinks, holes for service fittings and accessories, and butt joints assembled with epoxy adhesive and concealed metal splines.

    a. Flat Configuration: Thickness as directed with continuous drip groove on underside 1/2 inch (13 mm) from overhang edge.

        1) Edges and Corners: Beveled or Rounded as directed.
        2) Backsplash: Integral coved or Applied as directed.

    b. Marine-Edge Configuration: Minimum thickness, with integral or applied raised edge as directed.

        1) Edges and Corners: Beveled or Rounded as directed.
        2) Backsplash: Integral coved or Applied as directed.

    c. Construction: Uniform throughout full thickness or Epoxy composition not less than 1/4 inch (6 mm) thick, laminated to backing as directed.

2. Sink Fabrication: Molded in one piece with smooth surfaces, coved corners, and bottom sloped to outlet; 1/2-inch (13-mm) minimum thickness.

    a. Provide with polypropylene strainers and tailpieces.
    b. Provide integral sinks in epoxy countertops, bonded to countertops with invisible joint line.
    c. Provide sinks for drop-in installation with 1/4-inch (6-mm) thick lip around perimeter of sink.
    d. Provide sinks for underside installation with manufacturer's recommended adjustable support system for table- and cabinet-type installations.

E. Phenolic-Composite Countertops and Shelves:

1. Countertop Fabrication: Fabricate with cutouts for sinks, holes for service fittings and accessories, and butt joints assembled with epoxy adhesive and concealed metal splines.

    a. Flat Configuration: As directed thick with continuous drip groove on underside 1/2 inch (13 mm) from overhang edge and integral coved backsplash.

        1) Edges and Corners: Beveled or Rounded as directed.

    b. Marine-Edge Configuration: As directed minimum thickness, with raised edge and integral coved backsplash.

        1) Edges and Corners: Beveled or Rounded as directed.

2. Shelf Configuration: Flat, as directed thick.

    a. Edges and Corners: Beveled or Rounded as directed.

F. Stainless-Steel Countertops: Made from stainless-steel sheet, not less than 0.062-inch (1.59-mm) nominal thickness, with No. 4 satin finish.

1. Extend top down 1 inch (25 mm) at edges with a 1/2-inch (13-mm) return flange under frame. Apply heavy coating of heat-resistant, sound-deadening mastic to undersurface.
2. Form backsplash coved to and integral with top surface.
3. Provide raised (marine) edge around perimeter of countertops containing sinks and where indicated.
4. Pitch countertops that contain sinks two ways to sink, where indicated, without channeling or grooving.
5. Factory punch holes for service fittings.
6. Reinforce underside of countertop with channels, or thicker metal sheet where necessary to ensure rigidity without deflection.
7. Weld shop-made joints.
8. Where field-made joints are required, provide hairline butt joints mechanically bolted through continuous channels welded to underside at edges of joined ends. Keep field jointing to a minimum.
9. Where stainless-steel sinks and cup sinks occur in stainless-steel countertops, factory weld into one integral unit.

10. After fabricating and welding, grind surfaces smooth and polish to produce uniform, directionally textured finish with no cross scratches or evidence of welds. Passivate and rinse surfaces; remove embedded foreign matter and leave surfaces clean.

G. Stainless-Steel Shelves: Made from stainless-steel sheet, not less than 0.050-inch (1.27-mm) nominal thickness, with No. 4 satin finish. Weld shop-made joints. As directed fold down or up, front edge 3/4 inch (19 mm); fold up back edge 3 inches (75 mm).

1. Provide integral stiffening brackets, formed by folding up ends 3/4 inch (19 mm) and welding to upturned back edge or front and back edges as directed.
2. After fabricating, grind welds smooth and polish to produce uniform, directionally textured finish with no cross scratches or evidence of welds. Passivate and rinse surfaces; remove embedded foreign matter and leave surfaces clean.

H. Stainless-Steel Sinks: Made from stainless-steel sheet, not less than 0.050-inch (1.27-mm) nominal thickness. Fabricate with corners rounded and coved to at least 5/8-inch (16-mm) radius. Slope sink bottoms to outlet. Provide continuous butt-welded joints.

1. Provide double-wall construction for sink partitions with top edge rounded to at least 1/2-inch (13-mm) diameter.
2. After fabricating and welding, grind surfaces smooth and polish to produce uniform finish with no cross scratches or evidence of welds. Passivate and rinse surfaces; remove embedded foreign matter and leave surfaces clean.
3. Factory punch holes for fittings.
4. Provide with stainless-steel strainers and tailpieces.
5. Provide with integral rims except where located in stainless-steel countertops.
6. Apply 1/8-inch- (3-mm-) thick coating of heat-resistant, sound-deadening mastic to undersink surfaces.

I. Cup Sinks: Provide in material indicated, as directed.

1. Epoxy Cup Sinks: Provide with polypropylene strainers and integral tailpieces.
2. Polypropylene Cup Sinks: Provide with polypropylene strainers and integral tailpieces.
3. Stainless-Steel Cup Sinks: Provide with stainless-steel strainers and integral tailpieces.

J. Troughs: Provide in material indicated and pitch to drains not less than 1/8 inch/foot (10 mm/m). Except where troughs empty into sinks, provide NPS 1-1/2 (DN 40) outlets with strainers and tailpieces.

1. Epoxy Troughs: Molded in one piece with smooth surfaces and coved corners; As directed minimum thickness. Provide polypropylene strainers and tailpieces.
2. Stainless-Steel Troughs: Made from stainless-steel sheet, not less than 0.050-inch (1.27-mm) or 0.062-inch (1.59-mm) nominal thickness. Fabricate with corners rounded and coved to at least 5/8-inch (16-mm) radius. Provide continuous butt-welded joints. After fabricating and welding, grind surfaces smooth and polish to produce uniform finish with no cross scratches or evidence of welds. Passivate and rinse surfaces; remove embedded foreign matter and leave surfaces clean. Provide stainless-steel strainers and tailpieces.

2.11 LABORATORY ACCESSORIES

A. Reagent Shelves: Provide as indicated, fabricated from same material as adjacent countertop unless otherwise indicated.

B. Burette Rods: Aluminum or stainless-steel rods, 1/2 inch (13 mm) in diameter and 18 inches (450 mm) long, threaded on one end to fit tapered plug adapter for flush socket receptacle. Provide with tapered plug adapter and receptacle.

C. Upright Rod Assembly and Metal Crossbar: Aluminum or stainless steel. Two vertical rods and one horizontal crossbar, 3/4 inch (19 mm) in diameter and 36 inches (900 mm) long unless otherwise indicated; two flush socket receptacles and two crossbar clamps. Ends of vertical rods are tapered to fit receptacles; other rod ends are rounded.

D. Greenlaw Arm Assembly: Aluminum or stainless-steel vertical rod, tapered on one end to fit flush socket receptacle. Adjustable crossbar of hardwood with black, acid-resistant finish, secured to upright with adjustable clamp. Provide with receptacle.

E. Lattice Assembly: Aluminum or stainless-steel, vertical and horizontal rod lattice assembly with 3/4-inch- (19-mm-) diameter rods at approximately 12 inches (300 mm) o.c. with two flush socket receptacles for mounting.

1. Size: 36 inches (900 mm) or 48 inches (1200 mm) wide as directed by 24 inches (600 mm) or 36 inches (900 mm) high as directed.

F. Pegboards: Polypropylene, epoxy, or phenolic-composite pegboards with removable polypropylene pegs and stainless-steel drip troughs with drain outlet.

G. Pegboards: Stainless-steel pegboards with removable polypropylene pegs and stainless-steel drip troughs with drain outlet.

2.12 WATER AND LABORATORY GAS SERVICE FITTINGS

A. Service Fittings: Provide units that comply with SEFA 7, "Recommended Practices for Fixtures." Provide fittings complete with washers, locknuts, nipples, and other installation accessories. Include wall and deck flanges, escutcheons, handle extension rods, and similar items.

1. Provide units that comply with "Vandal-Resistant Faucets and Fixtures" recommendations in SEFA 7.

B. Materials: Fabricated from cast or forged red brass unless otherwise indicated.

1. Reagent-Grade Water Service Fittings: Polypropylene, PVC, or PVDF for parts in contact with water.

C. Finish: As directed.

1. Provide chemical-resistant powder coating in laboratory casework manufacturer's standard metallic brown, aluminum, white, or other color as approved by Architect.

D. Water Valves and Faucets: Provide units complying with ASME A112.18.1, with renewable seats, designed for working pressure up to 80 psig (550 kPa).

1. Vacuum Breakers: Provide ASSE 1035 vacuum breakers on water fittings with serrated outlets.
2. Aerators: Provide aerators on water fittings that do not have serrated outlets.
3. Self-Closing Valves: Provide self-closing valves where indicated.

E. Ball Valves: Chrome-plated ball and PTFE seals. Handle requires no more than 5 lbf (22 N) to operate. Provide units designed for working pressure up to 75 psig (520 kPa), with serrated outlets.

1. Locking Safety Handles: Where ball valves are indicated for fuel-gas use, provide handles that must be pushed in or pulled up before being turned on.

F. Ground-Key Cocks: Tapered core and handle of one-piece forged brass, ground and lapped, and held in place under constant spring pressure. Provide units designed for working pressure up to 40 psig (280 kPa), with serrated outlets.

G. Steam Valves: Stainless-steel seat and PTFE seat disc. Provide units designed for steam working pressure up to 20 psig (140 kPa), with serrated outlets.

H. Needle Valves: Provide units with renewable, self-centering, floating cones and renewable seats of stainless steel or Monel metal, with removable serrated outlets.

1. Provide units designed for working pressure as directed.

I. Hand of Fittings: Furnish right-hand fittings unless fitting designation is followed by "L."

J. Remote-Control Valves: Provide needle valves, straight-through or angle type as indicated for fume hoods and where indicated.

K. Handles: Provide three- or four-arm, forged-brass or three- or four-wing, molded-plastic or powder-coated-metal handles for valves unless otherwise indicated.

1. Provide lever-type handles for ground-key cocks. Lever handle aligns with outlet when valve is closed and is perpendicular to outlet when valve is fully open.
2. Provide lever-type handles for ball valves unless otherwise indicated. Lever handle aligns with outlet when valve is closed and is perpendicular to outlet when valve is fully open.
3. Provide heat-resistant plastic handles for steam valves.
4. Provide knurled, molded-plastic handles for needle valves.

L. Service-Outlet Identification: Provide color-coded plastic discs with embossed identification, secured to each service-fitting handle to be tamper resistant. Comply with SEFA 7 for colors and embossed identification.

2.13 ELECTRICAL AND COMMUNICATION SERVICE FITTINGS

A. Service Fittings, General: Provide units complete with metal housings, receptacles, switches, pilot lights, data communication outlets, cover plates, accessories, and gaskets required for mounting on laboratory casework.

B. Electrical Wiring Devices: Comply with requirements in Section 262726 "Wiring Devices" for receptacles, switches, pilot lights, cover plates, and accessories.

C. Twisted-Pair Copper Data Outlets: Comply with requirements in Section 271513 "Communications Copper Horizontal Cabling."

D. Optical Fiber Data Outlets: Comply with requirements in Section 271523 "Communications Optical Fiber Horizontal Cabling."

E. Electrical Receptacles: Hospital or General grade as directed. 125 V, 20 A; NEMA WD 6, Configuration 5-20R unless otherwise indicated.

1. GFCI Receptacles: Feed or Non-feed-through type as directed with integral LED indicator light.
2. SPD Receptacles: With LED indicator light and integral SPD in line to ground, line to neutral, and neutral to ground.
3. Color of Receptacles: Brown or Ivory unless otherwise indicated or required by NFPA 70.

F. USB Charger Receptacles: As directed, Type A, in color matching electrical receptacles.

1. Type: As directed.

G. Switches: Comply with NEMA WD 1, UL 20, and FS W-S-896.

1. Color of Switches: Brown or Ivory unless otherwise indicated or required by NFPA 70.

H. Data Communication Outlets: Two RJ-45 jacks for terminating 100-ohm, balanced, four-pair twisted-pair cabling complying with TIA-568-C.1; complying with Category 5e or Category 6 as directed. Comply with UL 1863.

I. Cover Plates: Provide satin-finish, chrome-plated or Type 304, stainless-steel cover plates as directed with formed, beveled edges.

J. Cover-Plate Identification: Use 1/4-inch- (6-mm-) high letters unless otherwise indicated. For stainless steel or chrome-plated metal, stamp or etch plate and fill in letters with black enamel.

1. Provide at every cover plate or at the following locations:

a. Receptacles other than standard 125-V duplex, grounding type.
b. Switches and thermal-overload switches.
c. Pilot lights when located remotely from associated equipment or switch, where function is not obvious.
d. Receptacles, switches, and other locations indicated.

2. Provide the following information:

a. Voltage and phase for receptacles other than standard 125-V duplex, grounding type.
b. Indicate equipment being controlled by switches and thermal-overload switches.
c. Indicate equipment being controlled for pilot lights when located remotely from associated equipment or switch, where function is not obvious.
d. Number of the breaker in panelboard that controls device.

K. Pedestal-Type Fittings: Cast-aluminum housings with sloped single face or two faces, as indicated, with neoprene gasket under base and with concealed mounting holes in base for attaching to laboratory casework. Provide holes tapped for conduits.

L. Line-Type Fittings: Provide with cast-metal boxes with threaded holes for mounting on rigid steel conduit. Provide cover plates same size as boxes.

M. Recessed-Type Fittings: Provide with galvanized-steel boxes.

N. Finishes for Service-Fitting Components: Provide housings or boxes for pedestal- and line-type fittings with manufacturer's standard baked-on, chemical-resistant enamel in color as selected by Architect from manufacturer's full range.

PART 3 - EXECUTION

3.1 INSTALLATION OF CABINETS

A. Comply with installation requirements in SEFA 2. Install level, plumb, and true in line; shim as required using concealed shims. Where laboratory casework abuts other finished work, apply filler strips and scribe for accurate fit, with fasteners concealed where practical.

B. Utility-Space Framing: Secure to floor with two fasteners at each frame. Fasten to partition framing, wood blocking, or metal reinforcements in partitions and to base cabinets.

C. Base Cabinets: Fasten cabinets to utility-space framing, partition framing, wood blocking, or reinforcements in partitions, with fasteners spaced not more than 16 inches (400 mm) o.c. Bolt adjacent cabinets together with joints flush, tight, and uniform.

1. Where base cabinets are installed away from walls, fasten to floor at toe space at not more than 24 inches (600 mm) o.c. and at sides of cabinets with not less than two fasteners per side.

D. Wall Cabinets: Fasten to hanging strips, masonry, partition framing, blocking, or reinforcements in partitions. Fasten each cabinet through back, near top, at not less than 16 inches (400 mm) o.c.

E. Install hardware uniformly and precisely.

F. Adjust operating hardware so doors and drawers align and operate smoothly without warp or bind and contact points meet accurately. Lubricate operating hardware as recommended by manufacturer.

3.2 INSTALLATION OF COUNTERTOPS

A. Comply with installation requirements in SEFA 2. Abut top and edge surfaces true in plane with flush hairline joints and with internal supports placed to prevent deflection. Locate joints where indicated on Shop Drawings.

B. Field Jointing: Where possible, make in same manner as shop-made joints, using dowels, splines, fasteners, adhesives, and sealants recommended by manufacturer. Shop prepare edges for field-made joints.

1. Plastic-Laminate Countertops: Secure field-made joints using concealed clamping devices located within 6 inches (150 mm) of front and back edges and at intervals not exceeding 24 inches (600 mm). Tighten according to manufacturer's written instructions to exert a uniform heavy pressure at joints.

C. Fastening:

1. Secure countertops, except for epoxy countertops, to cabinets with Z-type fasteners or equivalent, using two or more fasteners at each cabinet front, end, and back.
2. Secure epoxy countertops to cabinets with epoxy cement, applied at each corner and along perimeter edges at not more than 48 inches (1200 mm) o.c.
3. Where necessary to penetrate countertops with fasteners, countersink heads approximately 1/8 inch (3 mm) and plug hole flush with material equal to countertop in chemical resistance, hardness, and appearance.

D. Provide holes and cutouts required for service fittings.

E. Seal unfinished edges and cutouts in plastic-laminate countertops with heavy coat of polyurethane varnish.

F. Provide scribe moldings for closures at junctures of countertop, curb, and splash with walls as recommended by manufacturer for materials involved. Match materials and finish to adjacent laboratory casework. Use chemical-resistant, permanently elastic sealing compound where recommended by manufacturer.

G. Dress joints smooth, remove surface scratches, and clean entire surface.

3.3 INSTALLATION OF SINKS

A. Comply with installation requirements in SEFA 2.

B. Drop-in Installation of Epoxy Sinks: Rout groove in countertop to receive sink rim if not shop prepared. Set sink in adhesive and fill remainder of groove with sealant or adhesive. Use procedures and products recommended by sink and countertop manufacturers. Remove excess adhesive and sealant while still wet and finish joint for neat appearance.

C. Underside Installation of Epoxy Sinks: Use laboratory casework manufacturer's recommended adjustable support system for table- and cabinet-type installations. Set top edge of sink unit in sink and countertop manufacturers' recommended chemical-resistant sealing compound or adhesive, and firmly secure to produce a tight and fully leakproof joint. Adjust sink and

securely support to prevent movement. Remove excess sealant or adhesive while still wet and finish joint for neat appearance.

D. Semiflush Installation of Stainless-Steel Sinks: Before setting, apply sink and countertop manufacturers' recommended sealant under rim lip and along top. Remove excess sealant while still wet and finish joint for neat appearance.

E. Drop-in Installation of Epoxy and Polypropylene Cup Sinks: Rout groove in countertop to receive sink rim if not shop prepared. Set sink in adhesive and fill remainder of groove with sealant or adhesive. Use procedures and products recommended by sink and countertop manufacturers. Remove excess adhesive and sealant while still wet and finish joint for neat appearance.

F. Surface Installation of Epoxy and Polypropylene Cup Sinks: Set sink in sealant or adhesive. Use procedures and products recommended by sink and countertop manufacturers. Remove excess sealant or adhesive while still wet and finish joint for neat appearance.

3.4 INSTALLATION OF LABORATORY ACCESSORIES

A. Install accessories according to Shop Drawings, installation requirements in SEFA 2, and manufacturer's written instructions.

B. Securely fasten adjustable shelving supports, stainless-steel shelves, and pegboards to partition framing, wood blocking, or reinforcements in partitions.

C. Install shelf standards plumb and at heights to align shelf brackets for level shelves. Install shelving level and straight, closely fitted to other work where indicated.

D. Securely fasten pegboards to partition framing, wood blocking, or reinforcements in partitions.

3.5 INSTALLATION OF SERVICE FITTINGS

A. Comply with requirements in other Sections for installing water and laboratory gas service fittings and electrical devices.

B. Install fittings according to Shop Drawings, installation requirements in SEFA 2, and manufacturer's written instructions. Set bases and flanges of sink- and countertop-mounted fittings in sealant recommended by manufacturer of sink or countertop material. Securely anchor fittings to laboratory casework unless otherwise indicated.

3.6 CLEANING AND PROTECTING

A. Clean finished surfaces, touch up as required, and remove or refinish damaged or soiled areas to match original factory finish, as approved by Architect.

B. Protect countertop surfaces during construction with 6-mil (0.15-mm) plastic or other suitable water-resistant covering. Tape to underside of countertop at a minimum of 48 inches (1200 mm) o.c.

3.7 SERVICE-FITTING SCHEDULE

A. Water Service Fitting, Type WF as directed:

1. Fitting Type: As directed.
2. Outlet: Aerator or Vacuum breaker and removable serrated outlet as directed.
3. Mounting: As directed.
4. Additional Requirements: Self-closing valves or For reagent-grade water as directed.

B. Laboratory Steam Service Fitting, Type SF as directed:

1. Fitting Type: As directed.
2. Outlets: As directed.
3. Outlet Type: Straight or Angled as directed.

C. Laboratory Gas Service Fitting, Type GF as directed:

1. Service: As directed.
2. Fitting Type: As directed.
3. Outlets: As directed.
4. Outlet Type: Straight or Angled.
5. Valve Type: As directed.

D. Electrical Service Fitting, Type EF or as directed:

1. Fitting Type: As directed.
2. Device: As directed.
3. Additional Requirements: GFCI or SPD receptacles as directed.

E. Communication Service Fitting, Type CF as directed:

1. Fitting Type: As directed.
2. Device: One duplex communication receptacle or Two duplex receptacles as directed.

F. Electrical and Communication Service Fitting, Type ECF as directed:

1. Fitting Type: As directed
2. Device: As directed.
3. Additional Requirements: GFCI or SPD receptacles as directed.

END OF SECTION 123553.16

SECTION 123553.19 - WOOD LABORATORY CASEWORK

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Wood laboratory casework.
2. Utility-space framing at backs of base cabinets.
3. Filler and closure panels.
4. Laboratory countertops.
5. Tables.
6. Shelves.
7. Laboratory sinks and troughs.
8. Laboratory accessories.
9. Water, laboratory gas, and electrical service fittings.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

C. Shop Drawings: For laboratory casework.

D. Samples: For casework finishes and materials requiring color selection.

E. Delegated-Design Submittal: For laboratory casework indicated to comply with seismic performance requirements, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.4 INFORMATIONAL SUBMITTALS

A. Product test reports.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Product Designations: Drawings indicate sizes and configurations of laboratory casework by referencing designated manufacturer's catalog numbers. Other manufacturers' laboratory casework of similar sizes and similar door and drawer configurations and complying with the Specifications may be considered. See Section 016000 "Product Requirements."

2.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design laboratory casework installation.

B. Seismic Performance: Laboratory casework installation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. Design earthquake spectral response acceleration, short period (Sds) for Project is indicated on Drawings.
2. Component Importance Factor: 1.0 or 1.5 as directed.
3. Base Cabinet Load (Including Countertop and Load on Countertop): 320 lb/ft. (480 kg/m).
4. Wall Cabinet (Upper Cabinet) Load: 160 lb/ft. (240 kg/m).

2.3 CASEWORK, GENERAL

A. Casework Product Standard: Comply with SEFA 8 W, "Laboratory Grade Wood Casework."

B. Flammable Liquid Storage: Where cabinets are indicated for solvent or flammable liquid storage, provide units that are listed and labeled as complying with requirements in NFPA 30 by a testing and inspecting agency acceptable to authorities having jurisdiction or FM Approvals as directed.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.4 WOOD CASEWORK

A. Design: Lipped overlay with radiused edges, reveal overlay with square edges or Reveal overlay with radiused edges as directed.

B. Wood Species: Red oak, White birch, Red birch, Alder, White maple or Hickory as directed.

1. Wood Stain Colors and Finishes: As indicated by manufacturer's designations, Match Architect's sample or As selected by Architect from casework manufacturer's full range as directed.

C. Cut: Plain sliced/sawn, Quarter sliced/sawn, Rift cut/sawn or Rotary cut/plain sawn as directed.

D. Grain Direction:

1. Doors: Vertical with continuous vertical matching.
2. Drawer Fronts: Vertical with continuous vertical matching or Horizontal as directed.
3. Face Frame Members: Lengthwise.
4. End Panels: Vertical.
5. Bottoms and Tops of Units: Side to side.
6. Knee Space Panels: Vertical.
7. Aprons: Horizontal.

E. Exposed Materials:

1. General: Provide materials that are selected and arranged for compatible grain and color. Do not use materials adjacent to one another that are noticeably dissimilar in color, grain, figure, or natural character markings.
2. Plywood: Hardwood plywood, either veneer core or particleboard core with face veneer of species indicated. Grade A exposed faces, at least 1/50 inch (0.5 mm) thick, and Grade J crossbands. Provide backs of same species as faces.
3. Solid Wood: Clear hardwood lumber of species indicated.
4. Edgebanding: Solid wood, minimum 1/8 inch (3 mm) thick and of same species as face veneer, Wood veneer of same species as face veneer or PVC as directed.

    a. PVC Edgebanding Color: Casework manufacturer's standard or as selected by Architect from casework manufacturer's full range.

F. Semi-exposed Materials:

1. Wood: Provide solid wood or hardwood plywood for semi-exposed surfaces unless otherwise indicated.

    a. Solid Wood: Sound hardwood lumber, selected to eliminate appearance defects, of species similar in color and grain to or same species as exposed solid wood as directed.
    b. Plywood: Hardwood plywood of species similar in color and grain to or same species as exposed plywood as directed. Provide backs of same species as faces.

        1) Grade: As directed B or C faces and Grade J crossbands.

2. Metal for Steel Drawer Pans: Cold-rolled, carbon-steel sheet complying with ASTM A1008/A1008M; matte finish; suitable for exposed applications.

G. Concealed Materials:

1. Solid Wood: With no defects affecting strength or utility.
2. Plywood: Hardwood plywood. Provide backs of same species as faces.
3. Particleboard.
4. MDF.
5. Hardboard.

2.5 WOOD CABINET AND TABLE MATERIALS

A. General:

1. Maximum Moisture Content for Lumber: 7 percent for hardwood and 12 percent for softwood.

B. Hardwood Plywood: HPVA HP-1, particleboard core except where veneer core is indicated.

C. MDF: Medium-density fiberboard, ANSI A208.2, Grade 130.

D. Particleboard: ANSI A208.1, Grade M-2.

E. Hardboard: ANSI A135.4, Class 1 tempered.

F. PVC Edgebanding for Wood: Rigid PVC extrusions, through color with satin finish, 0.12 inch (3 mm) thick at doors and drawer fronts, 0.04 inch (1 mm) thick elsewhere.

2.6 AUXILIARY CABINET MATERIALS

A. Acid Storage-Cabinet Lining: 1/4-inch (6-mm) thick, glass-fiber cement board complying with ASTM C1186, polyethylene or polypropylene or polyethylene, polypropylene, epoxy, or phenolic-composite lining material as directed.

B. Glass for Glazed Doors: Clear float glass complying with ASTM C1036, Type I, Class 1, Quality-Q3; not less than 3.0 mm, 4.0 mm, 5.0 mm or 6.0 mm thick as directed.

C. Glass for Glazed Doors: Clear tempered glass complying with ASTM C1048, Kind FT, Condition A, Type I, Class 1, Quality-Q3; not less than 5.0 mm thick.

D. Glass for Glazed Doors: Clear laminated annealed glass complying with ASTM C1172, Kind LA, Condition A, Type I, Class I, Quality-Q3; with two plies not less than 3.0 mm thick and with clear, polyvinyl butyral interlayer.

2.7 CABINET HARDWARE

A. General: Provide laboratory casework manufacturer's standard, commercial-quality, heavy-duty hardware complying with requirements indicated for each type.

B. Butt Hinges: Stainless or Epoxy-coated-steel, five-knuckle hinges complying with BHMA A156.9, Grade 1, with antifriction bearings and rounded tips as directed.

C. Frameless Concealed Hinges (European Type): BHMA A156.9, Type B01602, self-closing.

D. Hinged-Door and Drawer Pulls: Solid-aluminum, stainless-steel, or chrome-plated-brass or Epoxy-coated-steel, back-mounted pulls as directed.

E. Sliding-Door Pulls: Stainless-steel or chrome-plated or Epoxy-coated-steel recessed flush pulls as directed.

F. Recessed Pulls: Aluminum or Polypropylene as directed.

G. Channel Pulls: Full-width, recessed solid-hardwood channels; matching exposed wood of cabinets.

H. Door Catches: Nylon-roller spring or Dual, self-aligning, permanent magnet catches as directed. Provide two catches on doors more than 48 inches (1200 mm) high.

I. Drawer Slides: Manufacturer's standard.

J. Locks: Cam type, brass with chrome-plated finish; complying with BHMA A156.11, Type E07281 or Type E07261.

1. Tumbler: Disc or Five pin as directed.
2. Lock Locations: Provide where indicated on drawers and doors.
3. Keying: Key locks alike within each room; key each room separately, each lock separately or locks as directed.

a. Masterkey for up to 225 or 500 key changes as directed.

4. Key Quantity: Minimum of two keys per lock.
5. Master Key System: Key locks to be operable by master key.

a. Master Keys: Provide two.

K. Sliding-Door Hardware Sets: Laboratory casework manufacturer's standard, to suit type and size of sliding-door units.

L. Adjustable Shelf Supports: BHMA A156.9, powder-coated steel shelf rests, Type B04013, standards, mortise type, and shelf rests, Type B04071 and Type B04091, standards, surface type, and epoxy powder-coated steel shelf brackets, Type B04102 and Type B04112 as directed.

2.8 COUNTERTOP, TABLETOP, SHELF TROUGH AND SINK MATERIALS

A. Plastic Laminate: High-pressure decorative laminate complying with NEMA LD 3.

1. Colors, Patterns, and Finishes: As indicated by manufacturer's designations, As selected by Architect from casework manufacturer's full range, As selected by Architect from plastic-laminate manufacturer's full range or As selected by Architect from plastic-laminate manufacturer's full range of solid colors.

B. Chemical-Resistant Plastic Laminate:
1. High-pressure decorative laminate, complying with NEMA LD 3, that has the following ratings when tested with indicated reagents according to NEMA LD 3, Test Procedure 3.4.5:

a. No Effect: Acetic acid (98 percent), acetone, ammonium hydroxide (28 percent), amyl acetate, benzene, butyl alcohol, carbon tetrachloride, chloroform, dimethyl formamide, dioxane, ethyl acetate, ethyl alcohol, ethyl ether, formaldehyde (37 percent), gasoline, gentian violet, hydrogen peroxide (3 percent), methyl alcohol,

methyl ethyl ketone, methylene chloride, mono chlorobenzene, naphthalene, toluene, trichloroethylene, xylene, and zinc chloride (saturated).

b. Slight Effect: Cresol, tincture of iodine, sodium sulfide (15 percent), phenol (90 percent), sodium hydroxide (20 percent), and methyl red.

c. Moderate Effect: Hydrochloric acid (37 percent), nitric acid (30 percent), phosphoric acid (75 percent), silver nitrate (saturated), and sulfuric acid (77 percent).

2. Color: Black, As indicated by manufacturer's designations or As selected by Architect from chemical-resistant, plastic-laminate manufacturer's full range as directed.

C. Core Materials for Plastic Laminate:

1. Particleboard: ANSI A208.1, Grade M-2.

2. Exterior-Glue Particleboard: ANSI A208.1, Grade M-2, exterior glue.

3. Exterior Plywood: DOC PS 1, Exterior A-C or Exterior B-C with fully sanded face as directed.

D. Adhesive for Bonding Plastic Laminate: Resorcinol, Urea formaldehyde, contact adhesive or Manufacturer's standard waterproof adhesive as directed.

E. Epoxy: Factory-molded, modified epoxy-resin formulation with smooth, non-specular finish.

1. Physical Properties:

a. Flexural Strength: Not less than 10,000 psi (70 MPa).

b. Modulus of Elasticity: Not less than 2,000,000 psi (1400 MPa).

c. Hardness (Rockwell M): Not less than 100.

d. Water Absorption (24 Hours): Not more than 0.02 percent.

e. Heat Distortion Point: Not less than 260 deg F (127 deg C).

2. Chemical Resistance: Epoxy-resin material has the following ratings when tested with indicated reagents according to NEMA LD 3, Test Procedure 3.4.5:

a. No Effect: Acetic acid (98 percent), acetone, ammonium hydroxide (28 percent), benzene, carbon tetrachloride, dimethyl formamide, ethyl acetate, ethyl alcohol, ethyl ether, methyl alcohol, nitric acid (70 percent), phenol, sulfuric acid (60 percent), and toluene.

b. Slight Effect: Chromic acid (60 percent) and sodium hydroxide (50 percent).

3. Color: Black, Gray, Beige, White or as selected by Architect from epoxy manufacturer's full range as directed.

F. Phenolic Composite: Solid, high-pressure decorative laminate, complying with NEMA LD 3, Grade CGS.

1. Chemical Resistance: Composite countertop material has the following ratings when tested with indicated reagents according to NEMA LD 3, Test Procedure 3.4.5:

a. No Effect: Acetic acid (98 percent), acetone, ammonium hydroxide (28 percent), ethyl acetate, ethyl alcohol, formaldehyde (37 percent), furfural, phosphoric acid (85 percent), sulfuric acid (33 percent), and toluene.

2. Color: Black, Gray, Beige, White or as selected by Architect from phenolic-composite manufacturer's full range as directed.

G. Stainless-Steel Sheet: ASTM A240/A240M, Type 304 or Type 316L as directed.

2.9 WOOD CABINET AND TABLE FABRICATION

A. Construction: Provide wood-faced laboratory casework complying with SEFA 8 W.

B. Tables: Solid-hardwood legs, not less than 2 inches (50 mm) square with solid-hardwood stretchers as needed to comply with product standard. Bolt stretchers to legs and cross-stretchers, and bolt legs to table aprons. Provide leveling device at bottom of each leg.

1. Leg Shoes: Black vinyl or rubber, open-bottom, slip-on type.

C. Utility-Space Framing: Steel framing units consisting of two steel slotted channels complying with MFMA-4, not less than 1-5/8 inches (41 mm) square by 0.105-inch (2.66-mm) nominal thickness, that are connected at top and bottom by U-shaped brackets made from 1-1/4-by-1/4-inch (32-by-6-mm) steel flat bars. Framing units may be made by welding channel material into rectangular frames instead of using U-shaped brackets.

D. Removable Backs: Provide backs that can be removed from within cabinets at utility spaces.

E. Filler and Closure Panels: Provide where indicated and as needed to close spaces between casework and walls, ceilings, and equipment. Fabricate from same material and with same finish as adjacent exposed casework surfaces unless otherwise indicated.

2.10 WOOD FINISH

A. Chemical-Resistant Finish: Finish complies with acceptance levels of cabinet surface finish tests in SEFA 8 W. Acceptance level for chemical spot test shall be no more than for Level 3 conditions.

2.11 COUNTERTOPS, TABLETOPS, SHELVES, TROUGHS, AND SINKS

A. Countertops, General: Provide units with smooth surfaces in uniform plane, free of defects. Make exposed edges and corners straight and uniformly beveled. Provide front and end overhang of 1 inch (25 mm).

B. Sinks, General: Provide sizes indicated or laboratory casework manufacturer's closest standard size of equal or greater volume, as approved by Architect.

1. Outlets: Provide with strainers and tailpieces, NPS 1-1/2 (DN 40), unless otherwise indicated.

2. Overflows: For each sink except cup sinks, where indicated, provide overflow of standard beehive or open-top design with separate strainer. Height 2 inches (50 mm) less than sink depth. Provide in same material as strainer.

C. Plastic-Laminate Countertops, Tabletops and Shelves:

1. Countertops: As directed Plastic or Chemical-resistant plastic laminate shop bonded to top surface and exposed edges of core with plastic-laminate backing bonded to bottom surface. Sand surfaces to which plastic laminate is to be bonded.

   a. Top Core Thickness: 3/4 inch (19 mm), 1 inch (25 mm) or 1-3/16 inch (30 mm) as directed.
   b. Backsplash Core Thickness: 3/4 inch (19 mm) or 1 inch (25 mm) as directed.
   c. Countertop Core: Particleboard, exterior-glue particleboard or exterior plywood as directed.
   d. Countertop Core for Counters Containing Sinks: Exterior-glue particleboard or exterior plywood.
   e. Flat Configuration: With square edges, flat backsplashes, and flat end splashes. Finish faces and exposed edges of splashes with same plastic laminate as top.
   f. Post-formed Configuration: With raised, rolled edge and integral coved backsplash with rolled top edge. Construct top and backsplash from one piece of plastic laminate. Where indicated, provide separate end splashes of same material as top and fitted to top.
   g. Plastic-Laminate Grade: HGS, HGL, HGF or HGP as directed.

2. Tabletops: As directed Plastic or Chemical-resistant plastic laminate shop bonded to top surface and exposed edges of core with plastic-laminate backing bonded to bottom surface. Sand surfaces to which plastic laminate is to be bonded.

   a. Tabletop Core: Particleboard or exterior plywood.
   b. Core Thickness: 3/4 inch (19 mm), 1 inch (25 mm) or 1-3/16 inches (30 mm) as directed.
   c. Plastic-Laminate Grade: HGS, HGL, HGF or HGP as directed.

3. Plastic-Laminate Shelves: As directed Plastic or Chemical-resistant plastic laminate shop bonded to both faces and edges of core. Sand surfaces to which plastic laminate is to be bonded.

   a. Shelf Core: Particleboard, exterior-glue particleboard or exterior plywood as directed.
   b. Core Thickness: 3/4 inch (19 mm) or 1 inch (25 mm) as directed.
   c. Plastic-Laminate Grade: HGS, HGL, HGF or HGP as directed.

D. Epoxy Countertops, Tabletops and Sinks:

1. Countertop Fabrication: Fabricate with factory cutouts for sinks, holes for service fittings and accessories, and butt joints assembled with epoxy adhesive and concealed metal splines.

a. Flat Configuration: As directed 5/8 inch (16 mm), 3/4 inch (19 mm) or 1 inch (25 mm) thick with continuous drip groove on underside 1/2 inch (13 mm) from overhang edge.

1) Edges and Corners: Beveled or Rounded as directed.
2) Backsplash: Integral coved or Applied as directed.

b. Marine-Edge Configuration: 5/8-inch (16-mm), 3/4-inch (19-mm) or 1-inch (25-mm) minimum thickness, with integral or applied raised edge as directed.

1) Edges and Corners: Beveled or Rounded as directed.
2) Backsplash: Integral coved or Applied as directed.

c. Construction: Uniform throughout full thickness or Epoxy composition not less than 1/4 inch (6 mm) thick, laminated to backing as directed.

2. Tabletop Fabrication:

a. Flat Configuration: As directed 5/8 inch (16 mm), 3/4 inch (19 mm) or 1 inch (25 mm) thick with continuous drip groove on underside at perimeter.

1) Edges and Corners: Beveled or Rounded as directed.

b. Marine-Edge Configuration: As directed 5/8-inch (16-mm), 3/4-inch (19-mm) or 1-inch (25-mm) minimum thickness with integral or applied raised edge.

1) Edges and Corners: Beveled or Rounded as directed.

c. Tabletop Construction: As directed Uniform throughout full thickness or Epoxy composition not less than 1/4 inch (6 mm) thick, laminated to backing.
d. Product Option: Phenolic-composite tabletops may be substituted for epoxy tabletops at Contractor's option.

3. Sink Fabrication: Molded in one piece with smooth surfaces, coved corners, and bottom sloped to outlet; 1/2-inch (13-mm) minimum thickness.

a. Provide with polypropylene strainers and tailpieces.
b. Provide integral sinks in epoxy countertops, bonded to countertops with invisible joint line.
c. Provide sinks for drop-in installation with 1/4-inch (6-mm) thick lip around perimeter of sink.
d. Provide sinks for underside installation with manufacturer's recommended adjustable support system for table- and cabinet-type installations.

E. Phenolic-Composite Countertops, Tabletops, and Shelves, as directed:

1. Countertop Fabrication: Fabricate with cutouts for sinks, holes for service fittings and accessories, and butt joints assembled with epoxy adhesive and concealed metal splines.

a. Flat Configuration: As directed 1/2 inch (13 mm), 5/8 inch (16 mm), 3/4 inch (19 mm) or 1 inch (25 mm) thick with continuous drip groove on underside 1/2 inch (13 mm) from overhang edge and integral coved backsplash.

1) Edges and Corners: Beveled or Rounded as directed.

b. Marine-Edge Configuration: As directed 1/2-inch (13-mm), 5/8-inch (16-mm), 3/4-inch (19-mm) or 1-inch (25-mm) minimum thickness, with raised edge and integral coved backsplash.

1) Edges and Corners: Beveled or Rounded as directed.

2. Tabletop Fabrication:

a. Flat Configuration: As directed 1/2 inch (13 mm), 5/8 inch (16 mm), 3/4 inch (19 mm) or 1 inch (25 mm) thick with continuous drip groove on underside at perimeter.

1) Edges and Corners: Beveled or Rounded as directed.

b. Marine-Edge Configuration: As directed 5/8-inch (16-mm), 3/4-inch (19-mm) or 1-inch (25-mm) minimum thickness with integral or applied raised edge.

1) Edges and Corners: Beveled or Rounded as directed.

3. Shelf Configuration: Flat, 5/8 inch (16 mm) or 3/4 inch (19 mm) thick as directed.

a. Edges and Corners: Beveled or Rounded as directed.

F. Stainless-Steel Countertops: Made from stainless-steel sheet, not less than 0.062-inch (1.59-mm) nominal thickness, with No. 4 satin finish.

1. Extend top down 1 inch (25 mm) at edges with a 1/2-inch (13-mm) return flange under frame. Apply heavy coating of heat-resistant, sound-deadening mastic to undersurface.
2. Form backsplash coved to and integral with top surface.
3. Provide raised (marine) edge around perimeter of countertops containing sinks and where indicated.
4. Pitch countertops that contain sinks two ways to sink, where indicated, without channeling or grooving.
5. Factory punch holes for service fittings.
6. Reinforce underside of countertop with channels, or thicker metal sheet where necessary to ensure rigidity without deflection.
7. Weld shop-made joints.
8. Where field-made joints are required, provide hairline butt joints mechanically bolted through continuous channels welded to underside at edges of joined ends. Keep field jointing to a minimum.
9. Where stainless-steel sinks and cup sinks occur in stainless-steel countertops, factory weld into one integral unit.

10. After fabricating and welding, grind surfaces smooth and polish to produce uniform, directionally textured finish with no cross scratches or evidence of welds. Passivate and rinse surfaces; remove embedded foreign matter and leave surfaces clean.

G. Stainless-Steel Shelves: Made from stainless-steel sheet, not less than 0.050-inch (1.27-mm) nominal thickness, with No. 4 satin finish. Weld shop-made joints. Fold down or up, front edge 3/4 inch (19 mm) as directed; fold up back edge 3 inches (75 mm).

1. Provide integral stiffening brackets, formed by folding up ends 3/4 inch (19 mm) and welding to upturned back edge or front and back edges as directed.
2. After fabricating, grind welds smooth and polish to produce uniform, directionally textured finish with no cross scratches or evidence of welds. Passivate and rinse surfaces; remove embedded foreign matter and leave surfaces clean.

H. Stainless-Steel Sinks: Made from stainless-steel sheet, not less than 0.050-inch (1.27-mm) nominal thickness. Fabricate with corners rounded and coved to at least 5/8-inch (16-mm) radius. Slope sink bottoms to outlet. Provide continuous butt-welded joints.

1. Provide double-wall construction for sink partitions with top edge rounded to at least 1/2-inch (13-mm) diameter.
2. After fabricating and welding, grind surfaces smooth and polish to produce uniform finish with no cross scratches or evidence of welds. Passivate and rinse surfaces; remove embedded foreign matter and leave surfaces clean.
3. Factory punch holes for fittings.
4. Provide with stainless-steel strainers and tailpieces.
5. Provide with integral rims except where located in stainless-steel countertops.
6. Apply 1/8-inch- (3-mm-) thick coating of heat-resistant, sound-deadening mastic to under sink surfaces.

I. Cup Sinks: Provide in material indicated, 3-by-6-inch (75-by-150-mm) oval, 3-by-9-inch (75-by-228-mm) oval, 5-inch (127-mm) diameter or as indicated on Drawings.

1. Epoxy Cup Sinks: Provide with polypropylene strainers and integral tailpieces.
2. Polypropylene Cup Sinks: Provide with polypropylene strainers and integral tailpieces.
3. Stainless-Steel Cup Sinks: Provide with stainless-steel strainers and integral tailpieces.

J. Troughs: Provide in material indicated and pitch to drains not less than 1/8 inch/foot (10 mm/m). Except where troughs empty into sinks, provide NPS 1-1/2 (DN 40) outlets with strainers and tailpieces.

1. Epoxy Troughs: Molded in one piece with smooth surfaces and coved corners; 1/2-inch (13-mm), 5/8-inch (16-mm) or 3/4-inch (19-mm) minimum thickness as directed. Provide polypropylene strainers and tailpieces.
2. Stainless-Steel Troughs: Made from stainless-steel sheet, not less than 0.050-inch (1.27-mm) or 0.062-inch (1.59-mm) nominal thickness as directed. Fabricate with corners rounded and coved to at least 5/8-inch (16-mm) radius. Provide continuous butt-welded joints. After fabricating and welding, grind surfaces smooth and polish to produce uniform finish with no cross scratches or evidence of welds. Passivate and rinse surfaces; remove embedded foreign matter and leave surfaces clean. Provide stainless-steel strainers and tailpieces.

2.12 LABORATORY ACCESSORIES

A. Reagent Shelves: Provide as indicated, fabricated from same material as adjacent countertop unless otherwise indicated.

B. Burette Rods: Aluminum or stainless-steel rods, 1/2 inch (13 mm) in diameter and 18 inches (450 mm) long, threaded on one end to fit tapered plug adapter for flush socket receptacle. Provide with tapered plug adapter and receptacle.

C. Upright Rod Assembly and Metal Crossbar: Aluminum or stainless steel. Two vertical rods and one horizontal crossbar, 3/4 inch (19 mm) in diameter and 36 inches (900 mm) long unless otherwise indicated; two flush socket receptacles and two crossbar clamps. Ends of vertical rods are tapered to fit receptacles; other rod ends are rounded.

D. Greenlaw Arm Assembly: Aluminum or stainless-steel vertical rod, tapered on one end to fit flush socket receptacle. Adjustable crossbar of hardwood with black, acid-resistant finish, secured to upright with adjustable clamp. Provide with receptacle.

E. Lattice Assembly: Aluminum or stainless-steel, vertical and horizontal rod lattice assembly with 3/4-inch (19-mm) diameter rods at approximately 12 inches (300 mm) o.c. with two flush socket receptacles for mounting.

1. Size: As directed, 36 inches (900 mm) or 48 inches (1200 mm) wide by 24 inches (600 mm) or 36 inches (900 mm) high.

F. Pegboards: Polypropylene, epoxy, or phenolic-composite pegboards with removable polypropylene pegs and stainless-steel drip troughs with drain outlet.

G. Pegboards: Stainless-steel pegboards with removable polypropylene pegs and stainless-steel drip troughs with drain outlet.

2.13 WATER AND LABORATORY GAS SERVICE FITTINGS

A. Service Fittings: Provide units that comply with SEFA 7, "Recommended Practices for Fixtures." Provide fittings complete with washers, locknuts, nipples, and other installation accessories. Include wall and deck flanges, escutcheons, handle extension rods, and similar items.

1. Provide units that comply with "Vandal-Resistant Faucets and Fixtures" recommendations in SEFA 7.

B. Materials: Fabricated from cast or forged red brass unless otherwise indicated.

1. Reagent-Grade Water Service Fittings: Polypropylene, PVC, or PVDF for parts in contact with water.

C. Finish: Chromium plated, Chromium plated unless otherwise indicated or Acid- and solvent-resistant powder coating complying with requirements in SEFA 7 for corrosion-resistant finishes as directed.

1. Provide chemical-resistant powder coating in laboratory casework manufacturer's standard metallic brown, aluminum, white, or other color as approved by Architect.

D. Water Valves and Faucets: Provide units complying with ASME A112.18.1, with renewable seats, designed for working pressure up to 80 psig (550 kPa).

1. Vacuum Breakers: Provide ASSE 1035 vacuum breakers on water fittings with serrated outlets.
2. Aerators: Provide aerators on water fittings that do not have serrated outlets.
3. Self-Closing Valves: Provide self-closing valves where indicated.

E. Ball Valves: Chrome-plated ball and PTFE seals. Handle requires no more than 5 lbf (22 N) to operate. Provide units designed for working pressure up to 75 psig (520 kPa), with serrated outlets.

1. Locking Safety Handles: Where ball valves are indicated for fuel-gas use, provide handles that must be pushed in or pulled up before being turned on.

F. Ground-Key Cocks: Tapered core and handle of one-piece forged brass, ground and lapped, and held in place under constant spring pressure. Provide units designed for working pressure up to 40 psig (280 kPa), with serrated outlets.

G. Steam Valves: Stainless-steel seat and PTFE seat disc. Provide units designed for steam working pressure up to 20 psig (140 kPa), with serrated outlets.

H. Needle Valves: Provide units with renewable, self-centering, floating cones and renewable seats of stainless steel or Monel metal, with removable serrated outlets.

1. Provide units designed for working pressure up to 60 psig (410 kPa), 100 psig (690 kPa), 125 psig (860 kPa), as indicated on Drawings or as indicated in schedules.

I. Hand of Fittings: Furnish right-hand fittings unless fitting designation is followed by "L."

J. Remote-Control Valves: Provide needle valves, straight-through or angle type as indicated for fume hoods and where indicated.

K. Handles: Provide three- or four-arm, forged-brass or three- or four-wing, molded-plastic or powder-coated-metal handles for valves unless otherwise indicated.

1. Provide lever-type handles for ground-key cocks. Lever handle aligns with outlet when valve is closed and is perpendicular to outlet when valve is fully open.
2. Provide lever-type handles for ball valves unless otherwise indicated. Lever handle aligns with outlet when valve is closed and is perpendicular to outlet when valve is fully open.
3. Provide heat-resistant plastic handles for steam valves.
4. Provide knurled, molded-plastic handles for needle valves.

L. Service-Outlet Identification: Provide color-coded plastic discs with embossed identification, secured to each service-fitting handle to be tamper resistant. Comply with SEFA 7 for colors and embossed identification.

2.14 ELECTRICAL AND COMMUNICATION SERVICE FITTINGS

A. Service Fittings, General: Provide units complete with metal housings, receptacles, switches, pilot lights, data communication outlets, cover plates, accessories, and gaskets required for mounting on laboratory casework.

B. Electrical Wiring Devices: Comply with requirements in Section 262726 "Wiring Devices" for receptacles, switches, pilot lights, cover plates, and accessories.

C. Twisted-Pair Copper Data Outlets: Comply with requirements in Section 271513 "Communications Copper Horizontal Cabling."

D. Optical Fiber Data Outlets: Comply with requirements in Section 271523 "Communications Optical Fiber Horizontal Cabling."

E. Electrical Receptacles: Hospital or General grade as directed. 125 V, 20 A; NEMA WD 6, Configuration 5-20R unless otherwise indicated.

1. GFCI Receptacles: As directed Feed or Non-feed-through type with integral LED indicator light.
2. SPD Receptacles: With LED indicator light and integral SPD in line to ground, line to neutral, and neutral to ground.
3. Color of Receptacles: Brown, Ivory or As selected by Architect unless otherwise indicated or required by NFPA 70.

F. USB Charger Receptacles: As directed Single, Dual or Quad, Type A, in color matching electrical receptacles.

1. Type: Hospital grade, Standard grade or Tamper resistant as directed.

G. Switches: Comply with NEMA WD 1, UL 20, and FS W-S-896.

1. Color of Switches: Brown, Ivory or as selected by Architect unless otherwise indicated or required by NFPA 70.

H. Data Communication Outlets: Two RJ-45 jacks for terminating 100-ohm, balanced, four-pair twisted-pair cabling complying with TIA-568-C.1; complying with Category 5e or Category 6 as directed. Comply with UL 1863.

I. Cover Plates: Provide satin-finish, chrome-plated or Type 304, stainless-steel cover plates with formed, beveled edges as directed.

J. Cover-Plate Identification: Use 1/4-inch (6-mm) high letters unless otherwise indicated. For stainless steel or chrome-plated metal, stamp or etch plate and fill in letters with black enamel.

1. Provide at every cover plate. At the following locations:

a. Receptacles other than standard 125-V duplex, grounding type.
b. Switches and thermal-overload switches.
c. Pilot lights when located remotely from associated equipment or switch, where function is not obvious.

d. Receptacles, switches, and other locations indicated.

2. Provide the following information:

a. Voltage and phase for receptacles other than standard 125-V duplex, grounding type.
b. Indicate equipment being controlled by switches and thermal-overload switches.
c. Indicate equipment being controlled for pilot lights when located remotely from associated equipment or switch, where function is not obvious.
d. Number of the breaker in panelboard that controls device.

K. Pedestal-Type Fittings: Cast-aluminum housings with sloped single face or two faces, as indicated, with neoprene gasket under base and with concealed mounting holes in base for attaching to laboratory casework. Provide holes tapped for conduits.

L. Line-Type Fittings: Provide with cast-metal boxes with threaded holes for mounting on rigid steel conduit. Provide cover plates same size as boxes.

M. Recessed-Type Fittings: Provide with galvanized-steel boxes.

N. Finishes for Service-Fitting Components: Provide housings or boxes for pedestal- and line-type fittings with manufacturer's standard baked-on, chemical-resistant enamel in color as selected by Architect from manufacturer's full range.

PART 3 - EXECUTION

3.1 INSTALLATION OF CABINETS

A. Comply with installation requirements in SEFA 2. Install level, plumb, and true in line; shim as required using concealed shims. Where laboratory casework abuts other finished work, apply filler strips and scribe for accurate fit, with fasteners concealed where practical.

B. Utility-Space Framing: Secure to floor with two fasteners at each frame. Fasten to partition framing, wood blocking, or metal reinforcements in partitions and to base cabinets.

C. Base Cabinets: Fasten cabinets to utility-space framing, partition framing, wood blocking, or reinforcements in partitions, with fasteners spaced not more than 16 inches (400 mm) o.c. Bolt adjacent cabinets together with joints flush, tight, and uniform.

1. Where base cabinets are installed away from walls, fasten to floor at toe space at not more than 24 inches (600 mm) o.c. and at sides of cabinets with not less than two fasteners per side.

D. Wall Cabinets: Fasten to hanging strips, masonry, partition framing, blocking, or reinforcements in partitions. Fasten each cabinet through back, near top, at not less than 16 inches (400 mm) o.c.

E. Install hardware uniformly and precisely.

F. Adjust operating hardware so doors and drawers align and operate smoothly without warp or bind and contact points meet accurately. Lubricate operating hardware as recommended by manufacturer.

3.2 INSTALLATION OF COUNTERTOPS

A. Comply with installation requirements in SEFA 2. Abut top and edge surfaces true in plane with flush hairline joints and with internal supports placed to prevent deflection. Locate joints where indicated on Shop Drawings.

B. Field Jointing: Where possible, make in same manner as shop-made joints, using dowels, splines, fasteners, adhesives, and sealants recommended by manufacturer. Shop prepare edges for field-made joints.

1. Plastic-Laminate Countertops: Secure field-made joints using concealed clamping devices located within 6 inches (150 mm) of front and back edges and at intervals not exceeding 24 inches (600 mm). Tighten according to manufacturer's written instructions to exert a uniform heavy pressure at joints.

C. Fastening:

1. Secure countertops, except for epoxy countertops, to cabinets with Z-type fasteners or equivalent, using two or more fasteners at each cabinet front, end, and back.
2. Secure epoxy countertops to cabinets with epoxy cement, applied at each corner and along perimeter edges at not more than 48 inches (1200 mm) o.c.
3. Where necessary to penetrate countertops with fasteners, countersink heads approximately 1/8 inch (3 mm) and plug hole flush with material equal to countertop in chemical resistance, hardness, and appearance.

D. Provide holes and cutouts required for service fittings.

E. Seal unfinished edges and cutouts in plastic-laminate countertops with heavy coat of polyurethane varnish.

F. Provide scribe moldings for closures at junctures of countertop, curb, and splash with walls as recommended by manufacturer for materials involved. Match materials and finish to adjacent laboratory casework. Use chemical-resistant, permanently elastic sealing compound where recommended by manufacturer.

G. Dress joints smooth, remove surface scratches, and clean entire surface.

3.3 INSTALLATION OF SINKS

A. Comply with installation requirements in SEFA 2.

B. Drop-in Installation of Epoxy Sinks: Rout groove in countertop to receive sink rim if not shop prepared. Set sink in adhesive and fill remainder of groove with sealant or adhesive. Use procedures and products recommended by sink and countertop manufacturers. Remove excess adhesive and sealant while still wet and finish joint for neat appearance.

C. Underside Installation of Epoxy Sinks: Use laboratory casework manufacturer's recommended adjustable support system for table- and cabinet-type installations. Set top edge of sink unit in sink and countertop manufacturers' recommended chemical-resistant sealing compound or adhesive, and firmly secure to produce a tight and fully leakproof joint. Adjust sink and securely support to prevent movement. Remove excess sealant or adhesive while still wet and finish joint for neat appearance.

D. Semi-flush Installation of Stainless-Steel Sinks: Before setting, apply sink and countertop manufacturers' recommended sealant under rim lip and along top. Remove excess sealant while still wet and finish joint for neat appearance.

E. Drop-in Installation of Epoxy and Polypropylene Cup Sinks: Rout groove in countertop to receive sink rim if not shop prepared. Set sink in adhesive and fill remainder of groove with sealant or adhesive. Use procedures and products recommended by sink and countertop manufacturers. Remove excess adhesive and sealant while still wet and finish joint for neat appearance.

F. Surface Installation of Epoxy and Polypropylene Cup Sinks: Set sink in sealant or adhesive. Use procedures and products recommended by sink and countertop manufacturers. Remove excess sealant or adhesive while still wet and finish joint for neat appearance.

3.4 INSTALLATION OF LABORATORY ACCESSORIES

A. Install accessories according to Shop Drawings, installation requirements in SEFA 2, and manufacturer's written instructions.

B. Securely fasten adjustable shelving supports, stainless-steel shelves, and pegboards to partition framing, wood blocking, or reinforcements in partitions.

C. Install shelf standards plumb and at heights to align shelf brackets for level shelves. Install shelving level and straight, closely fitted to other work where indicated.

D. Securely fasten pegboards to partition framing, wood blocking, or reinforcements in partitions.

3.5 INSTALLATION OF SERVICE FITTINGS

A. Comply with requirements in other Sections for installing water and laboratory gas service fittings and electrical devices.

B. Install fittings according to Shop Drawings, installation requirements in SEFA 2, and manufacturer's written instructions. Set bases and flanges of sink- and countertop-mounted fittings in sealant recommended by manufacturer of sink or countertop material. Securely anchor fittings to laboratory casework unless otherwise indicated.

3.6 CLEANING AND PROTECTING

A. Clean finished surfaces, touch up as required, and remove or refinish damaged or soiled areas to match original factory finish, as approved by Architect.

B. Protect countertop surfaces during construction with 6-mil (0.15-mm) plastic or other suitable water-resistant covering. Tape to underside of countertop at a minimum of 48 inches (1200 mm) o.c.

3.7 SERVICE-FITTING SCHEDULE

A. Water Service Fitting, Type WF-#:

1. Fitting Type: As directed Swing-spout mixing faucet, Rigid, gooseneck mixing faucet, Rigid, gooseneck, single-service faucet, Remote-control, rigid, gooseneck, single-service faucet or Single-service hose bib as directed.
2. Outlet: Aerator or Vacuum breaker and removable serrated outlet as directed.
3. Mounting: Wall, Deck or Line mounted as directed.
4. Additional Requirements: Self-closing valves or For reagent-grade water as directed.

B. Laboratory Steam Service Fitting, Type SF-#:

1. Fitting Type: Turret, Line mounted, Flange type, Remote-control turret or Remote-control flange type as directed.
2. Outlets: One, Two, at 90 degrees, Two, at 180 degrees, Three or Four as directed.
3. Outlet Type: Straight or Angled as directed.

C. Laboratory Gas Service Fitting, Type GF-#:

1. Service: Air, Gas (fuel gas) or Vacuum as directed.
2. Fitting Type: Turret, Line mounted, Flange type, Remote-control turret or Remote-control flange type as directed.
3. Outlets: One, Two, at 90 degrees, Two, at 180 degrees, Three or Four as directed.
4. Outlet Type: Straight or Angled as directed.
5. Valve Type: Ground-key cock, Ball valve or Needle valve as directed.

D. Electrical Service Fitting, Type EF-#:

1. Fitting Type: Pedestal, single faced, Pedestal, double faced, Recessed or Line mounted as directed.
2. Device: One duplex receptacle, two duplex receptacles, four duplex receptacles, one switched receptacle or one duplex receptacle, switch, and pilot light as directed.
3. Additional Requirements: GFCI or SPD receptacles as directed.

E. Communication Service Fitting, Type CF-#:

1. Fitting Type: Pedestal, single faced, Pedestal, double faced, Recessed or Line mounted as directed.
2. Device: One duplex communication receptacle or Two duplex receptacles as directed.

F. Electrical and Communication Service Fitting, Type ECF-#:

1. Fitting Type: Pedestal, single faced, Pedestal, double faced, Recessed or Line mounted as directed.

2. Device: One duplex receptacle and one duplex communication receptacle, two duplex receptacles and two duplex communication receptacles or one switched receptacle and one duplex communication receptacle as directed.
3. Additional Requirements: GFCI or SPD receptacles as directed.

END OF SECTION 123553.19

SECTION 123570 - HEALTHCARE CASEWORK

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Stainless steel healthcare casework.
2. Enameled-steel healthcare casework.
3. Specialty cabinets.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For healthcare casework. Include plans, elevations, sections, and attachments to other work, including locations of blocking and reinforcements required for installation.

C. Samples: For casework and hardware finishes.

D. Delegated-Design Submittal: For healthcare casework indicated to comply with seismic performance requirements, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Product Designations: Drawings indicate sizes and configurations of healthcare casework by referencing designated manufacturer's catalog numbers. Other manufacturers' metal healthcare casework of similar sizes, of similar door and drawer configurations, and complying with the Specifications may be considered. See Section 016000 "Product Requirements."

2.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design healthcare casework installation.

B. Seismic Performance: Healthcare casework, including attachments to other work, shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. Design earthquake spectral response acceleration, short period (Sds) for Project as directed.
2. Component Importance Factor: 1.0 or 1.5 as directed.

2.3 CASEWORK MATERIALS

A. Stainless Steel Healthcare Casework:

1. Stainless Steel Sheet: ASTM A240/A240M, Type 304, stretcher-leveled standard of flatness.
2. Nominal Stainless Steel Thicknesses:

    a. Sides, Ends, Fixed Backs, Bottoms, Cabinet Tops, Soffits, and Items Not Otherwise Indicated: 0.050 inch (1.27). Bottoms may be 0.038 inch (0.95 mm) if reinforced.
    b. Back Panels, Doors, Drawer Fronts and Bodies, and Shelves: 0.038 inch (0.95 mm) except 0.050 inch (1.27 mm) for unreinforced shelves more than 36 inches (900 mm) long.
    c. Intermediate Horizontal Rails, Center Posts, Tubular Legs, and Top Gussets: 0.062 inch (1.59 mm).
    d. Drawer Runners and Hinge Reinforcements: 0.078 inch (1.98 mm).
    e. Leveling and Corner Gussets: 0.109 inch (2.78 mm).

B. Enameled-Steel Healthcare Casework:

1. Steel Sheet: Cold-rolled commercial steel (CS) sheet, complying with ASTM A1008/A1008M; matte finish; suitable for exposed applications.
2. Nominal Steel Thicknesses:

    a. Sides, Ends, Fixed Backs, Bottoms, Cabinet Tops, Soffits, and Items Not Otherwise Indicated: 0.048 inch (1.21 mm). Bottoms may be 0.036 inch (0.91 mm) if reinforced.
    b. Back Panels, Doors, Drawer Fronts and Bodies, and Shelves: 0.036 inch (0.91 mm) except 0.048 inch (1.21 mm) for unreinforced shelves more than 36 inches (900 mm) long.
    c. Intermediate Horizontal Rails, Center Posts, and Top Gussets: 0.060 inch (1.52 mm).
    d. Drawer Runners and Hinge Reinforcements: 0.075 inch (1.90 mm).
    e. Leveling and Corner Gussets: 0.105 inch (2.66 mm).

C. Glass for Glazed Doors:

1. Float Glass: Clear float glass complying with ASTM C1036, Type I, Class 1, Quality-Q3; not less than 3.0 mm, 4.0 mm, 5.0 mm or 6.0 mm thick as directed.
2. Tempered Glass: Clear tempered glass complying with ASTM C1048, Kind FT, Condition A, Type I, Class 1, Quality-Q3; not less than 5.0 mm thick.

3. Laminated Glass: Clear laminated annealed glass complying with ASTM C1172, Kind LA, Condition A, Type I, Class I, Quality-Q3; with two plies not less than 3.0 mm thick and with clear, polyvinyl butyral interlayer.

D. Glass for Shelves: Clear tempered, ASTM C1048, Kind FT, Condition A, Type I, Class 1, Quality-Q3; 6.0 mm thick; with exposed edges seamed before tempering.

E. Hardboard Pegboard: 1/4-inch- (6.4-mm-) thick perforated hardboard, complying with ANSI A135.4, Class 1 tempered; with painted finish sealing faces, edges, and perimeter of holes.

F. Stainless Steel Pegboard: Perforated stainless steel sheet, 0.050-inch (1.27-mm) nominal thickness.

G. Sheet-Steel Pegboard: Perforated steel sheet, 0.048-inch (1.21-mm) nominal thickness, with powder-coated finish.

H. Insulation for Warming Cabinets: Semirigid, glass-fiber board insulation complying with ASTM C612, Type IA or Type IB.

I. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.4 CASEWORK HARDWARE

A. General: Provide healthcare casework manufacturer's standard, commercial-quality, heavy-duty hardware complying with requirements indicated for each type.

B. Door Hinges: As directed Stainless or Epoxy-coated-steel, five-knuckle hinges complying with BHMA A156.9, Grade 1, with antifriction bearings and hospital tips.

C. Hinged-Door and Drawer Pulls: Back-mounted pulls of solid aluminum, stainless steel, or chrome-plated brass or epoxy-coated steel as directed.

D. Sliding-Door Pulls: Recessed flush pulls of stainless steel or chrome plated or epoxy-coated steel as directed.

E. Door Catches: Nylon-roller spring catches or Dual, self-aligning, permanent magnet catches as directed. Provide two catches on doors more than 48 inches (1200 mm) high.

F. Drawer Slides: As directed Side-mounted, epoxy-coated or zinc-plated-steel, self-closing, ball-bearing drawer slides; designed to prevent rebound when drawers are closed; complying with BHMA A156.9, Type B05091.

G. Locks: Cam or half-mortise type; brass with chrome-plated finish; complying with BHMA A156.11, Type E07281, E07261, E07111, or E07021.

1. Tumbler: Disc or Five pin as directed.
2. Lock Locations: Provide where indicated or on drawers and doors as directed.
3. Keying: Key locks alike within each room, and key each room separately, each lock separately or locks as directed as directed.

a. Master key for up to 225 or 500 key changes as directed.

4. Key Quantity: Minimum of two keys per lock.
5. Master Key System: Key all locks to be operable by master key.

a. Master Keys: Provide two.

H. Sliding-Door Hardware Sets: Healthcare casework manufacturer's standard, to suit type and size of sliding-door unit.

2.5 CASEWORK FABRICATION

A. General: Assemble and finish units at point of manufacture. Use precision dies for interchangeability of like-size drawers, doors, and similar parts. Perform assembly on precision jigs to provide units that are square. Reinforce units with angles, gussets, and channels. Integrally frame and weld to form a dirt- and vermin-resistant enclosure. Maintain uniform clearance around door and drawer fronts of 1/16 to 3/32 inch (1.5 to 2.4 mm).

B. Metal Flush Doors: Outer and inner pans that nest into box formation, with full-height channel reinforcements at center of door. Fill doors with noncombustible, sound-deadening material.

C. Glazed Doors: Hollow-metal stiles and rails of similar construction as flush doors, with glass held in resilient channels or gasket material.

D. Hinged Doors: Mortise doors for hinges and reinforce with angles welded inside inner pans or hollow-metal stiles at hinge edge.

E. Metal Drawers: Fronts made from outer and inner pans that nest into box formation, with no raw metal edges at top. Sides, back, and bottom fabricated in one piece with rolled or formed top of sides for stiffening and comfortable grasp for drawer removal.

F. Metal Shelves: Front, back, and ends formed down, with edges returned horizontally at front and back to form reinforcing channels.

G. Shelf Supports: Provide clips, brackets, pilasters, or other means to support shelves from cabinet ends and to allow height of shelves to be adjusted in increments of not more than 2 inches (50 mm).

H. Sloping Tops: Unless tops are concealed by other construction, provide sloping tops on cabinets with tops 60 inches (1524 mm) or more above the finished floor. Slope tops 25 degrees or more and construct of same material and with same finish as cabinets.

I. Toe Space: Unless casework is fully recessed, provide metal toe space, fully enclosed, 4 inches (100 mm) high by 3 inches (75 mm) deep, with no open gaps or pockets.

J. Filler Strips: Provide as needed to close spaces between casework and walls, ceilings, and indicated equipment. Fabricate from same material and with same finish as casework and with hemmed or flanged edges.

K. Trim Flanges: Formed metal trim fabricated from same material and with same finish as casework. Provide at perimeter of recessed cabinets.

2.6 SPECIALTY CABINETS

A. Narcotics Cabinets: Construct of stainless steel as individual, freestanding units with finished sides and top and double-walled bottom. Provide with double-pan flush outer door and 0.062-inch- (1.59-mm-) nominal thickness, single-pan inner door, both with locks; each is individually keyed and not master keyed. Provide with stainless steel continuous hinges complying with BHMA A156.9, Grade 1.

B. Specimen Pass-Through Cabinets: Construct of stainless steel as through-wall units with double-walled construction and smooth interior. Provide with double-pan flush doors with interlocking hardware that prevents each door from being opened when the other door is open. Provide with stainless steel continuous hinges complying with BHMA A156.9, Grade 1. Provide with removable, stainless steel spill tray and trim flanges for both faces where indicated.

C. Warming Cabinets: Recessed units covered on back, top, and sides with 1-inch- (25-mm-) thick insulation. Insulate double-pan door and equip with heat-resistant gasket. Provide with thermostatically controlled heating system to maintain temperature within 10 deg F (5.5 deg C) of temperature setting that can be varied from 97 to 160 deg F (36 to 71 deg C).

1. Equip units with fan-forced electric or steam heating system.

D. Desk Units: Recessed units with sloped stainless steel writing surface, magnetic stainless steel, white marker board or tack board back panel, and built-in fluorescent light fixture as directed.

1. Provide drawers under the writing surface as indicated.
2. Provide keyboard drawer under the writing surface and provide drawers and space for desktop computer under keyboard drawer as indicated.

a. Provide rack or articulated arm for monitor over the writing surface as directed.

2.7 ENAMELED-STEEL FINISH

A. Chemical- and Physical-Resistant Finish: Finish complies with acceptance levels of casework surface finish tests in SEFA 8 M. Acceptance level for chemical spot test shall be no more than for Level 3 conditions.

1. Colors for Healthcare Casework Finish: As indicated by manufacturer's designations, Match Architect's sample or As selected by Architect from manufacturer's full range.

2.8 STAINLESS STEEL FINISH

A. Provide directional-satin finish matching No. 4 finish, with no evidence of welds and free of cross scratches. Run grain with long dimension of each piece.

PART 3 - EXECUTION

3.1 INSTALLATION OF HEALTHCARE CASEWORK

A. Install casework level, plumb, and true in line; shim as required using concealed shims. Where healthcare casework abuts other finished work, apply filler strips and scribe for accurate fit, with fasteners concealed where practical.

B. Recessed Cabinets: Set cabinets in openings and fasten to partition framing, wood blocking, or reinforcements in partitions with fasteners spaced not more than 24 inches (600 mm) o.c. Bolt adjacent cabinets together with joints flush, tight, and uniform.

C. Base Cabinets: Fasten cabinets to partition framing, wood blocking, or reinforcements in partitions with fasteners spaced not more than 16 inches (400 mm) o.c. Bolt adjacent cabinets together with joints flush, tight, and uniform.

D. Wall Cabinets: Fasten to hanging strips, masonry, partition framing, blocking, or reinforcements in partitions. Fasten each cabinet through the back, near the top, at not less than 16 inches (400 mm) o.c. unless continuously hung from hanging strips.

E. Install door and drawer hardware uniformly and precisely.

F. Adjust operating hardware so doors and drawers align and operate smoothly without warp or bind and so contact points meet accurately. Lubricate operating hardware as recommended by manufacturer.

G. Clean finished surfaces, touch up as required, and remove or refinish damaged or soiled areas to match original factory finish as approved by Architect.

END OF SECTION 123570

SECTION 123616 - METAL COUNTERTOPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Stainless-steel countertops.
2. Stainless-steel wall-mounted shelves.
3. Stainless-steel sinks.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: For metal fabrications.

1. Include plans, sections, details, and attachments to other work. Detail fabrication and installation, including field joints.
2. For countertops, show locations and sizes of cutouts and holes for items installed in metal countertops.
3. For wall-mounted shelves, indicate requirements for blocking or reinforcements in supporting construction.

PART 2 - PRODUCTS

2.1 STAINLESS-STEEL FABRICATIONS

A. Countertops: Fabricate from 0.062-inch (1.59-mm) thick, stainless-steel sheet. Provide smooth, clean exposed tops and edges in uniform plane, free of defects. Provide front and end overhang of 1 inch (25 mm) over the base cabinets.

1. Joints: Fabricate countertops without field-made joints or in sections for joining in field, with joints at locations indicated as directed.
2. Weld shop-made joints.
3. Sound deaden the undersurface with heavy-build mastic coating.
4. Extend the top down to provide a 1-inch (25-mm) thick edge with a 1/2-inch (12.7-mm) return flange.
5. Form the backsplash coved to and integral with top surface, with a 1/2-inch (12.7-mm) thick top edge and 1/2-inch (12.7-mm) return flange.
6. Provide raised (marine) edge around perimeter of tops containing sinks; pitch tops containing sinks two ways to provide drainage without channeling or grooving.

B. Wall-Mounted Shelves: Fabricate from stainless-steel sheet, not less than 0.050-inch (1.27-mm) nominal thickness. Weld shop-made joints. Fold front edge up or down a minimum of 3/4 inch (19 mm) as directed; fold back edge up a minimum of 3 inches (75 mm). Provide integral stiffening brackets, formed by folding up ends a minimum of 3/4 inch (19 mm) and by welding to upturned edges.

C. Stainless-Steel Sinks: Fabricate from stainless-steel sheet, not less than 0.050-inch (1.27-mm) nominal thickness. Fabricate with corners rounded and coved to at least 5/8-inch (16-mm) radius. Slope the sink bottoms to outlet without channeling or grooving. Provide continuous butt-welded joints.

1. Provide sizes indicated or manufacturer's closest standard size of equal or greater volume, as approved by Architect.
2. Provide double-wall construction for sink partitions with top edge rounded to at least 1/2-inch (13-mm) diameter.
3. Factory punch holes for fittings.
4. Provide sinks with stainless-steel strainers and tailpieces.
5. Factory weld sinks to stainless-steel countertops to provide one, integral unit.
6. Apply 1/8-inch (3-mm) thick coating of heat-resistant, sound-deadening mastic to under sink surfaces.

2.2 MATERIALS

A. Stainless-Steel Sheet: ASTM A240/A240M, Type 304 or Type 316L as directed.

B. Sealant for Countertops: Manufacturer's standard sealant that complies with applicable requirements in Section 079200 "Joint Sealants" and the following:

1. Mildew-Resistant Joint Sealant: Mildew resistant, single component, nonsag, neutral curing, silicone, Mildew resistant, single component, nonsag, acid curing, silicone as directed.
2. Joint Sealant: Latex or Single component, nonsag, neutral curing, silicone; Class 25 as directed.
3. Color: As directed Clear or as selected by Architect from manufacturer's full range.

2.3 STAINLESS-STEEL FINISH

A. Grind and polish surfaces to produce uniform, directional satin finish matching No. 4 finish, with no evidence of welds and free of cross scratches. Run grain with long dimension of each piece. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces clean.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install metal countertops level, plumb, and true; shim as required, using concealed shims.

B. Field Jointing: Where possible, make field jointing in the same manner as shop jointing; use fasteners recommended by manufacturer. Prepare edges to be joined in shop so Project-site processing of top and edge surfaces is not required. Locate field joints where shown on Shop Drawings.

C. Secure countertops to cabinets with Z- or L-type fasteners or equivalent; use two or more fasteners at each front, end, and back.

D. Abut top and edge surfaces in one true plane, with internal supports placed to prevent deflection.

E. Seal junctures of countertops, splashes, and walls with sealant for countertops.

F. Wall-Mounted Shelves: Fasten to supporting construction through upturned back edge at not less than 24 inches (600 mm) o.c.

1. For framed construction, fasten through wall or partition finishes directly to framing, blocking, or reinforcements.

G. Protection: Provide 6-mil (0.15-mm) plastic or other suitable water-resistant covering over countertop surfaces. Tape to underside of countertop at a minimum of 48 inches (1220 mm) o.c. Remove protection at Substantial Completion.

END OF SECTION 123616

SECTION 123619 - WOOD COUNTERTOPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Wood countertops.
2. Shop finishing of wood countertops.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: For wood countertops.

1. Apply AWI Quality Certification or WI Certified Compliance Program label to Shop Drawings as directed.

D. Samples: For each shop-applied transparent finish and for each color and wood species specified.

1.3 INFORMATIONAL SUBMITTALS

A. Product Certificates: For the following:

1. Composite wood products.
2. Adhesives.

B. Quality Standard Compliance Certificates: AWI Quality Certification Program or WI Certified Compliance Program as directed.

1.4 QUALITY ASSURANCE

A. Fabricator Qualifications: Shop that employs skilled workers who custom fabricate products similar to those required for this Project and whose products have a record of successful in-service performance.

1. Shop Certification: AWI's Quality Certification Program accredited participant or WI's Certified Compliance Program licensee as directed.

B. Installer Qualifications: As directed Fabricator of products, AWI's Quality Certification Program accredited participant or WI's Certified Compliance Program licensee as directed.

PART 2 - PRODUCTS

2.1 FABRICATORS

A. Fabricators: Subject to compliance with requirements, provide products by the following, provide products by one of the following or available fabricators offering products that may be incorporated into the Work include, but are not limited to, the following:

2.2 WOOD COUNTERTOPS

A. Quality Standard: Unless otherwise indicated, comply with the "Architectural Woodwork Standards" for grades of wood countertops indicated for construction, finishes, installation, and other requirements.

1. Provide inspections of fabrication and installation together with labels and certificates from AWI or WI certification program indicating that countertops comply with requirements of grades specified as directed.

B. Grade: As directed Premium, Custom or Economy.

C. Solid-Wood Countertops: For transparent finish. Fabricated from solid wood, edge glued, with crown direction reversed in adjacent boards, to produce widths indicated. Select boards for similarity of color and grain, arrange boards for optimum match between adjacent boards.

1. Wood Species: Red oak, White oak, White ash, White birch or as indicated on Drawings.
2. Wood Cut: Plain sawn, Rift sawn, Quarter sawn or as indicated on Drawings.

D. Butcher-Block Countertops: For transparent finish. Fabricated from narrow strips of lumber glued together and arranged for random mix of color and grain.

1. Wood Species: Red oak, Hard maple, Teak or as indicated on Drawings.
2. Strip Thickness: 3/4 inch (19 mm), 1-1/2 inches (38 mm) or as indicated on Drawings.

E. Wood-Veneer Countertops: For transparent finish. Fabricated from wood veneer laminated over panel-product core.

1. Wood Species: Red oak, White oak, White ash, White birch or as indicated on Drawings.
2. Wood Cut: Plain sawn, Rift sawn, Quarter sawn or as indicated on Drawings.
3. Matching of Adjacent Veneer Leaves: Book, Slip or Random as directed.

    a. End match leaves where countertops are longer than veneer leaves or as indicated on Drawings.

4. Veneer Matching within Panel Face: Running, Balance or Center-balance match as directed.
5. Edge Treatment: Solid wood matching face for species and cut, Wood veneer matching face for species and cut or as indicated on Drawings.
6. Core Material: Particleboard or MDF, Particleboard, MDF, Particleboard made with exterior glue, MDF made with exterior glue, Exterior-grade plywood or as selected by fabricator to comply with quality standard.

2.3 WOOD MATERIALS

A. Wood Products: Provide materials that comply with requirements of referenced quality standard for each type of wood countertop and quality grade specified unless otherwise indicated.

1. Do not use plain-sawn softwood lumber with exposed, flat surfaces more than 3 inches (75 mm) wide.
2. Wood Moisture Content: 5 to 10, 8 to 13 or 4 to 9 percent as directed.

B. Composite Wood Products: Provide materials that comply with requirements of referenced quality standard for each type of countertop and quality grade specified unless otherwise indicated.
1. MDF: Medium-density fiberboard, ANSI A208.2, Grade 130.
2. Particleboard: ANSI A208.1, Grade M-2 or Grade M-2-Exterior Glue as directed.
3. Softwood Plywood: DOC PS 1.

2.4 ACCESSORIES

A. Wire-Management Grommets: Circular, molded-plastic grommets and matching plastic caps with slot for wire passage.
1. Outside Diameter: 1-1/4 inches (32-mm) or 2 inches (51-mm) as directed.
2. Color: Brown or Black as directed.

B. Paper Slots: As directed 12 inches (305 mm) or 17 inches (432 mm) long by 1-3/4 inches (45 mm) wide by 1 inch (25 mm) deep; molded-plastic, paper-slot liner with 1/4-inch (6.4-mm) lip.

1. Color: Brown or Black as directed.

2.5 MISCELLANEOUS MATERIALS

A. Installation Adhesive:

2.6 FABRICATION

A. Fabricate wood countertops to dimensions, profiles, and details indicated. Ease edges to radius indicated for the following:

1. Solid-Wood (Lumber) Members: 1/16 inch (1.5 mm) unless otherwise indicated.
2. Edges of Members More Than 3/4 Inch (19 mm) Thick: 1/8 inch (3 mm).

B. Complete fabrication, including assembly and hardware application, to maximum extent possible before shipment to Project site. Disassemble components only as necessary for shipment and installation. Where necessary for fitting at site, provide ample allowance for scribing, trimming, and fitting.

C. Shop cut openings to maximum extent possible to receive appliances, plumbing fixtures, electrical work, and similar items. Locate openings accurately and use templates or roughing-in

diagrams to produce accurately sized and shaped openings. Sand edges of cutouts to remove splinters and burrs.

1. Seal edges of openings in countertops with a coat of varnish.

2.7 SHOP FINISHING

A. General: Finish wood countertops at fabrication shop as specified in this Section. Defer only final touchup, cleaning, and polishing until after installation.

B. Finish Materials: Use finish materials that comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

C. Shop Priming: Shop apply the prime coat including backpriming, if any, for items specified to be field finished. Refer to Section 099300 "Staining and Transparent Finishing" for material and application requirements.

D. Preparation for Finishing: Comply with referenced quality standard for sanding, filling countersunk fasteners, sealing concealed surfaces, and similar preparations for finishing wood countertops, as applicable to each unit of work.

1. Backpriming: Apply one coat of sealer or primer, compatible with finish coats, to concealed surfaces of wood countertops. Apply two coats to end-grain surfaces.

E. Transparent Finish:

1. Grade: As directed Premium, Custom, Economy or Same as item to be finished.
2. Finish: System – As directed 1, nitrocellulose lacquer, 2, precatalyzed lacquer, 3, postcatalyzed lacquer, 4, water-based latex acrylic, 5, conversion varnish, 6, synthetic penetrating oil, 7, catalyzed vinyl, 8, water-based cross linking acrylic, 9, UV-curable acrylated epoxy, polyester, or urethane, 10, water-based UV curable, 11, catalyzed polyurethane, 12, water-based polyurethane or 13, catalyzed polyester.
3. Washcoat for Closed-Grain Woods: Apply washcoat sealer to woodwork made from closed-grain wood before staining and finishing.
4. Staining: None required, match approved sample for color or Match Architect's sample as directed.
5. Open Finish for Open-Grain Woods: Do not apply filler to open-grain woods.
6. Filled Finish for Open-Grain Woods: After staining, apply washcoat sealer and allow to dry. Apply paste wood filler and wipe off excess. Tint filler to match stained wood.
7. Sheen: As directed Flat, 15-30, Satin, 31-45, Semigloss, 46-60 or Gloss, 61-100 gloss units measured on 60-degree gloss meter per ASTM D523.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Grade: Install wood countertops to comply with same grade as item to be installed.

B. Assemble wood countertops and complete fabrication at Project site to the extent that it was not completed in the shop.

C. Field Jointing: Where possible, make in the same manner as shop jointing, using dowels, splines, adhesives, and fasteners recommended by manufacturer. Prepare edges to be joined in shop so Project-site processing of top and edge surfaces is not required. Locate field joints where shown on Shop Drawings.

1. Secure field joints in countertops with concealed clamping devices located within 6 inches (150 mm) of front and back edges and at intervals not exceeding 24 inches (600 mm). Tighten according to manufacturer's written instructions to exert a constant, heavy-clamping pressure at joints.

D. Scribe and cut wood countertops to fit adjoining work, refinish cut surfaces, and repair damaged finish at cuts.

E. Countertop Installation: Anchor securely by screwing through corner blocks of base cabinets or other supports into underside of countertop.

1. Install countertops level and true in line. Use concealed shims as required to maintain not more than a 1/8-inch-in-96-inches (3-mm-in-2400-mm) variation from a straight, level plane.
2. Secure backsplashes to tops with concealed metal brackets at 16 inches (400 mm) o.c. and to walls with adhesive.
3. Seal joints between countertop and backsplash, and joints where countertop and backsplash abut walls with sealant specified in Section 079200 "Joint Sealants."

F. Shop Finishes: Touch up finishing after installation of wood countertops.

1. Apply specified finish coats, including stains and paste fillers if any, to exposed surfaces where only sealer/prime coats are shop applied.

G. Field Finishing: See Section 099123 "Interior Painting" and Section 099300 "Staining and Transparent Finishing" for finishing installed wood countertops.

H. Protection: Provide Kraft paper or other suitable covering over countertop surfaces, taped to underside of countertop at a minimum of 48 inches (1220 mm) o.c. Remove protection at Substantial Completion.

END OF SECTION 123619

SECTION 123623.13 - PLASTIC-LAMINATE-CLAD COUNTERTOPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes plastic-laminate-clad countertops.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: For plastic-laminate-clad countertops.

1. Apply AWI Quality Certification or WI Certified Compliance Program label to Shop Drawings as directed.

D. Samples: Plastic laminates in each type, color, pattern, and surface finish required.

1.3 INFORMATIONAL SUBMITTALS

A. Product Certificates: For the following:

1. Composite wood products.
2. High-pressure decorative laminate.
3. Adhesives.

B. Quality Standard Compliance Certificates: AWI Quality Certification Program or WI Certified Compliance Program as directed.

1.4 QUALITY ASSURANCE

A. Fabricator Qualifications: Shop that employs skilled workers who custom fabricate products similar to those required for this Project and whose products have a record of successful in-service performance.

1. Shop Certification: AWI's Quality Certification Program accredited participant or WI's Certified Compliance Program licensee as directed.

B. Installer Qualifications: Fabricator of products or AWI's Quality Certification Program accredited participant WI's Certified Compliance Program licensee as directed.

PART 2 - PRODUCTS

2.1 FABRICATORS

A. Fabricators: Subject to compliance with requirements:

1. Insert, in separate subparagraphs, names and contact information for preapproved woodworking firms as directed.

2.2 PLASTIC-LAMINATE-CLAD COUNTERTOPS

A. Quality Standard: Unless otherwise indicated, comply with the "Architectural Woodwork Standards" for grades of plastic-laminate-clad countertops indicated for construction, finishes, installation, and other requirements.

1. Provide inspections of fabrication and installation together with labels and certificates from AWI or WI certification program as directed indicating that countertops comply with requirements of grades specified.

B. Grade: As directed.

C. High-Pressure Decorative Laminate: NEMA LD 3, as directed.

D. Colors, Patterns, and Finishes: Provide materials and products that result in colors and textures of exposed laminate surfaces complying with the following requirements:

1. As indicated by manufacturer's designations.
2. Match Architect's sample.
3. As selected by Architect from manufacturer's full range in the following categories:

a. Solid colors, gloss or matte finish as directed.
b. Solid colors with core same color as surface, gloss or matte finish as directed.
c. Wood grains, gloss or matte finish with grain running parallel to length of countertop as directed.
d. Patterns, gloss or matte finish as directed.

E. Edge Treatment: As directed.

F. Core Material: As directed.

G. Core Material at Sinks: Particleboard made with exterior glue, MDF made with exterior glue or exterior-grade plywood as directed.

H. Core Thickness: 3/4 inch (19 mm) or 1-1/8 inch (29 mm) as directed.

1. Build up countertop thickness to 1-1/2 inches (38 mm) at front, back, and ends with additional layers of core material laminated to top.

I. Backer Sheet: Provide plastic-laminate backer sheet, NEMA LD 3, Grade BKL, on underside of countertop substrate.

J. Paper Backing: Provide paper backing on underside of countertop substrate.

2.3 WOOD MATERIALS

A. Wood Products: Provide materials that comply with requirements of referenced quality standard unless otherwise indicated.

1. Wood Moisture Content: Percent as directed.

B. Composite Wood Products: Provide materials that comply with requirements of referenced quality standard for each type of countertop and quality grade specified unless otherwise indicated.
1. MDF: Medium-density fiberboard, ANSI A208.2, Grade 130 as directed.
2. Particleboard: ANSI A208.1, Grade M-2 or Grade M-2-Exterior Glue as directed.
3. Softwood Plywood: DOC PS 1.

2.4 ACCESSORIES

A. Wire-Management Grommets: Circular, molded-plastic grommets and matching plastic caps with slot for wire passage.
1. Outside Diameter: 1-1/4 inch (32 mm) or 2 inches (51 mm) as directed.
2. Color: Brown or Black as directed,

B. Paper Slots: 12 inches (305 mm) or 17 inches (432 mm) long as directed by 1-3/4 inches (45 mm) wide by 1 inch (25 mm) deep; molded-plastic, paper-slot liner with 1/4-inch (6.4-mm) lip.

1. Color: Brown or Black as directed.

2.5 MISCELLANEOUS MATERIALS

A. Adhesive for Bonding Plastic Laminate: As directed.

1. Adhesive for Bonding Edges: Hot-melt adhesive or adhesive specified above for faces.

B. Installation Adhesive:

2.6 FABRICATION

A. Fabricate countertops to dimensions, profiles, and details indicated. Provide front and end overhang of 1 inch (25 mm) over base cabinets. Ease edges to radius indicated for the following:

1. Solid-Wood (Lumber) Members: 1/16 inch (1.5 mm) unless otherwise indicated.

B. Complete fabrication, including assembly, to maximum extent possible before shipment to Project site. Disassemble components only as necessary for shipment and installation. Where necessary for fitting at site, provide ample allowance for scribing, trimming, and fitting.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Grade: Install countertops to comply with same grade as item to be installed.

B. Assemble countertops and complete fabrication at Project site to the extent that it was not completed in the shop.

1. Provide cutouts for appliances, plumbing fixtures, electrical work, and similar items. Locate openings accurately, use templates or roughing-in diagrams to produce accurately sized and shaped openings. Sand edges of cutouts to remove splinters and burrs.
2. Seal edges of cutouts by saturating with varnish.

C. Field Jointing: Where possible, make in the same manner as shop jointing, using dowels, splines, adhesives, and fasteners recommended by manufacturer. Prepare edges to be joined in shop so Project-site processing of top and edge surfaces is not required. Locate field joints where shown on Shop Drawings.

1. Secure field joints in countertops with concealed clamping devices located within 6 inches (150 mm) of front and back edges and at intervals not exceeding 24 inches (600 mm). Tighten according to manufacturer's written instructions to exert a constant, heavy-clamping pressure at joints.

D. Scribe and cut countertops to fit adjoining work, refinish cut surfaces, and repair damaged finish at cuts.

E. Countertop Installation: Anchor securely by screwing through corner blocks of base cabinets or other supports into underside of countertop.

1. Install countertops level and true in line. Use concealed shims as required to maintain not more than a 1/8-inch-in-96-inches (3-mm-in-2400-mm) variation from a straight, level plane.
2. Secure backsplashes to tops with concealed metal brackets at 16 inches (400 mm) o.c. and to walls with adhesive.
3. Seal joints between countertop and backsplash, if any, and joints where countertop and backsplash abut walls with mildew-resistant silicone sealant or another permanently elastic sealing compound recommended by countertop material manufacturer.

F. Protection: Provide Kraft paper or other suitable covering over countertop surfaces, taped to underside of countertop at a minimum of 48 inches (1220 mm) o.c. Remove protection at Substantial Completion.

END OF SECTION 123623.13

SECTION 123640 - STONE COUNTERTOPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes stone countertops.

1.2 ACTION SUBMITTALS

A. Product Data: For each variety of stone, stone accessory and manufactured product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: Include plans, sections, details, and attachments to other work.

D. Samples: For each stone type indicated.

1.3 QUALITY ASSURANCE

A. Installer Qualifications: Fabricator of stone countertops.

1.4 FIELD CONDITIONS

A. Field Measurements: Verify dimensions of construction to receive stone countertops by field measurements before fabrication and indicate measurements on Shop Drawings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations for Stone: Obtain each variety of stone, regardless of finish, from a single quarry, whether specified in this Section or in another Specification Section, with resources to provide materials of consistent quality in appearance and physical properties.

1. Make stone slabs available for examination by Architect.

2.2 GRANITE

A. Material Standard: Comply with ASTM C615/C615M.

B. Varieties and Sources: Subject to compliance with requirements, as directed:

C. Finish: As directed

2.3 MARBLE

A. Material Standard: Comply with ASTM C503/C503M, as directed.

B. Varieties and Sources: Subject to compliance with requirements, as directed:

C. Finish: As directed.

2.4 SERPENTINE

A. Material Standard: Comply with ASTM C1526, Classification I Exterior, Classification II Interior as directed.

B. Varieties and Sources: Subject to compliance with requirements, as directed:

C. Finish: Polished or Honed as directed.

2.5 SLATE

A. Material Standard: Comply with ASTM C629/C629M, Classification I Exterior, Classification II Interior.

B. Varieties and Sources: Subject to compliance with requirements, as directed:

C. Finish: As directed

2.6 OTHER STONE

A. Varieties and Sources: Subject to compliance with requirements, as directed:

B. Finish: As directed.

2.7 ADHESIVES, GROUT, SEALANTS, AND STONE ACCESSORIES

A. General: Use only adhesives formulated for stone and ceramic tile and that are recommended by their manufacturer for the application indicated.

B. Water-Cleanable Epoxy Adhesive: ANSI A118.3.

C. Water-Cleanable Epoxy Grout: ANSI A118.3, chemical-resistant, water-cleanable, tile-setting and -grouting epoxy.

D. Sealant for Countertops: Manufacturer's standard sealant that complies with applicable requirements in Section 079200 "Joint Sealants" and that will not stain the stone it is applied to.

1. Mildew-Resistant Joint Sealant: Mildew resistant, single component, nonsag, neutral curing, silicone or Single component, nonsag, mildew resistant, acid curing, silicone as directed.
2. Joint Sealant: Latex or Single component, nonsag, neutral curing, silicone; Class 25 as directed.
3. Color: Clear or As selected by Architect from manufacturer's full range.

E. Particleboard Subtops: ANSI A208.1, Grade M-2 or Grade M-2-Exterior Glue as directed.

F. Plywood Subtops: Exterior softwood plywood complying with DOC PS 1, Grade C-C Plugged, touch sanded.

G. Stone Sealer: Colorless, stain-resistant sealer that does not affect color or physical properties of stone surfaces, as recommended by stone producer for application indicated.

2.8 STONE FABRICATION, GENERAL

A. Select stone for intended use to prevent fabricated units from containing cracks, seams, and starts that may impair structural integrity, function, or appearance.

B. Fabricate stone countertops in sizes and shapes required to comply with requirements indicated.

1. Dress joints straight and at right angle to face unless otherwise indicated.
2. Fabricate molded edges with machines having abrasive shaping wheels made to reverse contour of edge profile to produce uniform shape throughout entire length of edge and with precisely formed arris slightly eased to prevent snipping, and matched at joints between units. Form corners of molded edges as indicated with outside corners slightly eased unless otherwise indicated.
3. Finish exposed faces of stone to comply with requirements indicated for finish of each stone type required and to match approved Samples and mockups. Provide matching finish on exposed edges of countertops, splashes, and cutouts.

2.9 STONE COUNTERTOPS

A. General: Comply with recommendations in MIA's "Dimension Stone - Design Manual VII."

B. Nominal Thickness: Provide thickness indicated, but not less than 3/4 inch (20 mm) or 7/8 inch (22 mm) or 1-1/4 inches (32 mm) as directed. Gage backs to provide units of identical thickness.

C. Splashes: Provide 3/4-inch- (20-mm-) thick backsplashes and end splashes unless otherwise indicated.

D. Joints: Fabricate countertops without joints.

E. Joints: Fabricate countertops in sections for joining in field, with joints at locations indicated.

F. Cutouts and Holes:

1. Undercounter Fixtures: Make cutouts for undercounter fixtures in shop using template or pattern furnished by fixture manufacturer. Form cutouts to smooth, even curves.
2. Counter-Mounted Fixtures: Prepare countertops in shop for field cutting openings for counter-mounted fixtures. Mark tops for cutouts and drill holes at corners of cutout locations. Make corner holes of largest radius practical.
3. Fittings: Drill countertops in shop for plumbing fittings, undercounter soap dispensers, and similar items.

PART 3 - EXECUTION

3.1 INSTALLATION OF COUNTERTOPS

A. Install countertops over subtops with full spread of water-cleanable epoxy adhesive.

B. Install countertops by adhering to supports with water-cleanable epoxy adhesive.

C. Set stone to comply with requirements indicated. Shim and adjust stone to locations indicated, with uniform joints of widths indicated and with edges and faces aligned according to established relationships.

D. Space joints with 1/16-inch (1.5-mm) gap for filling with grout or sealant as directed. Use temporary shims to ensure uniform spacing.

1. Clamp units to temporary bracing, supports, or each other to ensure that countertops are properly aligned and joints are of specified width.

E. Complete cutouts not finished in shop. Mask areas of countertops adjacent to cutouts to prevent damage while cutting. Use power saws with diamond blades to cut stone. Make cutouts to accurately fit items to be installed, and at right angles to finished surfaces unless beveling is required for clearance. Ease edges slightly to prevent snipping.

F. Install backsplashes and end splashes by adhering to wall with water-cleanable epoxy adhesive. Leave 1/16-inch (1.5-mm) gap between countertop and splashes for filling with sealant. Use temporary shims to ensure uniform spacing.

G. Grout joints to comply with ANSI A108.10. Remove temporary shims before grouting. Tool grout uniformly and smoothly with plastic tool.

H. Apply sealant to joints and gaps specified for filling with sealant; comply with Section 079200 "Joint Sealants." Remove temporary shims before applying sealant.

3.2 ADJUSTING AND CLEANING

A. In-Progress Cleaning: Clean countertops as work progresses. Remove adhesive, grout, mortar, and sealant smears immediately.

B. Clean stone countertops no fewer than six days after completion of sealant installation or installation as directed, using clean water and soft rags. Do not use wire brushes, acid-type

cleaning agents, cleaning compounds with caustic or harsh fillers, or other materials or methods that may damage stone.

C. Sealer Application: Apply stone sealer to comply with stone producer's and sealer manufacturer's written instructions.

END OF SECTION 123640

SECTION 123661.13 - CULTURED MARBLE COUNTERTOPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cultured marble countertops.
2. Integral sinks.
3. Integral backsplashes.
4. Integral end splashes.
5. Loose end splashes.

1.2 ACTION SUBMITTALS

A. Product Data: For countertop materials.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: For countertops. Show materials, finishes, edge and backsplash profiles, integral sinks, and methods of joining.

D. Samples: For each type of material exposed to view.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 CULTURED MARBLE COUNTERTOPS

A. Cultured Marble: Gel-coated solid fabrication of filled plastic resin complying with CSA B45.5/IAPMO Z124.

1. Colors and Patterns: As directed.

B. Configuration: One-piece units with integral sink bowls and backsplashes unless otherwise indicated, not less than 1/2 inch (12.7 mm) thick.

1. Front: As directed.
2. Backsplash: As directed.
3. End Splash: Matching backsplash or none as directed.

2.3 INSTALLATION MATERIALS

A. Adhesive: Product recommended by cultured marble manufacturer.

B. Sealant for Countertops: Comply with applicable requirements in Section 079200 "Joint Sealants."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Fasten countertops by screwing through corner blocks of base units into underside of countertop. Predrill holes for screws as recommended by manufacturer.

B. Install aprons to backing and countertops with adhesive. Fasten by screwing through backing. Predrill holes for screws as recommended by manufacturer.

C. Apply sealant to gaps at walls; comply with Section 079200 "Joint Sealants."

END OF SECTION 123661.13

SECTION 123661.16 - SOLID SURFACING COUNTERTOPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Solid surface material countertops.
2. Solid surface material backsplashes.
3. Solid surface material end splashes.
4. Solid surface material apron fronts.
5. Solid surface material sinks.

1.2 ACTION SUBMITTALS

A. Product Data: For countertop materials and sinks.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: For countertops. Show materials, finishes, edge and backsplash profiles, methods of joining, and cutouts for plumbing fixtures.

D. Samples: For each type of material exposed to view.

PART 2 - PRODUCTS

2.1 SOLID SURFACE COUNTERTOP MATERIALS

A. Solid Surface Material: Homogeneous-filled plastic resin complying with ICPA SS-1.
1. Type: Provide Standard type or Veneer type made from material complying with requirements for Standard type, as indicated unless Special Purpose type is indicated.
2. Integral Sink Bowls: Comply with CSA B45.5/IAPMO Z124.
3. Colors and Patterns: As directed.

B. Solid Wood Edges and Trim: As directed clear lumber, free of defects, selected for compatible grain and color, and kiln dried to 7 percent moisture content.

C. Particleboard: ANSI A208.1, Grade M-2 or Grade M-2-Exterior Glue as directed.

D. Plywood: Exterior softwood plywood complying with DOC PS 1, Grade C-C Plugged, touch sanded.

2.2 COUNTERTOP FABRICATION

A. Fabricate countertops according to solid surface material manufacturer's written instructions and to the AWI/AWMAC/WI's "Architectural Woodwork Standards."

1. Grade: As directed.

B. Configuration:

1. Front: As directed.
2. Backsplash: As directed.
3. End Splash: Matching backsplash or None as directed.

C. Countertops: 1/2-inch (12.7-mm) or 3/4-inch (19-mm) thick as directed, solid surface material with wood-trimmed edges or with front edge built up with same material as directed.

D. Countertops: 1/4-inch (6.4-mm) thick, solid surface material laminated to 3/4-inch (19-mm) thick particleboard as directed.

E. Backsplashes: 1/2-inch (12.7-mm) or 3/4-inch (19-mm) thick as directed, solid surface material with wood-trimmed edges.

F. Joints: Fabricate countertops without joints.

G. Joints: Fabricate countertops in sections for joining in field, with joints at locations indicated.

H. Cutouts and Holes:

1. Undercounter Plumbing Fixtures: Make cutouts for fixtures in shop using template or pattern furnished by fixture manufacturer. Form cutouts to smooth, even curves.

2.3 INSTALLATION MATERIALS

A. Adhesive: Product recommended by solid surface material manufacturer.

B. Sealant for Countertops: Comply with applicable requirements in Section 079200 "Joint Sealants."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Fasten countertops by screwing through corner blocks of base units into underside of countertop. Predrill holes for screws as recommended by manufacturer.

B. Fasten subtops to cabinets by screwing through subtops into cornerblocks of base cabinets. Shim as needed to align subtops in a level plane.

C. Secure countertops to subtops with adhesive according to solid surface material manufacturer's written instructions.

D. Bond joints with adhesive and draw tight as countertops are set. Mask areas of countertops adjacent to joints to prevent adhesive smears.

E. Install backsplashes and end splashes by adhering to wall and countertops with adhesive.

F. Install aprons to backing and countertops with adhesive.

G. Complete cutouts not finished in shop. Mask areas of countertops adjacent to cutouts to prevent damage while cutting. Make cutouts to accurately fit items to be installed, and at right angles to finished surfaces unless beveling is required for clearance. Ease edges slightly to prevent snipping.

H. Apply sealant to gaps at walls; comply with Section 079200 "Joint Sealants."

END OF SECTION 123661.16

SECTION 123661.19 - QUARTZ AGGLOMERATE COUNTERTOPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Quartz agglomerate countertops.
2. Quartz agglomerate backsplashes.
3. Quartz agglomerate end splashes.
4. Quartz agglomerate apron fronts.

1.2 ACTION SUBMITTALS

A. Product Data: For countertop materials.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: For countertops. Show materials, finishes, edge and backsplash profiles, methods of joining, and cutouts for plumbing fixtures.

D. Samples: For each type of material exposed to view.

PART 2 - PRODUCTS

2.1 QUARTZ AGGLOMERATE COUNTERTOP MATERIALS

A. Quartz Agglomerate: Solid sheets consisting of quartz aggregates bound together with a matrix of filled plastic resin and complying with ICPA SS-1, except for composition.
1. Colors and Patterns: As directed.

B. Solid Wood Edges and Trim: Lumber, free of defects, selected for compatible grain and color, and kiln dried to 7 percent moisture content as directed.

C. Particleboard: ANSI A208.1, Grade M-2 or Grade M-2-Exterior Glue as directed.

D. Plywood: Exterior softwood plywood complying with DOC PS 1, Grade C-C Plugged, touch sanded.

2.2 COUNTERTOP FABRICATION

A. Fabricate countertops according to quartz agglomerate manufacturer's written instructions and the AWI/AWMAC/WI's "Architectural Woodwork Standards."

1. Grade: As directed.

B. Configuration:

1. Front: As directed.
2. Backsplash: As directed.
3. End Splash: Matching backsplash or None as directed.

C. Countertops: 1/2-inch (12.7-mm) or 3/4-inch (19-mm) thick as directed, quartz agglomerate with wood-trimmed edges or with front edge built up with same material as directed.

D. Backsplashes: 1/2-inch (12.7-mm) or 3/4-inch (19-mm) thick as directed, quartz agglomerate with wood-trimmed edges.

E. Joints: Fabricate countertops without joints.

F. Joints: Fabricate countertops in sections for joining in field, with joints at locations indicated.

G. Cutouts and Holes:

1. Undercounter Plumbing Fixtures: Make cutouts for fixtures in shop using template or pattern furnished by fixture manufacturer. Form cutouts to smooth, even curves.

2.3 INSTALLATION MATERIALS

A. Adhesive: Product recommended by quartz agglomerate manufacturer.

B. Sealant for Countertops: Comply with applicable requirements in Section 079200 "Joint Sealants."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Fasten countertops by screwing through corner blocks of base units into underside of countertop. Predrill holes for screws as recommended by manufacturer.

B. Fasten subtops to cabinets by screwing through subtops into cornerblocks of base cabinets. Shim as needed to align subtops in a level plane.

C. Secure countertops to subtops with adhesive according to quartz agglomerate manufacturer's written instructions.

D. Bond joints with adhesive and draw tight as countertops are set. Mask areas of countertops adjacent to joints to prevent adhesive smears.

E. Install backsplashes and end splashes by adhering to wall and countertops with adhesive.

F. Install aprons to backing and countertops with adhesive.

G. Complete cutouts not finished in shop. Mask areas of countertops adjacent to cutouts to prevent damage while cutting. Make cutouts to accurately fit items to be installed, and at right angles to finished surfaces unless beveling is required for clearance. Ease edges slightly to prevent snipping.

H. Apply sealant to gaps at walls; comply with Section 079200 "Joint Sealants."

END OF SECTION 123661.19

SECTION 124813 - ENTRANCE FLOOR MATS AND FRAMES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Roll-up rail mats.
2. Resilient entrance mats.
3. Recessed or Surface-mounted frames as directed.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Items penetrating floor mats and frames, including door control devices.
2. Divisions between mat sections.
3. Perimeter floor moldings and frames.
4. Custom Graphics: Scale drawing indicating colors.

C. Samples: For each exposed product and for each color and texture specified.

1.3 CLOSEOUT SUBMITTALS

A. Maintenance data.

PART 2 - PRODUCTS

2.1 ENTRANCE FLOOR MATS AND FRAMES, GENERAL

A. Accessibility Standard: Comply with applicable provisions in the DOJ's "2010 ADA Standards for Accessible Design" and ICC A117.1.

2.2 ROLL-UP RAIL MATS

A. Roll-up, Aluminum-Rail Hinged Mats: Extruded-aluminum tread rails 1-1/2 inches (38 mm) or 2 inches (50 mm) wide as directed by 3/8 inch (9.5 mm) thick, sitting on continuous vinyl cushions.

1. Tread Inserts: As directed.
2. Colors, Textures, and Patterns of Inserts: As directed.

3. Rail Color: As directed.
4. Hinges: Plastic or Aluminum as directed.
5. Mat Size: As indicated.

B. Roll-up, Vinyl-Rail Hinged Mats: Vinyl-acrylic tread rails 1-1/2 inches (38 mm) or 2 inches (50 mm) wide as directed by 3/8 inch (9.5 mm) thick, with slotted or perforated hinges.

1. Tread Inserts: As directed.
2. Colors, Textures, and Patterns of Inserts: As directed.
3. Rail Color: As directed.
4. Hinges: Vinyl or Aluminum as directed.
5. Mat Size: As indicated.

2.3 RESILIENT ENTRANCE MATS

A. Resilient Link Mats: As directed reversible link mats, 3/8 inch (9.5 mm) or 7/16 inch (11 mm) thick, with galvanized-spring or stainless-steel wire link rods as directed, vulcanized edge-nosing trim, steel-reinforced end trim, and links consisting of rectangular units or continuous strips as directed.

1. Color: As directed.
2. Mat Size: As indicated.

B. Rubber or Vinyl Mats: As directed thick mats; with square edges for recessed installations or beveled edges for surface applications as directed and with top profile as directed, and bottom surface as directed.

1. Color: As directed.
2. Mat Size: As indicated.

C. Cocoa Mats: Constructed from cocoa fiber yarn permanently bonded to PVC backing for dimensional stability and resistance to shedding; weight as directed.

1. Color: As directed.
2. Mat Size: As indicated.

D. Rubber-Tire Mats: Units of edge-grain-laminated and chenille-buffed, rubber-tire wall cuts; bonded to sheet rubber or other durable flexible backing sheet to form 3/8- to 7/16-inch- (9.5- to 11-mm-) thick, 12-inch- (300-mm-) wide, continuous linear strip up to 25 feet (7.6 m) long.

1. Mat Size: As indicated.

E. Carpet-Type Mats: Carpet bonded as directed to 1/8- to 1/4-inch- (3.2- to 6.4-mm-) thick, flexible vinyl backing to form mats 3/8 or 7/16 inch (9.5 or 11 mm) thick with non-raveling edges.

1. Colors, Textures, and Patterns: As directed.
2. Mat Size: As indicated.

F. Graphics: Custom inlaid or woven-in graphic as indicated.

2.4 FRAMES

A. Recessed Frames: Manufacturer's standard extrusion.

1. Extruded Aluminum: ASTM B221 (ASTM B221M).

a. Color: As directed.

B. Surface-Mounted Frames:

1. Tapered Frames: Tapered flexible vinyl edge- or aluminum frame members as directed, not less than 2 inches (50 mm) or 1-1/2 inches (38 mm) wide as directed, attached to mat at all four edges, with welded mitered corners.

a. Vinyl Color: As directed.
b. Aluminum Color: As directed.

2.5 FABRICATION

A. Floor Mats: Shop fabricate units to greatest extent possible in sizes indicated. Unless otherwise indicated, provide single unit for each mat installation; do not exceed manufacturer's recommended maximum sizes for units that are removed for maintenance and cleaning. Where joints in mats are necessary, space symmetrically and away from normal traffic lanes. Miter corner joints in framing elements with hairline joints or provide prefabricated corner units without joints.

B. Coat concealed surfaces of aluminum frames that contact cementitious material with manufacturer's standard protective coating.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install recessed mat frames and mats to comply with manufacturer's written instructions so that tops of mats will be flush with adjoining finished flooring. Set mats with tops at height recommended by manufacturer for most effective cleaning action; coordinate tops of mat surfaces with bottoms of doors that swing across mats to provide clearance between door and mat.

B. Install surface-type units to comply with manufacturer's written instructions; coordinate with entrance locations and traffic patterns.

3.2 PROTECTION

A. After completing frame installation and concrete work, provide temporary filler of plywood or fiberboard in recesses and cover frames with plywood protective flooring. Maintain protection until construction traffic has ended and Project is near Substantial Completion.

END OF SECTION 124813

SECTION 124816 - ENTRANCE FLOOR GRILLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes recessed floor grilles and frames.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Items penetrating floor grilles and frames, including door control devices.
2. Divisions between grille sections.
3. Perimeter floor moldings.

C. Samples: For each exposed product and for each color and texture specified.

1.3 CLOSEOUT SUBMITTALS

A. Maintenance data.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 ENTRANCE FLOOR GRILLES, GENERAL

A. Accessibility Standard: Comply with applicable provisions in the DOJ's "2010 ADA Standards for Accessible Design" and ICC A117.1.

2.3 FLOOR GRILLES

A. Aluminum Floor Grilles: Provide manufacturer's standard floor grilles with extruded members, top-surfaced tread rails, and as follows:

1. Aluminum Color: Mill finish, Clear, Light bronze, Medium bronze, Dark bronze, Black, Match Architect's sample or as selected by Architect from full range of industry colors and color densities.

2. Tread Rail Spacing: 1-1/2 inches (38 mm) o.c. with 1/8- to 3/16-inch- (3.2- to 4.8-mm-) or 2 inches (50 mm) o.c. with 1/4-inch (6.4-mm) wide openings between treads as directed.
3. Top Surface: Serrated aluminum, Serrated vinyl cap with UV stabilizer and antifungal additive, Textured-surface, resilient vinyl insert, Aluminum-oxide or silicon-carbide grit in epoxy matrix, Abrasive particles bonded to or imbedded in vinyl insert or Fusion-bonded, level-cut-pile nylon carpet insert; 1/4 inch (6.4 mm) high, 28 oz./sq. yd. (950 g/sq. m) as directed.

    a. Top Surface Color: Match tread rail, as indicated by manufacturer's designations, Match Architect's sample or as selected by Architect from manufacturer's full range of industry colors.

4. Grille Size: As indicated.

B. Stainless-Steel Floor Grille: Type 304.

1. Surface Treads: 0.071-by-0.177-inch (1.8-by-4.49-mm) wire with 0.125-inch- (3.17-mm-), 0.090-by-0.172-inch (2.2-by-4.37-mm) wire with 0.145-inch- (3.68-mm-) or 0.093-by-0.156-inch (2.36-by-3.96-mm) wire with 0.125-inch- (3.17-mm-) wide openings between wires as directed.
2. Support Rods: Spaced 1 inch (25.4 mm) o.c., welded to each wire.
3. Mat Grating: 5/8 inch (15.8 mm) deep.
4. Pit Grating: 1-1/8 inches (28.5 mm) deep.
5. Stainless-Steel Finish: Mill or No. 4 as directed.
6. Grille Size: As indicated.

C. Lockdown: Manufacturer's standard, hidden or in view as directed.

2.4 FRAMES

A. Provide manufacturer's standard frames of size and style for grille type.

2.5 SUPPORT SYSTEM

A. Level Bed Applications: Provide manufacturer's standard, vinyl cushion support system.

B. Drainage Pit Applications: Provide manufacturer's special deep-pit frame and support extrusion system with intermediate support beams, sized and spaced as recommended by manufacturer for indicated spans and equipped with vinyl support cushions.

2.6 DRAIN PANS

A. As directed Provide manufacturer's standard, 0.060-inch (1.52-mm) thick, metallic-coated steel, aluminum or stainless-steel sheet drain pan with NPS 2 (DN 50) drain outlet for each floor-grille unit. Coat bottom of pan with protective coating recommended by manufacturer.

2.7 MATERIALS

A. Metallic-Coated Steel Sheet: ASTM A653/A653M, Commercial Steel (CS), Type B.

B. Stainless-Steel Sheet, Strip, Plate, and Flat Bars: ASTM A666, Type 304.

C. Stainless-Steel Angles: ASTM A276 or ASTM A479/A479M, Type 304.

D. Aluminum Sheet: ASTM B209 (ASTM B209M).

E. Extruded Aluminum: ASTM B221 (ASTM B221M).

2.8 FABRICATION

A. Shop fabricate floor grilles to greatest extent possible in sizes as indicated.

B. Fabricate frame members in single lengths or, where frame dimensions exceed maximum available lengths, provide minimum number of pieces possible.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install recessed floor grilles and frames and drain pans to comply with manufacturer's written instructions at locations indicated and with top of floor grilles and frames in relationship to one another and to adjoining finished flooring as recommended by manufacturer. Set floor-grille tops at height for most effective cleaning action. Coordinate top of floor-grille surfaces with doors that swing across grilles to provide clearance under door.

3.2 PROTECTION

A. After completing frame installations, provide temporary filler of plywood or fiberboard in floor-grille recesses and cover frames with plywood protective flooring. Maintain protection until construction traffic has ended and Project is near Substantial Completion.

END OF SECTION 124816

SECTION 125500 - DETENTION FURNITURE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Detention bunks.
2. Detention mattresses.
3. Detention desks.
4. Detention tables.
5. Detention seating.

1.2 COORDINATION

A. Detention Specialist: Coordinate with Section 013513.16 "Special Project Procedures for Detention Facilities" for requirements of this Section that are to be performed by a Detention Specialist or other entity.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

C. Shop Drawings: Include plans, elevations, sections, and attachment details.

D. Samples: For factory-applied color finishes.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Anchor inspection reports.

C. Field quality-control reports.

1. Field quality-control certification, signed by Contractor and Detention Specialist.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.7 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."
3. AWS D1.6/D1.6M, "Structural Welding Code - Stainless Steel."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

2.2 DETENTION BUNKS

A. Freestanding Single Bunks:
1. Bunk Pan: As directed Formed from 0.134-inch (3.42-mm) or 0.105-inch (2.66-mm) nominal-thickness steel sheet, perforated with at least six holes.
    a. Size: Minimum 27 inches (689 mm) wide by 76 inches (1930 mm) long with bunk pan 14 inches (356 mm) above floor.
    b. Edges: As directed Turn up edges of back and sides and turn down edge of front or back, sides, and front, with minimum 2-inch (51-mm) flanges.
2. Drawer: As directed Minimum 21 inches (533 mm) wide by 24 inches (610 mm) deep by 5 inches (127 mm) high, with full-width integral pull formed from steel sheet or solid-steel bar pull; formed from 0.134-inch (3.42-mm) nominal-thickness steel sheet.
3. Legs and Frames: Formed from 2-by-2-by-3/16-inch (51-by-51-by-4.8-mm) steel angle welded at connections to each other and to bunk pan; provide four legs for each bunk.
4. Mounting Plates: Formed from 1/4-inch- (6-mm-) thick, steel plate punched with one hole for floor anchorage; provide one mounting plate for each leg.

B. Freestanding Double Bunks:
1. Bunk Pan: As directed Formed from 0.134-inch (3.42-mm) or 0.105-inch (2.66-mm) nominal-thickness steel sheet, each pan perforated with at least six holes.
    a. Size: Minimum 27 inches (689 mm) wide by 76 inches (1930 mm) long with lower bunk pan 14 inches (356 mm) above floor and upper bunk pan at least 49 inches (1245 mm) above floor.
    b. Upper Bunk Edges: Turn up edges of back and sides and turn down edge of front, with minimum 2-inch (51-mm) flanges.
    c. Lower Bunk Edges: As directed Turn up edges of back and sides and turn down edge of front or back, sides, and front, with minimum 2-inch (51-mm) flanges.

2. Drawers: Two; minimum 21 inches (533 mm) wide by 24 inches (610 mm) deep by 5 inches (127 mm) high, with full-width integral pull formed from steel sheet or solid-steel bar pull; formed from 0.134-inch (3.42-mm) nominal-thickness steel sheet.
3. Legs and Frames: Formed from 2-by-2-by-3/16-inch (51-by-51-by-4.8-mm) steel angle welded at connections to each other and to bunk pan; provide four legs for each bunk.
4. Mounting Plates: Formed from 1/4-inch- (6-mm-) thick, steel plate punched with one hole for floor anchorage; provide one mounting plate for each leg.
5. Assembly: Factory assembled or Knocked down for field assembly as directed.

C. Wall-Mounted Bunks:
1. Bunk Pan: Formed from 0.134-inch (3.42-mm) or 0.105-inch (2.66-mm) nominal-thickness steel sheet, perforated with at least six holes.

a. Size: Minimum 27 inches (689 mm) wide by 76 inches (1930 mm) long with bunk pan 2 inches (51 mm) from wall.
b. Edges: As directed Turn up edges of back and sides and turn down edge of front or back, sides, and front, with minimum 2-inch (51-mm) flanges.

2. Drawer: Minimum 21 inches (533 mm) wide by 24 inches (610 mm) deep by 5 inches (127 mm) high, with full-width integral pull formed from steel sheet or solid-steel bar pull as directed; formed from 0.134-inch (3.42-mm) nominal-thickness steel sheet.
3. Combination End Panel/Mounting Plate: Formed from 3/16-inch- (0.048-mm-) thick steel sheet welded at connections to bunk pan, with 2-inch (51-mm) flange for wall mounting; provide two end panel/mounting plates for each bunk.

D. Materials:

1. Steel Plates, Shapes, and Bars: ASTM A36/A36M.
2. Cold-Rolled Steel Sheet: ASTM A1008/A1008M, CS (Commercial Steel), Type B; suitable for exposed applications.
3. Hot-Rolled Steel Sheet: ASTM A1011/A1011M, CS (Commercial Steel), Type B; free of scale, pitting, or surface defects; pickled and oiled.

E. Finishes: As directed Steel factory prime or baked-enamel or powder-coat finish.

1. Color and Gloss: As indicated by manufacturer's designations, Match Architect's sample or As selected by Architect from manufacturer's full range.

2.3 DETENTION MATTRESSES

A. General: Comply with 16 CFR 1633 and California Technical Bulletin 121 as determined by testing identical products by a testing and inspecting agency acceptable to authorities having jurisdiction. Identify materials with appropriate markings of applicable testing and inspecting agency.

B. Core: As directed Fire-resistive solid foam, Fire-resistive densified polyester or Cotton, with 10 percent boric acid treatment, tufted to nylon netting to retain shape.

C. Cover Fabric: Vinyl bonded to nylon scrim; with a minimum total weight of 10 oz./sq. yd. (339 g/sq. m). Fabricate cover using all sealed-seam construction with radio-frequency welded inverted seams, four-corner box construction with seams facing inside of detention mattress except end closing seam located at foot of mattress; sew with nylon thread in a double-lock stitch, with integral pillow as directed.

1. Color: Clear or Manufacturer's standard as directed.

D. Thickness: 4 inches (102 mm) or 6 inches (152 mm) as directed.

2.4 DETENTION DESKS

A. Single-Seat, Floor-Mounted Desks:
1. Desk Top: Formed from 0.134-inch (3.42-mm) nominal-thickness steel, 0.105-inch (2.66-mm) nominal-thickness steel, 0.141-inch (3.57-mm) thick, stainless-steel or 0.062-inch (1.59-mm) thick, stainless-steel sheet, with minimum 1-1/2-inch (38-mm) flanged edges as directed.

a. Size: Minimum 36 inches (914 mm) wide by 15-1/2 inches (381 mm) deep.

2. Pedestal: Provide two storage shelves with sides and shelves formed from 0.134-inch (3.42-mm) nominal-thickness steel.
3. Legs: Formed from 1-1/2-inch-square by 3/16-inch- (38-mm-square by 4.8-mm-) thick steel tubing welded to desk top and mounting plate for an overall desk height of not less than 30 inches (762 mm).
4. Seat: As directed 12-inch (305-mm) diameter, formed from 0.134-inch (3.42-mm) nominal-thickness steel, 0.075-inch (1.90-mm) nominal-thickness steel, 0.141-inch (3.57-mm) thick, stainless-steel or 0.062-inch (1.59-mm) thick, stainless-steel sheet; reinforced with 0.134-inch (3.42-mm) nominal-thickness steel sheet, with minimum 1-1/2-inch (38-mm) flanged edges.
5. Swivel Seat Support: Formed from 1-by-2-by-0.075-inch (25-by-51-by-1.90-mm) nominal-thickness steel tubing, 2-inch-OD-by-0.075-inch (51-mm-OD-by-1.90-mm) nominal-thickness steel tubing, or 3/8-inch (9.5-mm) thick, steel plate bar; with 1/2-inch (12.7-mm) pivot pin welded to legs.
6. Towel Bar: Formed from 1/4-by-1-1/2-inch (6-by-38-mm) steel or stainless-steel plate as directed, mounted on one side of desk.
7. Mounting Plates: Formed from 1/4-inch (6-mm) thick, steel plate punched with one hole for floor anchorage; provide one mounting plate for each leg.

B. Materials:

1. Steel Plates, Shapes, and Bars: ASTM A36/A36M.
2. Cold-Rolled Steel Sheet: ASTM A1008/A1008M, CS (Commercial Steel), Type B; suitable for exposed applications.
3. Hot-Rolled Steel Sheet: ASTM A1011/A1011M, CS (Commercial Steel), Type B; free of scale, pitting, or surface defects; pickled and oiled.
4. Stainless-Steel Sheet, Strip, Plate, and Flat Bars: ASTM A666 or ASTM A240/A240M, austenitic stainless steel, Type 304.
5. Steel Tubing: ASTM A513/A513M, Type B unless otherwise indicated; thickness indicated or required by structural loads.

C. Finishes: Steel factory prime or baked-enamel or powder-coat finish as directed.

1. Color and Gloss: As indicated by manufacturer's designations, Match Architect's sample or As selected by Architect from manufacturer's full range.
2. Stainless-Steel Finish: As directed No. 3 or No. 4.

2.5 DETENTION TABLES

A. Pedestal-Style Table:
1. Tabletop: As directed Formed from 0.134-inch (3.42-mm) nominal-thickness steel, 0.105-inch (2.66-mm) nominal-thickness steel, 0.109-inch (2.78-mm) thick, stainless-steel, 0.078-inch- (1.98-mm-) thick, stainless-steel or 0.062-inch (1.59-mm) thick, stainless-steel sheet; reinforced with steel shapes or steel plate, with minimum 1-1/2-inch (38-mm) flanged edges.

a. Size: As directed Minimum 30 inches (762 mm) or 40 inches (1016 mm) wide by length required for capacity by 30 inches (762 mm) or 35 inches (889 mm) high.
b. Game Top: Engrave, or otherwise integrally incorporate, checkerboard into tabletop.

2. Seats: As directed 12-inch (305-mm) diameter, formed from 0.105-inch (2.66-mm) nominal-thickness steel, 0.075-inch (1.90-mm) nominal-thickness steel, 0.078-inch (1.98-mm) thick, stainless-steel or 0.062-inch (1.59-mm) thick, stainless-steel sheet; reinforced with 0.134-inch (3.42-mm) nominal-thickness steel plate, with minimum 1-1/2-inch (38-mm) flanged edges.
3. Pedestal Supports: Formed from 3-inch-square by 3/16-inch (76-mm-square by 4.8-mm) or 4-inch-square by 0.134-inch (102-mm-square by 3.42-mm) thick, steel tubing welded to top and base plate as directed. Provide two pedestals for tables with capacity of more than four persons.
4. Seat Framing: As directed Formed from 3-inch-square by 0.134-inch (76-mm-square by 3.42-mm) or 3-by-2-by-3/16-inch (76-by-51-by-4.8-mm) thick, steel tubing welded to pedestal supports.
5. Base Plate: Minimum 16-inch (406-mm) square, 1/4-inch (6-mm) thick, steel plate punched with four holes for floor anchorage.
6. Capacity: Four persons, six persons, eight persons or as indicated on Drawings.

B. Materials:

1. Steel Plates, Shapes, and Bars: ASTM A36/A36M.
2. Cold-Rolled Steel Sheet: ASTM A1008/A1008M, CS (Commercial Steel), Type B; suitable for exposed applications.
3. Hot-Rolled Steel Sheet: ASTM A1011/A1011M, CS (Commercial Steel), Type B; free of scale, pitting, or surface defects; pickled and oiled.
4. Stainless-Steel Sheet, Strip, Plate, and Flat Bars: ASTM A666 or ASTM A240/A240M, austenitic stainless steel, Type 304.
5. Steel Tubing: ASTM A513/A513M, Type B unless otherwise indicated; thickness indicated or required by structural loads.

C. Finishes: Steel As directed factory prime or baked-enamel or powder-coat finish.

1. Color and Gloss: As indicated by manufacturer's designations, Match Architect's sample or As selected by Architect from manufacturer's full range.
2. Stainless-Steel Finish: No. 3 or No 4 as directed.

2.6 DETENTION SEATING

A. Floor-Mounted Stool:
1. Seats: Minimum 12-inch (305-mm) diameter, formed from 0.134-inch (3.42-mm) nominal-thickness steel, 0.075-inch (1.90-mm) nominal-thickness steel, 0.125-inch- (3.18-mm-) thick, stainless-steel or 0.062-inch- (1.59-mm-) thick, stainless-steel sheet as directed; reinforced with 0.134-inch- (3.42-mm-) thick steel sheet cut to interior dimension of seat, with minimum 1-1/2-inch (38-mm) flanged edges.
2. Seat Support: Formed from steel pipe or 2-inch-OD-by-0.075-inch- (51-mm-OD-by-1.90-mm-) thick, steel tubing welded to seat reinforcement and base plate for an overall stool height of not less than 18 inches (457 mm).
3. Base Plate: Minimum 6-by-1/4-inch- (152-by-6-mm-) thick, square, round or steel punched with four holes for floor anchorage as directed.

B. Materials:

1. Steel Plates, Shapes, and Bars: ASTM A36/A36M.
2. Cold-Rolled Steel Sheet: ASTM A1008/A1008M, CS (Commercial Steel), Type B; suitable for exposed applications.
3. Hot-Rolled Steel Sheet: ASTM A1011/A1011M, CS (Commercial Steel), Type B; free of scale, pitting, or surface defects; pickled and oiled.
4. Stainless-Steel Sheet, Strip, Plate, and Flat Bars: ASTM A666 or ASTM A240/A240M, austenitic stainless steel, Type 304.
5. Steel Tubing: ASTM A513/A513M, Type B unless otherwise indicated; thickness indicated or required by structural loads.
6. Steel Pipe: ASTM A53/A53M, Standard Weight (Schedule 40) unless another weight is indicated or required by structural loads.

C. Finishes: As directed Steel factory prime or baked-enamel or powder-coat finish.

1. Color and Gloss: As indicated by manufacturer's designations, Match Architect's sample or As selected by Architect from manufacturer's full range.
2. Stainless-Steel Finish: No. 3 or No 4 as directed.

2.7 FABRICATION

A. Shop Assembly: Preassemble items in shop to greatest extent possible to minimize field splicing and assembly.

B. Coordinate dimensions and attachment methods of detention furniture with those of adjoining construction to produce integrated assemblies with closely fitting joints and with edges and surfaces aligned unless otherwise indicated.

C. Shear and punch metals cleanly and accurately. Remove burrs.

D. Form and grind edges and corners to be free of sharp edges or rough areas.

E. Form metal in maximum lengths to minimize joints. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing the Work.

F. Weld corners and seams continuously to comply with referenced AWS standard.

G. Provide for anchorage of type indicated; coordinate with supporting structure. Fabricate and space anchoring devices to secure detention furniture rigidly in place and to support expected loads.

H. Cut, reinforce, drill, and tap detention furniture as indicated to receive hardware, security fasteners, and similar items.

I. Form exposed work true to line and level with accurate angles, surfaces, and straight sharp edges.

J. Form exposed connections with hairline joints, flush and smooth using concealed fasteners where possible.

K. Attach drawer slides or shelves to furniture by welding or with security fasteners as directed.

2.8 SECURITY FASTENERS

A. Operable only by tools produced by fastener manufacturer or other licensed fabricator for use on specific type of fastener.
   1. Drive-System Type: Pinned Torx-Plus or Pinned Torx as directed.

2.9 SECURITY SEALANTS

A. Polyurethane Security Sealants: Manufacturer's standard, nonsag, tamper-resistant sealant for joints with low movement.

B. Epoxy Security Sealants: Manufacturer's standard, non-sag, tamper-resistant sealant for joints with no movement.

2.10 ACCESSORIES

A. Concealed Bolts: ASTM A307, Grade A unless otherwise indicated.

B. Cast-in-Place Anchors in Concrete: Fabricated from corrosion-resistant materials capable of sustaining, without failure, a load equal to four times the load imposed, as determined by testing per ASTM E488/E488M, conducted by a qualified testing agency; of type indicated below:

   1. Threaded or wedge type; galvanized ferrous castings, either ASTM A47/A47M malleable iron or ASTM A27/A27M cast steel. Provide bolts, washers, and shims as needed; hot-dip galvanized per ASTM A153/A153M or ASTM F2329/F2329M.

C. Embedded Plate Anchors: Fabricated from mild steel shapes and plates, minimum 3/16 inch (4.8 mm) thick; with minimum 1/2-inch- (12.7-mm-) diameter, headed studs welded to back of plate.

D. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Inspect built-in and cast-in anchor installations, before installing detention furniture, to verify that anchor installations comply with requirements. Prepare inspection reports.

B. Fastening to In-Place Construction: Provide anchorage devices and fasteners where necessary for securing detention furniture to in-place construction. Include threaded fasteners for concrete and masonry inserts, security fasteners, and other connectors.

C. Cutting, Fitting, and Placement: Obtain manufacturer's written approval for cutting, drilling, and fitting required for installing detention furniture. Set detention furniture accurately in location, alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack; and measured from established lines and levels.

D. Provide temporary bracing or anchors in formwork for items that are to be built into concrete or masonry or similar construction.

E. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations.

F. Field Welding: Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.

G. Assemble detention furniture requiring field assembly with security fasteners with no exposed fasteners on exposed faces and frames.

H. Anchor furniture with security fasteners, by welding or as indicated on Drawings to floors and walls at intervals required by expected loads, but not more than 12 inches (305 mm) o.c.

1. Install anchors through backup reinforcing plates where necessary to avoid metal distortion.
2. Use security fasteners with head styles appropriate for installation requirements, strength, and finish of adjacent materials, except that a maximum of two different sets of tools shall be required to operate security fasteners for Project. Provide stainless-steel security fasteners in painted materials.
3. Weld nuts onto cast-in-place anchors after installation so as to be nonremovable.

I. As Directed Apply polyurethane or epoxy security sealant at all exposed gaps between detention furniture and adjcent construction greater than 1/16 inch (1.6 mm).

J. Install one detention mattress for each detention bunk.

3.2 FIELD QUALITY CONTROL

A. Inspect installed products to verify compliance with requirements. Prepare inspection reports and indicate compliance with and deviations from the Contract Documents.

B. Prepare field quality-control certification endorsed by Detention Specialist that states installed products and their installation comply with requirements in the Contract Documents.

END OF SECTION 125500

SECTION 126100 - FIXED AUDIENCE SEATING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes fixed, chair-type seating with the following:
   1. As directed

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings:

   1. Seating Layout: Show seating layout, aisle widths, aisle-end alignment or stepping, row-lettering and chair-numbering scheme, chair widths, and chair spacing in each row.
   2. Accessories: Show locations and features of accessories and accessibility provisions as directed.

D. Samples: For each type of exposed color, finish, texture, and pattern.

1.4 INFORMATIONAL SUBMITTALS

A. Product certificates.

B. Material certificates.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same production run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Chair Seats and Backs: 5 percent of quantity installed for each type and size of chair seat and back.
2. Upholstered, Slip-on Cushions: 5 percent of quantity installed for each type and size of cushion.
3. Fabric: 5 percent on the bolt of quantity installed for each type.
4. Tablet Arms: 5 percent of quantity installed for each type and size of tablet arm; left- and right-hand mounted.
5. Armrests: 5 percent of quantity installed for each type of armrest.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain each type of seating required, including accessories and mounting components, from single source from single manufacturer.

1. Upholstery Fabric: Obtain fabric of a single dye lot for each color and pattern of fabric required.

2.2 PERFORMANCE REQUIREMENTS

A. Fire-Test-Response Characteristics of Upholstered Chairs:

1. Fabric and Padding:

a. Fabric: Class 1 according to DOC CS 191 or 16 CFR 1610, tested according to California Technical Bulletin 117-2000.
b. Padding: Comply with California Technical Bulletin 117-2000.

2. Upholstery Assembly: Assembly shall comply with component-testing requirements of California Technical Bulletin 117-2013.
3. Full-Scale Fire Test: Comply with California Technical Bulletin 133.

B. Strength and Durability Performance: Chairs and components shall pass testing according to BIFMA X5.4.

2.3 FIXED AUDIENCE SEATING

A. Description: Assembly-space seating in permanent arrangement as indicated on Drawings.

B. Chair Mounting Standards: Floor or riser attached as directed of the following material:

1. Material: As directed.

C. Chair Mounting Beam: Steel horizontal beam mounted on floor or riser-attached steel support pedestals as directed.

D. Chair Mounting Pedestal: Floor-attached pedestal, manufacturer's standard base with 90-degree left and right rotation capability or base with 360-degree rotation capability as directed.

E. End Panels: As directed.

1. Cast-Metal Design: As directed.
2. Decorative Insert: As directed.
3. Style: As directed.

F. Fabric Upholstered Chairs:

1. Back:

a. Padding Thickness: As directed.
b. Outer Back Surface: As directed.
c. Top Corners: Square or Rounded as directed.
d. Upholstery Options: As directed.

2. Seat: As directed and as follows:

a. Top Padding Thickness: As directed.
b. Seat Bottom: As directed.

G. Plastic Chairs: Single or Double-wall molded plastic as directed and as follows:

1. Back: As directed.
2. Seat: As directed.
3. Upholstered Inserts: Padding and fabric covering over 1/8-inch (3-mm) plywood or MDF backing board, recessed 3/16 inch (5 mm) into plastic surface, centered, and attached with hidden, vandal-resistant fasteners.

H. Formed Hardwood-Veneer Chairs: Hardwood-veneer-faced, formed plywood backs and seats, with concealed or exposed fasteners as directed.

1. Back Top Corners: Square or Rounded as directed.

I. Chair Width: Vary chair widths to optimize sightlines and row lengths or Single-width chair in each row as directed, with minimum chair width as directed from center to center of armrests.

J. Back Height: As directed high from the floor.

K. Back Pitch: As directed.

L. Chair Seat Hinges: Self-lubricating, with noiseless self-rising seat mechanism passing ASTM F851 or manual operation as directed, positive internal stops cushioned with rubber or neoprene, and requiring no maintenance.

M. Armrests: As directed with rounded edges, integral cup holder, and concealed mounting.

N. Aisle-Lighting Fixtures: As directed.

1. Bulb: LED or incandescent.
2. Power: V as directed.
3. For low-voltage lighting, provide manufacturer's voltage-reduction device housed in safety enclosure equipped with fuses, terminal blocks, and safety disconnect.

O. Tablet Arms: As directed fixed or foldaway tablet arm as directed with plastic-laminate writing surface over MDF or plywood core and with rounded, matching PVC edges.

1. Mounting: Right-hand mounted unless otherwise indicated.

P. Accessible Seating:

1. Provide As directed chair for each wheelchair space unless otherwise indicated.
2. Provide chairs with folding armrest on aisle side in locations indicated, but not less than 5 percent of aisle seats, dispersed through the audience seating area. Identify these seats with a sign or marker.

Q. Row-Letter and Chair-Number Plates: As directed.

1. Material: As directed with black embossed characters.

R. Accessibility-Logo and Donor Plates: As directed.

1. Material: As directed with black embossed characters.

S. Bookracks: Manufacturer's standard under-chair or back-of-chair boxes, matching material and finish of mounting surface.

1. Size: Minimum as directed.

2.4 MATERIALS AND FINISHES

A. MDF (Medium-Density Fiberboard): ANSI A208.2, Grade MD.

B. Concealed Plywood: HPVA HP-1 hardwood plywood or DOC PS 1 softwood plywood as standard with manufacturer.

C. Exposed Plywood: HPVA HP-1, Face Grade A, hardwood-veneer core with color-matched hardwood-veneer faces.

D. Hardwood Lumber and Veneer Faces: As directed to be free of visible defects.

1. Stain and Finish: As directed.

E. Plastic Laminate: NEMA LD 3, Grade VGS for vertical surfaces and Grade HGS for horizontal surfaces.

1. Color and Pattern: As directed.

F. Molded Plastic: High-density polyethylene or polypropylene, blow or injection molded, with surface that is mar and dent resistant.

1. Provide with UV inhibitors to retard fading.
2. Color and Texture: As directed.

G. Fabric: Manufacturer's standard 100 percent nylon or 100 percent polyolefin as directed with flame-retardant treatment if required to meet performance requirements.

1. Weight: As directed.
2. Color and Pattern: As directed.

H. Metal Finish: Finish exposed metal parts with manufacturer's standard coating.

1. Color: As directed.

I. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install seating in locations indicated and fasten to substrates according to manufacturer's written installation instructions.

1. Install seating with each chair capable of complying with performance requirements without failure or other conditions that might impair the chair's usefulness.
2. Install standards and pedestals plumb.
3. Install seating so moving components operate smoothly and quietly.

B. Install seating with end standards aligned or stepped as indicated from first to last row and with backs and seats varied in width and spacing to optimize sightlines as directed.

C. Install riser-mounted standards and attachments to maintain uniform chair heights above floor.

D. Where seating is indicated in curved rows, install seating at a constant radius unless otherwise indicated.

E. Install wiring conductors and cables concealed in components of seating and accessible for servicing.

3.2 ADJUSTING

A. Adjust chair backs so that they are at required angles and aligned with each other in uniform rows.

B. Adjust self-rising seat mechanisms so seats in each row are aligned when in upright position.

END OF SECTION 126100

SECTION 126313 - STADIUM AND ARENA BENCH SEATING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes fixed, continuous bench- or plank-type metal seating.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: For bench seating.

1. Seating Layout: Show seating layout, aisle widths, aisle-end alignment or stepping, and row-lettering scheme.

D. Samples: For each exposed product and for each color and texture specified.

1.4 INFORMATIONAL SUBMITTALS

A. Product certificates.

B. Sample warranty.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of bench seating that fail in materials or workmanship within specified warranty period.

1. Warranty Periods: Five years from date of Substantial Completion, or as directed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Structural Performance: Bench seating shall withstand the effects of gravity and other loads within limits and under conditions indicated.

1. Vertical Live Load: 120 lb/ft. (179 kg/m) or as indicated on Drawings.
2. Horizontal Sway Loads: 24 lb/ft. (36 kg/m) parallel to bench and 10 lb/ft. (15 kg/m), perpendicular to bench or as indicated on Drawings.

B. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.2 BENCH SEATING

A. Description: Plank-type seating in permanent arrangement as indicated on Drawings.

B. Seat Planks: Horizontal, continuous bench components on which spectators sit.

1. Material: One-piece aluminum extrusion, approximately 12 inches wide by 1-1/2 inches thick (300 mm wide by 40 mm thick) or 10 inches wide by 1-1/2 inches thick (250 mm wide by 40 mm thick).
2. Finish: Clear anodic finish.

C. Backrest: Bracket mounted to underside of the seat planks.

1. Material: One-piece aluminum extrusion.
2. Finish: Clear anodic finish.

D. Seat-Plank Support Brackets: Manufacturer's standard one-piece, welded-aluminum or welded-steel brackets that support and raise the seating off the supporting substrate, as indicated on Drawings.

E. Individual Seat Pads: Manufacturer's standard molded-plastic units with smoothly rolled edges, reinforcing ribs on underside to prevent deflection and strengthen attachment points, and designed for attachment to seat plank.

F. Individual Backrest Pads: Manufacturer's standard UV-resistant, molded-plastic units with smoothly rolled edges, reinforcing ribs on underside to prevent deflection and strengthen attachment points, and designed for attachment to backrest.

2.3 ACCESSORIES

A. Row-Letter Plates: Manufacturer's standard.

1. Material: Clear-anodized aluminum with black embossed characters.

B. Seat-Number Plates: Manufacturer's standard.

1. Material: Clear-anodized aluminum with black embossed characters.

C. Donor Plates: Manufacturer's standard.

1. Material: Clear-anodized aluminum with black embossed characters.

2.4 MATERIALS

A. Aluminum: Alloy and temper recommended in writing by manufacturer for type of use and finish indicated.

B. Steel: Hot-dip galvanized after fabrication.

C. Molded Plastic: High-density plastic, blow or injection molded, with surface that is mar and dent resistant.

1. Color and Texture: As indicated by manufacturer's designations or as selected by Architect from manufacturer's full range.
2. Provide with UV inhibitors to retard fading.

D. Fasteners: Aluminum, hot-dip galvanized steel, or stainless steel. Use fasteners of the same basic metal as fastened metal unless otherwise indicated. Use metals that are noncorrosive and compatible with each metal joined.

1. Use concealed fasteners for interconnecting metal components and for attaching them to other work unless exposed fasteners are unavoidable.
2. For exposed fasteners, use tamper-resistant screws of head profile flush with metal surface unless otherwise indicated.
3. Finish heads of exposed fasteners to match finish of metal fastened unless otherwise indicated.
4. Do not use power-actuated fasteners for concrete substrates.

2.5 ALUMINUM FINISHES

A. Clear Anodic Finish: As directed AAMA 611, AA-M12C22A41, Class I, 0.018 mm or AA-M10C22A31, Class II, 0.010 mm or thicker.

2.6 FABRICATION

A. Seat-Plank Assembly: Assemble seat plank sections end to end to form continuous benches of lengths indicated on Drawings. Provide tightly fitting aluminum end caps, interior joint sleeves at splices, and welded mounting plates for attaching support and backrest brackets.

B. Backrest Assembly: Assemble backrest sections end to end to form continuous backrest surface of lengths indicated on Drawings. Provide tightly fitting aluminum end caps, interior joint sleeves at splices, and welded mounting plates for attaching to backrest brackets.

C. Shop-Fabricated Connections: Welded according to AWS standards by AWS-certified welders.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install seating in locations indicated and fasten to substrates according to manufacturer's written installation instructions unless otherwise indicated.

B. Install seating level, with uniform bench height above walking surface, and without sharp edges.

C. Attach end caps tightly abutting ends of seat planks, with exposed end-cap contour aligned with contour of seat planks.

D. Space and attach seat-plank support brackets only to substrate concrete or structural components of metal substrates.

E. Install accessories in visual alignment.

END OF SECTION 126313

SECTION 126600 - TELESCOPING STANDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Manually operated telescoping stands.
2. Electrically operated telescoping stands.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: For telescoping stands in both stacked and extended positions.

1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power, signal, and control wiring.

D. Samples: For each exposed product and for each color and texture specified.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Product certificates.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

B. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Structural Performance: Telescoping stands shall withstand the effects of gravity loads, operational loads, and other loads and stresses according to ICC 300.

B. Accessibility Standard: Comply with applicable provisions in the DOJ's 2010 ADA Standards for Accessible Design, the ABA Standards of the Federal agency having jurisdiction, and ICC A117.1 as directed.

2.2 TELESCOPING STANDS

A. System Description: Operable system of multiple-tiered seating on interconnected folding platforms that close for storage, without being dismantled, into a nested stack. Telescoping-stand units permit opening and closing of adjacent, individual and multiple rows, and close with vertical faces of platforms in the same vertical plane.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Telescoping-Stands Standard: ICC 300.

B. Wall-Attached Telescoping Stands: Forward-folding system, in which the bleachers open in the forward direction by moving the front row away from the stack to the fully extended position and the rear of bleacher understructure permanently attaches to wall construction.
1. Operation: As directed Manually operated, Electrically operated, with friction-type, integral power unit or Electrically operated, with non-friction-type, integral power unit.
2. Electrical Characteristics for Each Seating Section:

    a. Horsepower: ½, 1-1/2 or 2 as directed.
    b. Voltage: As directed 115 V ac, 208 V ac or 230 V ac, single phase, 60 hertz.
    c. Voltage: As directed 208 V ac, 230 V ac or 460 V ac, three phase, 60 hertz.

3. Electrical Controls:

    a. Control Devices: As directed Wall-attached, Walk-along pendant or Wireless control system.
    b. Limit Switches: Automatically stop power system when telescoping stands reach fully opened or closed positions.

c. Motion Monitor: Flashing light with self-contained warning horn, rated at 85 dB at 10 feet (3 m), mounted under telescoping seating for audio and visual warning during operation.
d. Transformer: As required to coordinate current characteristics of motor and control station with building electrical system.

C. Recessed Telescoping Stands: Forward-folding system, in which the bleachers open in the forward direction by moving the front row away from the stack to the fully extended position and the rear of bleacher understructure permanently attaches to building construction so that closed stands are recessed in opening.
1. Operation: As directed Manually operated, Electrically operated, with friction-type, integral power unit or Electrically operated, with non-friction-type, integral power unit.
2. Electrical Characteristics for Each Seating Section:

a. Horsepower: ½, 1-1/2 or 2 as directed.
b. Voltage: 115 V ac, 208 V ac or 230 V ac, single phase, 60 hertz as directed.
c. Voltage: 208 V ac, 230 V ac or 460 V ac, three phase, 60 hertz as directed.

3. Electrical Controls:

a. Control Devices: Wall-attached, Walk-along pendant or Wireless control system as directed.
b. Limit Switches: Automatically stop power system when telescoping stands reach fully opened or closed positions.
c. Motion Monitor: Flashing light with self-contained warning horn, rated at 85 dB at 10 feet (3 m), mounted under telescoping seating for audio and visual warning during integral power operation.
d. Transformer: As required to coordinate current characteristics of motor and control station with building electrical system.

D. Freestanding, Forward-Folding, Telescoping Stands: Floor-attached system, in which the bleachers open in the forward direction, by moving the front row away from the stack to the fully extended position, and the rear of bleacher understructure permanently attaches to floor construction.
1. Operation: Manually operated, electrically operated, with friction-type, integral power unit or Electrically operated, with non-friction-type, integral power unit as directed.
2. Electrical Characteristics for Each Seating Section:

a. Horsepower: ½, 1-1/2 or 2 as directed.
b. Voltage: 115 V ac, 208 V ac or 230 V ac, single phase, 60 hertz as directed.
c. Voltage: As directed 208 V ac, 230 V ac or 460 V ac, three phase, 60 hertz as directed.

3. Electrical Controls:

a. Control Devices: Wall-attached, Walk-along pendant or Wireless control system as directed.
b. Limit Switches: Automatically stop power system when telescoping stands reach fully opened or closed positions.

c. Motion Monitor: Flashing light with self-contained warning horn, rated at 85 dB at 10 feet (3 m), mounted under telescoping seating for audio and visual warning during integral power operation.
d. Transformer: As required to coordinate current characteristics of motor and control station with building electrical system.

E. Freestanding, Reverse-Folding, Telescoping Stands: Floor-attached, reverse-opening system, in which the bleachers open in the backward direction, by moving the last row away from the stack to the fully extended position, and the front of bleacher understructure permanently attaches to floor construction.
1. Aisle Recovery: Equip unit with ability to create a front cross-aisle 36 inches (914 mm) or 42 inches (1067 mm) wide when stand is open.
2. Operation: Manually operated, Electrically operated, with friction-type, integral power unit or Electrically operated, with non-friction-type, integral power unit.
3. Electrical Characteristics for Each Seating Section:

a. Horsepower: ½, 1-1/2 or 2 as directed.
b. Voltage: As directed 115 V ac, 208 V ac or 230 V ac, single phase, 60 hertz.
c. Voltage: As directed 208 V ac, 230 V ac or 460 V ac, three phase, 60 hertz.

4. Electrical Controls:

a. Control Devices: Wall-attached, Walk-along pendant, Wireless control system or as directed.
b. Limit Switches: Automatically stop power system when telescoping stands reach fully opened or closed positions.
c. Motion Monitor: Flashing light with self-contained warning horn, rated at 85 dB at 10 feet (3 m), mounted under telescoping seating for audio and visual warning during integral power operation.
d. Transformer: As required to coordinate current characteristics of motor and control station with building electrical system.

2.3 COMPONENTS

A. Benches: Seats and skirts.

1. Material: As directed Lumber with transparent finish, Molded plastic with contour surfaces or Steel sheet with vinyl-clad finish.

a. Color: As indicated by manufacturer's designations, Match Architect's sample, Manufacturer's standard or as selected by Architect from manufacturer's standard.

2. Bench Height: Not less than 16 inches (406 mm) or more than 18 inches (457 mm).
3. Bench Depth: As directed 10 inches (254 mm) or 12 inches (305 mm).
4. Backs: Folding backrests permanently attached to bench units.

a. Material: As directed Lumber with transparent finish or Molded plastic with contour support surface in color matching seat.
b. Operation: As directed Manual or Automatic.

B. Wheelchair-Accessible Seating: As directed Locate seating cutouts or retractable truncated benches to provide wheelchair-accessible seating at locations indicated on Drawings.

1. Equip tiers adjacent to wheelchair-accessible seating with front rails as required by ICC 300.
2. Equip cutouts with full-width front closure panels that match decking construction and finish and that extend from underside of tiers adjacent to cutouts to 1-1/2 inches (38 mm) from finished floor.

C. Deck: As directed Aluminum, Plywood, 5/8 inch (16 mm) thick, Plywood, 3/4 inch (19 mm) thick or Manufacturer's standard laminated panel.

1. Finish: As directed Mill, Clear anodized, Color anodized, Polyethylene textured overlay bonded to substrate with exterior glue, Transparent, Paint, Manufacturer's standard carpet bonded to substrate or Manufacturer's standard.

a. Color: As indicated by manufacturer's designations, Match Architect's sample, Manufacturer's standard or as selected by Architect from manufacturer's standard colors.

D. Risers: Steel sheet with manufacturer's standard, rust-inhibiting coating or hot-dip galvanized finish.

E. Safety Rails: Steel, finished with manufacturer's standard powder coat system.

1. As directed Removable, Folding or Self-storing mid-aisle handrails located at centerline of each aisle with seating on both sides.
2. As directed End rails (guards) that are telescoping and self-storing or removable.
3. Back rails (guards) along rear of units where required by ICC 300.
4. As directed Removable or Fixed front rails (guards) along front of units where required by ICC 300.
5. As directed Removable or Fixed rails around accessible seating cutouts and truncations.
6. Removable, programming-support front rails to allow seating in upper rows while lower rows remain in the stored position.
7. Color: Black, Match Architect's sample or Manufacturer's standard neutral color.

F. Understructure: Structural steel.

1. Finish: As directed Manufacturer's standard, Water-based acrylic, Alkyd-enamel, two-coat system, or Epoxy-resin-based, textured, powder coat system, rust-inhibiting finish.
2. Color: Manufacturer's standard.

G. Support Column Wheels: Nonmarring, soft, rubber-face wheel assembly under each support column.

1. Include wheels of size, number, and design required to support stands and operate smoothly without damaging the flooring surface, but no fewer than four per column or less than 4 inches (100 mm) in diameter and 1-1/2 inch (32 mm) wide.

H. Control Devices:

1. Wall Attached: Manufacturer's standard or Keyed-switch control station, located within full view of each stand and its movement area. Provide two keys per station.
2. Walk-Along Pendant: Manufacturer's standard unit, which plugs into first row of each operating section. Provide one unit, two units, three units or one unit for each operating section as directed.
3. Wireless: Hand-held, wireless transmission unit that operates wireless receivers in each operating section, with a transmission range to keep handheld control unit within close proximity and with full view of stand and its movement area. As directed Provide one unit, two units, three units or one unit for each operating section.

2.4 ACCESSORIES

A. Steps:

1. As directed Slip-resistant, abrasive tread nosings or surfaces at aisles.
2. Intermediate aisle steps, fully enclosed, at each aisle.
3. Transitional top step, fully enclosed, at each aisle where last row of telescoping stands is adjacent to a cross aisle.
4. Removable front steps, fully enclosed, at each aisle, that engage with front row to prevent accidental separation or movement and are equipped with a minimum of four skid-resistant feet.

B. Portable Stairs: Portable access-stair units equipped with handrails, with no fewer than four full-swiveling, nonmarring wheels and a locking mechanism to prevent movement during use.

C. Ramps: Portable access-ramp units, slope as indicated on drawings to comply with requirements of accessibility standard, equipped with handrails, with no fewer than four full-swiveling, nonmarring wheels and a locking mechanism to prevent movement during use.

D. Closure Panels and Void Fillers:

1. Aisle closures at foot level that produce flush vertical face at aisles when system is stored.
2. End panels covering exposed ends of stands in the stored position.
3. Back panels covering rear of freestanding units. Panels extend full height and width of unit.
4. Panels at cutouts and truncations for accessible seating.
5. Rear fillers including supports for closing openings between top row and rear wall of adjoining construction.
6. Gap fillers for closing openings between stand units or between stand units and adjoining construction.

2.5 MATERIALS

A. Lumber: Kiln dried, surfaced four sides; southern pine complying with SPIB's "Standard Grading Rules for Southern Pine Lumber" for B & B finish (B and better) or C & Btr finish (C and better) grade-of-finish requirements as directed.

B. Plywood: PS 1 as standard with manufacturer.

2.6 FABRICATION

A. Fabricate telescoping stands to operate easily without special tools or separate fasteners unless otherwise indicated.

B. Round corners and edges of components and exposed fasteners to reduce snagging and pinching hazards.

C. Form exposed work with flat, flush surfaces, level and true in line.

D. Supports: Fabricate supports to withstand, without damage to components, the forces imposed by use of stands without failure or other conditions that might impair their usefulness.

1. Cantilever bench seat supports to produce toe space uninterrupted by vertical bracing.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install telescoping stands according to ICC 300 and manufacturer's written instructions.

3.2 FIELD QUALITY CONTROL

A. Testing Agency: As directed Owner will engage or Engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests and inspections:

1. ICC 300 Inspection: Inspect installed telescoping stands to verify that construction, installation, and operation are according to ICC 300 requirements.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Telescoping stands will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.3 ADJUSTING

A. Adjust backrests so that they are at proper angles and aligned with each other in uniform rows.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to inspect, adjust, operate, and maintain telescoping stands.

END OF SECTION 126600

SECTION 129200 - INTERIOR PLANTERS AND ARTIFICIAL PLANTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Freestanding interior planters.
2. Planter liners.
3. Manufactured interior plants.

B. Owner-Furnished, Contractor-Installed Material

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Metal Planter Liners: Show layouts, profiles, shapes, seams, and dimensions.
2. Self-Contained Sub-irrigation Units: Show fabrication and installation details of units and accessories.

C. Samples: For each freestanding planter finish, color, and texture specified.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance data.

PART 2 - PRODUCTS

2.1 FREESTANDING INTERIOR PLANTERS

A. Type: As directed Hanging, Tabletop, Panel/Wall mounted or Floor set.

B. Material: As directed Ceramic, Fiberglass, Metal, Plastic, Cast stone, GFRC or Terra cotta.

C. Inside Width: As directed.

D. Outside Width: As directed.

E. Inside Length: As directed.

F. Outside Length: As directed.

G. Inside Diameter: As directed.

H. Outside Diameter: As directed.

I. Height: As directed.

J. Pattern: As directed.

K. Color: As directed.

L. Finish: As directed.

M. Accessories: As directed Planter pad, Matching saucer, Carpet protector disc or Casters.

2.2 PLASTIC PLANTER LINERS

A. Planter Liners: As directed Seamless or Welded plastic planter liners.

1. Size: As directed.
2. Color: Black.

2.3 METAL PLANTER LINERS

A. Materials:

1. Zinc-Coated (Galvanized) Steel Sheet: ASTM A653/A653M, G90 (Z275) coating designation; structural quality, mill phosphatized for field painting, 0.0276 inch (0.7 mm) or 0.0336 inch (0.85 mm) thick as directed.
2. Stainless-Steel Sheet: ASTM A240/A240M, Type 304, No. 2D finish, 0.040 inch (1.0 mm) or 0.050 inch (1.2 mm) thick as directed.

    a. Solder for Stainless Steel: ASTM B32, Grade Sn60, with acid flux of type recommended by stainless-steel sheet manufacturer.

3. Copper Sheet: ASTM B370, Temper H00 or H01, cold-rolled copper sheet, 16 oz./sq. ft. (0.55 mm thick) or 20 oz./sq. ft. (0.7 mm thick) as directed.

    a. Solder for Copper: ASTM B32, Grade Sn50, 50 percent tin and 50 percent lead.

4. Elastomeric Sealant: ASTM C920, elastomeric polymer sealant; of type, grade, class, and use classifications required to seal joints in sheet metal and remain watertight.

B. Fabrication:

1. Comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to design, dimensions, metal, and other characteristics of planter liner indicated.
2. Shop fabricate where practical. Obtain field measurements for accurate fit before shop fabrication.
3. Fabricate sheet metal without excessive oil canning, buckling, and tool marks and true to line and levels indicated, with exposed edges folded back to form hems.
4. Fabricate sheet metal joints with soldered, flat-lock seams. Clean surfaces to be soldered, removing oils and foreign matter. Pretin edges of sheets to be soldered to a width of 1-1/2 inches (38 mm).

    a. Stainless-Steel Soldering: Pretin edges of uncoated sheets to be soldered using phosphoric acid flux and solder for stainless steel. Promptly wash off acid flux residue from metal after soldering.
    b. Copper Soldering: Tin uncoated copper surfaces at edges of sheets using solder for copper.

5. Fabricate joints in sheet metal to accommodate elastomeric sealant.

    a. Seal joints with elastomeric sealant as required for watertight construction. Embed hooked flanges of joint members not less than 1 inch (25 mm) into sealant. Form joints to completely conceal sealant. Prepare joints and apply sealants according to manufacturer's written instructions.

2.4 MANUFACTURED INTERIOR PLANTS

A. Plant Type: As directed.

B. Treat trunk, branch, and foliage surfaces with flame retardant to comply with NFPA 701.

2.5 MINERAL MULCH

A. Mineral Mulch: Hard, durable stone, washed free of loam, sand, clay, and other foreign substances, of the following type, size range, and color:

1. Type: As directed Rounded riverbed gravel or smooth-faced stone, Crushed stone or gravel, Marble chips or Granite chips.
2. Size Range: 1-1/2 inches (38 mm) maximum, 3/4 inch (19 mm) minimum or 3/4 inch (19 mm) maximum, 1/4 inch (6 mm) minimum.
3. Color: Uniform tan-beige color range acceptable to Architect or Readily available natural gravel color range as directed.

PART 3 - EXECUTION

3.1 FREESTANDING PLANTER PLACEMENT

A. Examine areas, with Installer present, for compliance with requirements for environmental conditions, and other conditions affecting performance of the Work.

B. Before installation, lay out interior planters in locations indicated. Adjust locations when requested by Architect and obtain Architect's acceptance of layout before installation.

C. Install freestanding planters, level and plumb. Use concealed shims where required for alignment.

D. Remove stickers and other temporary labels from interior planters.

3.2 INSTALLATION OF PLANTER LINERS

A. Set liners in planters according to freestanding planter manufacturer's written instructions or as indicated on Drawings.

B. Install liners to allow for liner removal.

3.3 MANUFACTURED PLANT PLACEMENT

A. Set manufactured plants at locations indicated on Drawings according to manufacturer's written instructions.

B. Place mineral mulch in locations indicated on Drawings.

END OF SECTION 129200

SECTION 132416 - SAUNAS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Modular saunas with convection heaters.
2. Modular saunas with infrared heaters.
3. Precut saunas with convection heaters.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:
1. As directed

C. Shop Drawings:

1. Include plans, elevations, sections, and details.
2. Indicate dimensions, required clearances, method of field assembly, and location and size of each field connection.
3. Include locations of sauna heater, lighting, and controls.

D. Samples: For each exposed wood member.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.4 QUALITY ASSURANCE

1.5 WARRANTY

A. Manufacturer's Special Warranty: Manufacturer agrees to repair or replace components of sauna heaters that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MODULAR SAUNAS WITH CONVECTION HEATERS

A. Modular Saunas with Convection Heaters: Freestanding, demountable, panelized system complete with manufacturer's standard framing, insulation, and vapor retarders; designed for use with convection heater. Include the following:

1. Door of style and construction indicated.
2. Exterior Wall Finish: Same wood species and grade as interior paneling, 11/32-inch-thick (8.7-mm-thick), Grade B, rough-sawn mahogany hardwood plywood or prepared to receive gypsum board as directed.
3. Bench.
4. Removable flooring.

2.2 MODULAR SAUNAS WITH INFRARED HEATERS

A. Modular Saunas with Infrared Heaters: Freestanding, demountable, panelized system complete with manufacturer's standard framing, insulation, and vapor retarders; designed for use with infrared heater. Include the following:

1. Door of style and construction indicated.
2. Exterior Wall Finish: Same wood species and grade as interior paneling, 11/32-inch-thick (8.7-mm-thick), Grade B, rough-sawn mahogany hardwood plywood or Prepared to receive gypsum board as directed.
3. Bench.
4. Removable flooring.

2.3 PRECUT SAUNAS WITH CONVECTION HEATERS

A. Precut Saunas with Convection Heaters: Kit of precut components for site installation over existing framing; designed for use with convection heater. Include the following:

1. Door of style and construction indicated.
2. Bench.
3. Vapor retarder.

2.4 HEATERS AND CONTROLS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Convection Heater: Manufacturer's standard compact electric convection unit with stainless-steel elements, stainless-steel interior, baked-enamel or stainless-steel exterior as directed, and wire protective top grill. Provide heat-tested, shatter-resistant igneous rocks that are in direct contact with and completely cover heating-unit coils.

1. Capacity: Determined by manufacturer for sauna size indicated.

2. Power Supply: 120 V, 208 V or 240 V ac as directed.
3. Mounting: Wall mounted with bracket, Corner mounted with bracket, Floor mounted with integral floor stand or legs or As indicated.

C. Infrared Heater: As directed Manufacturer's standard far-infrared heater with ceramic or carbon heating elements; factory-installed into sauna modules.

1. Capacity: Determined by manufacturer for sauna size indicated.
2. Power Supply: 120 V, 208 V or 240 V ac as directed.

D. Mechanical Controls:

1. Built-in: Manufacturer's standard system mounted integral with heater unit, with thermostat and the following features:

a. As directed Dial timer that automatically shuts off heater after 30 or 60 minutes.
b. Dial time delay that allows heater to be preset up to nine hours in advance.

2. Remote: Manufacturer's standard system designed for remote wall mounting, with thermostat and the following features:

a. Mounting: As directed Surface ort Recessed.
b. Heater switch.
c. Light switch.
d. Heat-indicator light.
e. Adjustable temperature control.
f. As directed Dial timer that automatically shuts off heater after 30 or 60 minutes.
g. Dial time delay that allows heater to be preset up to nine hours, 12 hours, 24 hours or seven days in advance as directed, with manual override.

E. Digital Controls: Manufacturer's standard system designed for remote wall mounting, with touchpad controls, digital display, thermostat, and the following features:

1. Mounting: As directed Surface or Recessed.
2. Heater switch.
3. Light switch.
4. Heat-indicator light.
5. Adjustable temperature control.
6. Programmable time and temperature for heater startup and shutdown.
7. Preset temperature lock.

2.5 COMPONENTS

A. Wood Doors: Manufacturer's standard prehung door assembly as follows:

1. Door Wood Species: Same wood species and grade as interior paneling.
2. Size: As directed 24 by 80 inches (610 by 2032 mm) or 36 by 80 inches (914 by 2032 mm).
3. Glass Vision Panel: Insulating-glass unit made from two lites of 3-mm-thick, clear or bronze-tinted as directed, tempered float glass with 1/4-inch (6.4-mm) airspace.

B. All-Glass Doors: Manufacturer's standard prehung door assembly of 8-mm-thick, clear or bronze-tinted as directed, tempered float glass; mounted on 2-inch- (51-mm-) thick western red cedar jambs and head.

1. Size: As directed hinges, one ball catch, and two wood door pulls of same wood species as interior paneling for each door.

C. Benches: Fabricate from S4S, 1-by-4-inch-nominal (19-by-89-mm-actual) or 2-by-2-inch-nominal (38-by-38-mm-actual) wood as directed, spaced not more than 1/2 inch (13 mm) apart and supported by 2-by-4-inch-nominal (38-by-89-mm-actual) wood framing; of same wood species as interior paneling.

D. Flooring: Manufacturer's standard removable 1-by-4-inch-nominal (19-by-89-mm-actual) wood duckboards, of same species and grade as interior paneling, spaced not more than 1/2 inch (13 mm) apart and mounted on preservative-pressure-treated wood sleepers.

2.6 MATERIALS

A. Interior Paneling: 1-by-4-inch-nominal (19-by-89-mm-actual), V-joint, tongue-and-groove wood boards; sanded smooth; kiln dried to no more than 12 percent moisture content.

1. Wood Species and Grades: Lumber of grades indicated according to DOC PS 20 and the provisions of the grading agency indicated.

a. Western Red Cedar: WCLIB or WWPA; Clear Heart.
b. Redwood: RIS; Clear All Heart, VG (Vertical Grain).
c. Douglas Fir: WCLIB or WWPA; Superior, VG (Vertical Grain).
d. Species and grade as directed.

B. Softwood Plywood: DOC PS 1.

C. Hardwood Plywood: HPVA HP-1, containing no urea formaldehyde.

D. Tempered Float Glass: ASTM C1048, Kind FT (fully tempered), Condition A (uncoated), Type I (transparent glass, flat), Quality Q3 (glazing select), Class 1 (clear) or Class 2 (tinted, heat absorbing, and light reducing) as directed; manufactured by horizontal (roller-hearth) process, with exposed edges seamed before tempering.

1. Safety Glazing Labeling: Permanently mark glazing with certification label of the SGCC, the manufacturer, or another certification agency acceptable to authorities having jurisdiction. Label shall indicate manufacturer's name, type of glass, thickness, and safety glazing standard with which glass complies.

E. Insulating-Glass Units: Factory-assembled units consisting of sealed lites of glass separated by a dehydrated interspace, qualified according to ASTM E2190, and complying with other requirements specified.

F. Fasteners: Stainless steel or hot-dip galvanized.

G. Vapor Retarder: Laminated aluminum foil and kraft-paper vapor barrier with water-vapor transmission rate of no more than 0.006 perms (0.34 ng/Pa x s x sq. m) as tested according to ASTM E96/E96M.

2.7 ACCESSORIES

A. Provide the following accessories. Provide wood accessories of same wood species as interior paneling unless otherwise indicated.

1. Wood guardrail for heater, of dimensions required by listing.
2. Wood-slat backrest for each bench.
3. Sloping wood-slat headrest.
4. Arched wood-slat leg rest.
5. As directed Thermometer, 4-inch (102-mm), Hygrometer, 4-inch (102-mm) or Combination thermometer/hygrometer, 5-inch (127-mm) diameter, with chrome casing.
6. Wood light valance with low-voltage light fixture.
7. Wall-mounted light fixture rated for damp locations; brushed satin aluminum with white glass globe.
8. Wood clothes hanger with two, three or four pegs as directed.

2.8 FABRICATION

A. Fabricate saunas to dimensions, profiles, and details indicated. Sand boards smooth and ease edges to a radius of not less than 1/16 inch (1.6 mm).

B. Shop cut openings, to maximum extent possible, to receive hardware, electrical work, vents, and similar items. Locate openings accurately and use templates or roughing-in diagrams to produce accurately sized and shaped openings. Sand edges of cutouts to remove splinters and burrs.

C. Countersink or conceal all metal fasteners.

D. Modular Saunas: Complete fabrication of modular sauna panels, including assembly and hardware application, to maximum extent possible, before shipment to Project site. Disassemble components only as necessary for shipment and installation.

PART 3 - EXECUTION

3.1 INSTALLATION OF MODULAR SAUNAS

A. Complete field assembly with joining methods recommended in writing by manufacturer.

B. Set saunas level, plumb, and securely in place. Anchor as required for secure installation.

3.2 INSTALLATION OF PRECUT SAUNAS

A. Install sauna according to manufacturer's written instructions.

B. Install sauna components level, plumb, true, and straight with no distortions. Shim, as required, with concealed shims. Install level, plumb, and to a true plane to a tolerance of 1/8 inch in 96 inches (3 mm in 2400 mm). Install with no more than 1/16 inch in 96-inch (1.6 mm in 2400-mm) vertical cup or bow.

C. Install interior paneling vertically or horizontally as directed and anchor to supporting substrate with blind nailing through tongue and groove. Do not use face fastening. Install with fewest joints possible, using full-length pieces.

3.3 ADJUSTING

A. Adjust sauna door to close securely without binding. Adjust door to operate at room temperature and at sauna operating temperature.

END OF SECTION 132416

SECTION 132700 - VAULTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes burglary-resistance-rated, modular vault assemblies.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference as directed.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For modular vault assemblies.

1. Include plans, elevations, sections, and attachment and assembly details.
2. Include diagrams for power, signal, and control wiring.
3. Indicate locations of electrical receptacles and light fixtures.
4. Indicate locations of fire sprinklers.

C. Samples: For each exposed product and for each color and texture specified.

D. Delegated-Design Submittal: For modular vault assemblies.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Product certificates.

C. Product test reports: For each vault assembly, for tests performed by a qualified testing agency.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer and whose place of business is located not more than 2 hours' normal travel time from Project site.

B. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design modular vault assemblies.

B. Seismic Performance: Modular vault assemblies shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the vault assembly will remain in place without separation of any parts when subjected to the seismic forces specified and the vault assembly will be fully operational after the seismic event."

2.2 BURGLARY-RESISTANCE-RATED MODULAR VAULTS

A. Vault Assembly:

1. Burglary Classification: ASTM F1090, Type as directed.

B. Vault Panels: Interlocking panels with integral penetrations for sprinklers and conduits for power, signal, and communications systems. Tested according to UL 608 and listed and labeled for burglary-resistance rating corresponding to ASTM F1090 Type classification indicated by a qualified testing agency.

1. Vault-Ventilating Ports: Tested according to UL 680 and listed and labeled for burglary-resistance rating corresponding to ASTM F1090 Type classification indicated for vault assembly by a qualified testing agency; locations as indicated on Drawings. Fabricate ports integral with wall panel.

C. Vault Door Assembly: Tested according to UL 608 and listed and labeled for burglary-resistance rating corresponding to ASTM F1090 Type classification indicated for vault assembly by a qualified testing agency.

1. Emergency Vault Ventilator: Complying with UL 680, with same burglary classification as vault door.
2. Handle: As directed.
3. Combination Locks: As directed.

    a. Quantity: Two – three per door, as directed.

4. Timelock: UL 887 listed, three movement, 144 - 199 hour, as directed.
5. Day Guard Lock: Secures locking bar in open position to prevent lock in of personnel.

    a. Door contact alarm device.
    b. Heat detector.

c. In-door telephone jack.
d. Stainless-steel back panel to conceal timelock.
e. Can be side lifted.

6. Finish: Manufacturer's standard stainless-steel clad or factory-applied, baked-on coating finish applied to door, frame, and wall flanges.

a. Color: As directed.

D. Day Gate: Full width of door opening and designed to restrict entry through vault door; with piano-type or self-closing gravity hinges and cylinder-type lock, controlled by key on nonsecure side and by knob on secure side.

1. Features:

a. Deal window.
b. Automatic closure.

E. Nonshrink Grout: ASTM C1107, factory-packaged, nonmetallic aggregate grout; noncorrosive; nonstaining; mixed with water to consistency suitable for application and 30-minute working time.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install modular vault assemblies according to manufacturer's written instructions, including clearances between exterior of vault panels and other construction.

B. Set panels and doors accurately in position, level, plumb, aligned, and braced securely until permanent anchors are set. After panel erection is complete, remove temporary braces and spreaders, leaving surfaces smooth and undamaged.

C. Install panels, doors and frames, accessories, supplemental structural supports, and installation materials required to provide a complete modular vault assembly with the burglary-resistance rating indicated.

D. Panel Connections:

1. Wall Panel to Wall Panel: Bolted or Welded, as directed.
2. Wall Panel to Ceiling Panel: Welded.
3. Wall Panel to Floor Panel: Bolted or Welded, as directed.
4. Wall Panel to Concrete Slab: Bolted or Welded, as directed.

E. Slab Recess: After vault is installed, grout perimeter of vault recess flush with top of slab with nonshrink grout.

F. Penetrations: Seal with firestopping as specified in Section 078413 "Penetration Firestopping."

G. Touchup Painting: Immediately after erection, clean abraded areas of shop paint; paint exposed areas with same material as used for shop painting.

1. Comply with SSPC-PA 1 for touching up shop-painted surfaces. Section 099123 "Interior Painting.", as directed.

3.2 DEMONSTRATION

A. Engage a factory-authorized service representative to train to train Owner's maintenance personnel to adjust, operate, and maintain modular vault doors.

END OF SECTION 132700

SECTION 133419 - METAL BUILDING SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Structural-steel framing.
2. Metal roof panels.
3. Metal wall panels.
4. Metal soffit panels.
5. Thermal insulation.
6. Personnel doors and frames.
7. Windows.
8. Accessories.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference as directed.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of metal building system component.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: Indicate components by others. Include full building plan, elevations, sections, details and attachments to other work.

D. Samples: For units with factory-applied finishes.

E. Delegated-Design Submittal: For metal building systems.

1. Include analysis data indicating compliance with performance requirements and design data signed and sealed by the qualified professional engineer responsible for their preparation.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Letter of Design Certification: Signed and sealed by a qualified professional engineer. Include the following:

1. Name and location of Project.

2. Order number.
3. Name of manufacturer.
4. Name of Contractor.
5. Building dimensions including width, length, height, and roof slope.
6. Indicate compliance with AISC standards for hot-rolled steel and AISI standards for cold-rolled steel, including edition dates of each standard.
7. Governing building code and year of edition.
8. Design Loads: Include dead load, roof live load, collateral loads, roof snow load, deflection, wind loads/speeds and exposure, seismic design category or effective peak velocity-related acceleration/peak acceleration, and auxiliary loads (cranes).
9. Load Combinations: Indicate that loads were applied acting simultaneously with concentrated loads, according to governing building code.
10. Building-Use Category: Indicate category of building use and its effect on load importance factors.

C. Material test reports.

D. Source quality-control reports.

E. Field quality-control reports.

F. Sample warranties.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: A qualified manufacturer.

1. Accreditation: Manufacturer's facility accredited according to the International Accreditation Service's AC472, "Accreditation Criteria for Inspection Programs for Manufacturers of Metal Building Systems."
2. Engineering Responsibility: Preparation of comprehensive engineering analysis and Shop Drawings by a professional engineer who is legally qualified to practice in jurisdiction where Project is located.

B. Erector Qualifications: An experienced erector who specializes in erecting and installing work similar in material, design, and extent to that indicated for this Project and who is acceptable to manufacturer.

C. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. AWS D1.3, "Structural Welding Code - Sheet Steel."

1.7 WARRANTY

A. Special Warranty on Metal Panel Finishes: Manufacturer agrees to repair finish or replace metal panels that show evidence of deterioration of factory-applied finishes within specified warranty period.

1. Finish Warranty Period: Years from date of Substantial Completion, as directed.

B. Special Weathertightness Warranty for Standing-Seam Metal Roof Panels: Manufacturer agrees to repair or replace standing-seam metal roof panel assemblies that leak or otherwise fail to remain weathertight within specified warranty period.

1. Warranty Period: 20 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design metal building system.

B. Structural Performance: Metal building systems shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated according to procedures in MBMA's "Metal Building Systems Manual."

1. Design Loads: As directed.
2. Deflection and Drift Limits: Design metal building system assemblies to withstand serviceability design loads without exceeding deflections and drift limits recommended in AISC Steel Design Guide No. 3 "Serviceability Design Considerations for Steel Buildings."
3. Deflection and Drift Limits: No greater than the following:

    a. Purlins and Rafters: Vertical deflection of the span, as directed.
    b. Girts: Horizontal deflection of the span, as directed.
    c. Metal Roof Panels: Vertical deflection of the span, as directed.
    d. Metal Wall Panels: Horizontal deflection of 1/180 - 1/240 of the span, as directed.
    e. Design secondary-framing system to accommodate deflection of primary framing and construction tolerances, and to maintain clearances at openings.
    f. Lateral Drift: Maximum of the building height, as directed.

C. Seismic Performance: Metal building system shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes by preventing buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.

1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

E. Fire-Resistance Ratings: Where assemblies are indicated to have a fire-resistance rating, provide metal panel assemblies identical to those of assemblies tested for fire resistance per ASTM E119 or ASTM E108 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Indicate design designations from UL's "Fire Resistance Directory," FM Global's "Approval Guide," or from the listings of another qualified testing agency.

F. Fire-Rated Door Assemblies: Assemblies complying with NFPA 80 that are listed and labeled by a qualified testing agency, for fire-protection ratings indicated, based on testing at positive pressure according to NFPA 252 or UL 10C.

1. Oversize Fire-Rated Door Assemblies: For units exceeding sizes of tested assemblies, provide certification by a qualified testing agency that doors comply with standard construction requirements for tested and labeled fire-rated door assemblies except for size.

G. Structural Performance for Metal Roof and Wall Panels: Provide metal panel systems capable of withstanding the effects of the following loads, based on testing according to ASTM E1592:

1. Wind Loads: As indicated on Drawings.

H. Air Infiltration for Metal Roof Panels: Air leakage of not more than 0.06 cfm/sq. ft. (0.3 L/s per sq. m) when tested according to ASTM E1680 or ASTM E283 at the following test-pressure difference:

1. Test-Pressure Difference: 1.57 lbf/sq. ft. (75 Pa) - 6.24 lbf/sq. ft. (300 Pa).

I. Air Infiltration for Metal Wall Panels: Air leakage of not more than 0.06 cfm/sq. ft. (0.3 L/s per sq. m) when tested according to ASTM E283 at the following test-pressure difference:

1. Test-Pressure Difference: 1.57 lbf/sq. ft. (75 Pa) - 6.24 lbf/sq. ft. (300 Pa).

J. Water Penetration for Metal Roof Panels: No water penetration when tested according to ASTM E1646 or ASTM E331 at the following test-pressure difference:

1. Test-Pressure Difference: 2.86 lbf/sq. ft. (137 Pa) - 6.24 lbf/sq. ft. (300 Pa).

K. Water Penetration for Metal Wall Panels: No water penetration when tested according to ASTM E331 at the following test-pressure difference:

1. Test-Pressure Difference: 2.86 lbf/sq. ft. (137 Pa) - 6.24 lbf/sq. ft. (300 Pa).

L. Wind-Uplift Resistance: Provide metal roof panel assemblies that comply with UL 580 for wind-uplift-resistance class indicated.

1. Uplift Rating: As directed.

M. FM Global Listing: Provide metal roof panels and component materials that comply with requirements in FM Global 4471 as part of a panel roofing system and that are listed in FM Global's "Approval Guide" for Class 1 or noncombustible construction, as applicable. Identify materials with FM Global markings.

1. Fire/Windstorm Classification: Class 1A, as directed.
2. Hail Resistance: MH or SH.

N. Energy Star Listing: Roof panels that are listed on the DOE's ENERGY STAR "Roof Products Qualified Product List" for low or steep slope roof products.

O. Energy Performance: Provide roof panels according to one of the following when tested according to CRRC-1:

1. Three-year, aged, solar reflectance of not less than 0.55 and emissivity of not less than 0.75.
2. Three-year, aged, Solar Reflectance Index of not less than 64 when calculated according to ASTM E1980.

P. Thermal Performance for Opaque Elements: Provide the following maximum U-factors and minimum R-values when tested according to ASTM C1363 or ASTM C518:

1. Roof:

a. U-Factor: As directed.
b. R-Value: As directed.

2. Walls:

a. U-Factor: As directed.
b. R-Value: As directed.

2.3 STRUCTURAL-STEEL FRAMING

A. Structural Steel: Comply with AISC 360, "Specification for Structural Steel Buildings."

B. Bolted Connections: Comply with RCSC's "Specification for Structural Joints Using High-Strength Bolts."

C. Cold-Formed Steel: Comply with AISI's "North American Specification for the Design of Cold-Formed Steel Structural Members" for design requirements and allowable stresses.

D. Primary Framing: Manufacturer's standard primary-framing system, designed to withstand required loads and specified requirements. Primary framing includes transverse and lean-to frames; rafters and rake beams; sidewall, intermediate, end-wall, and corner columns; and wind bracing.

1. General: Provide frames with attachment plates, bearing plates, and splice members. Factory drill for field-bolted assembly. Provide frame span and spacing indicated.

a. Slight variations in span and spacing may be acceptable if necessary to comply with manufacturer's standard, as approved by Architect.

2. Frame Configuration: As directed.
3. Exterior Column: Uniform depth or Tapered.
4. Rafter: Uniform depth or Tapered.

E. End-Wall Framing: Manufacturer's standard primary end-wall framing fabricated for field-bolted assembly to comply with the following:

F. Secondary Framing: Manufacturer's standard secondary framing, including purlins, girts, eave struts, flange bracing, base members, gable angles, clips, headers, jambs, and other miscellaneous structural members. Unless otherwise indicated, fabricate framing from either cold-formed, structural-steel sheet or roll-formed, metallic-coated steel sheet, prepainted with coil coating, to comply with the following:

G. Anchor Rods: Headed anchor rods as indicated in Anchor Rod Plan for attachment of metal building to foundation.

2.4 METAL ROOF PANELS

A. Standing-Seam, Vertical-Rib or Trapezoidal-Rib, Metal Roof Panels, as directed: Formed with interlocking ribs at panel edges and intermediate stiffening ribs symmetrically spaced or flat pan between ribs; designed for sequential installation by mechanically attaching panels to supports using concealed clips located under one side of panels and engaging opposite edge of adjacent panels.

1. Material: Zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet, 0.018-inch (0.46-mm), 0.024-inch (0.61-mm), 0.030-inch (0.76-mm), as directed, nominal uncoated steel thickness. Pre-painted by the coil-coating process to comply with ASTM A755/A755M.

a. Exterior Finish: As directed.
b. Color: As directed.

2. Clips: One-piece fixed or two-piece floating to accommodate thermal movement.
3. Joint Type: Panels snapped together or Mechanically seamed.
4. Panel Coverage: 16 inches (406 mm) or 24 inches (610 mm).
5. Panel Height: 2 inches (51 mm) or 3 inches (76 mm).

B. Exposed Fastener, Tapered-Rib, Metal Roof Panels: Formed with raised, trapezoidal major ribs and intermediate stiffening ribs symmetrically spaced or flat pan between major ribs; designed to be installed by lapping side edges of adjacent panels and mechanically attaching panels to supports using exposed fasteners in side laps.

1. Material: Zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet, 0.018-inch (0.46-mm), 0.024-inch (0.61-mm) or 0.030-inch (0.76-mm) nominal uncoated steel thickness. Pre-painted by the coil-coating process to comply with ASTM A755/A755M.

a. Exterior Finish: As directed.

b. Color: As directed.

2. Major-Rib Spacing: 6 inches (152 mm) or 12 inches (305 mm) o.c.
3. Panel Coverage: 36 inches (914 mm).
4. Panel Height: As directed.

2.5 METAL WALL PANELS

A. Exposed-Fastener, Tapered-Rib, Metal Wall Panels: Formed with raised, trapezoidal major ribs and intermediate stiffening ribs symmetrically spaced or flat pan between major ribs; designed to be installed by lapping side edges of adjacent panels and mechanically attaching panels to supports using exposed fasteners in side laps.

1. Material: Zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet, 0.018-inch (0.46-mm), 0.024-inch (0.61-mm) or 0.030-inch (0.76-mm) nominal uncoated steel thickness. Pre-painted by the coil-coating process to comply with ASTM A755/A755M.

   a. Exterior Finish: As directed.
   b. Color: As directed.

2. Major-Rib Spacing: 6 inches (152 mm) or 12 inches (305 mm) o.c.
3. Panel Coverage: 36 inches (914 mm).
4. Panel Height: As directed.

B. Concealed-Fastener, Flush-Profile, Metal Wall Panels: Formed with vertical panel edges and a single wide recess, centered between panel edges or flush surface; with flush joint between panels; with 1-inch (25-mm) wide flange for attaching interior finish; designed to be installed by lapping and interconnecting side edges of adjacent panels and mechanically attaching through panel to supports using concealed fasteners and factory-applied sealant in side laps.

1. Material: Zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet, 0.024-inch (0.61-mm) or 0.030-inch (0.76-mm) nominal uncoated steel thickness. Pre-painted by the coil-coating process to comply with ASTM A755/A755M.

   a. Exterior Finish: Fluoropolymer or Siliconized polyester.
   b. Color: As directed.

2. Panel Coverage: 16 inches (406 mm).
3. Panel Height: 3 inches (76 mm).

2.6 METAL SOFFIT PANELS

A. General: Provide factory-formed metal soffit panels designed to be installed by lapping and interconnecting side edges of adjacent panels and mechanically attaching through panel to supports using concealed fasteners and factory-applied sealant in side laps. Include accessories required for weathertight installation.

B. Metal Soffit Panels: Match profile and material of metal roof or wall panels.

1. Finish: As directed.

2.7 THERMAL INSULATION

A. Faced Metal Building Insulation: ASTM C991, Type II, glass-fiber-blanket insulation; 0.5-lb/cu. ft. (8-kg/cu. m) density; 2-inch- (51-mm) wide, continuous, vapor-tight edge tabs; with a flame-spread index of 25 or less.

B. Unfaced Metal Building Insulation: ASTM C991, Type I, or NAIMA 202, glass-fiber-blanket insulation; 0.5-lb/cu. ft. (8-kg/cu. m) density; 2-inch- (51-mm-) wide, continuous, vapor-tight edge tabs; with a flame-spread index of 25 or less.

C. Retainer Strips: For securing insulation between supports, 0.025-inch (0.64-mm) nominal-thickness, formed, metallic-coated steel or PVC retainer clips colored to match insulation facing.

D. Vapor-Retarder Facing: ASTM C1136, with permeance not greater than 0.02 perm (1.15 ng/Pa x s x sq. m) when tested according to ASTM E96/E96M, Desiccant Method.

2.8 PERSONNEL DOORS AND FRAMES

A. Swinging Personnel Doors and Frames: Metal building system manufacturer's standard doors and frames; prepared and reinforced at strike and at hinges to receive factory- and field-applied hardware according to BHMA A156 Series.

1. Hardware:

a. Provide hardware for each door leaf, as follows:

1) Hinges: BHMA A156.1. Three plain or antifriction bearing, standard-weight, full-mortise, stainless-steel or bronze, template-type hinges; 4-1/2 by 4-1/2 inches (114 by 114 mm), with nonremovable pin.
2) Lockset: BHMA A156.2. Key-in-lever cylindrical or Mortise, with lever handle type.
3) Exit Device: BHMA A156.3. Touch- or push-bar type.
4) Threshold: BHMA A156.21. Extruded aluminum.
5) Silencers: Pneumatic rubber; three silencers on strike jambs of single door frames and two silencers on heads of double door frames.
6) Closer: BHMA A156.4. Surface-applied, standard-duty hydraulic type.
7) Weather Stripping: Vinyl applied to head and jambs, with vinyl sweep at sill.

B. Finishes for Personnel Doors and Frames:

1. Prime Finish: Factory-apply manufacturer's standard primer immediately after cleaning and pretreating.
2. Factory-Applied Paint Finish: Manufacturer's standard, complying with SDI A250.3 for performance and acceptance criteria.

a. Color and Gloss: As directed.

2.9 WINDOWS

A. Aluminum Windows: Metal building system manufacturer's standard, with self-flashing mounting fins, and as follows:

1. Type, Performance Class, and Performance Grade: Comply with AAMA/WDMA/CSA 101/I.S.2/A440 and as follows:

    a. Horizontal-Sliding Units: HS-LC25 or HS-CW30.
    b. Single-Hung Units: H-LC25 or H-CW30.
    c. Fixed Units: As directed.

2. Hardware: Manufacturer's standard; of aluminum, stainless steel, die-cast steel, malleable iron, or bronze; including the following:

    a. Cam-action sweep sash lock and keeper at meeting rails.
    b. Spring-loaded, snap-type lock at jambs.
    c. Pole-operated, cam-action locking device on meeting rail where rail is more than 72 inches (1830 mm) above floor.
    d. Lift handles for single-hung units.
    e. Nylon sash rollers for horizontal-sliding units.
    f. Steel or bronze operating arms.

3. Sliding-Type Weather Stripping: Woven-pile weather stripping of wool, polypropylene, or nylon pile and resin-impregnated backing fabric; complying with AAMA 701/702.
4. Insect Screens: Provide removable insect screen on each operable exterior sash, with screen frame finished to match window unit, and as follows:

B. Glazing: Comply with requirements specified in Section 088000 "Glazing."

C. Finish:

1. Mill finish.
2. Baked-Enamel Finish, Organic Coating: Thermosetting, modified-acrylic enamel primer/topcoat system complying with AAMA 2603 except with a minimum dry film thickness of 0.7 mil (0.02 mm), medium gloss.

    a. Color: As directed.

2.10 ACCESSORIES

A. General: Provide accessories as standard with metal building system manufacturer and as specified. Fabricate and finish accessories at the factory to greatest extent possible, by manufacturer's standard procedures and processes. Comply with indicated profiles and with dimensional and structural requirements.

1. Form exposed sheet metal accessories that are without excessive oil-canning, buckling, and tool marks and that are true to line and levels indicated, with exposed edges folded back to form hems.

B. Roof Panel Accessories: Provide components required for a complete metal roof panel assembly including copings, fasciae, corner units, ridge closures, clips, sealants, gaskets, fillers, closure strips, and similar items. Match material and finish of metal roof panels unless otherwise indicated.

C. Wall Panel Accessories: Provide components required for a complete metal wall panel assembly including copings, fasciae, mullions, sills, corner units, clips, sealants, gaskets, fillers, closure strips, and similar items. Match material and finish of metal wall panels unless otherwise indicated.

D. Flashing and Trim: Zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet, 0.018-inch (0.46-mm) nominal uncoated steel thickness, pre-painted with coil coating; finished to match adjacent metal panels.

E. Gutters: Zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet, 0.018-inch (0.46-mm) nominal uncoated steel thickness, pre-painted with coil coating; finished to match roof fascia and rake trim. Match profile of gable trim, complete with end pieces, outlet tubes, and other special pieces as required. Fabricate in minimum 96-inch (2438-mm) long sections, sized according to SMACNA's "Architectural Sheet Metal Manual."

1. Gutter Supports: Fabricated from same material and finish as gutters.
2. Strainers: Bronze, copper, or aluminum wire ball type at outlets.

F. Downspouts: Zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet, 0.018-inch (0.46-mm) nominal uncoated steel thickness, pre-painted with coil coating; finished to match metal wall panels. Fabricate in minimum 10-foot (3-m) long sections, complete with formed elbows and offsets.

1. Mounting Straps: Fabricated from same material and finish as gutters.

G. Roof Ventilators: Gravity type, complete with hardware, flashing, closures, and fittings.

1. Circular-Revolving Type: Minimum 20-inch (508-mm) diameter throat opening; zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet, 0.024-inch (0.61-mm) nominal uncoated steel thickness, with coil coating; finished to match metal roof panels; with matching base and rain cap.

   a. Type: Directional or stationary revolving.
   b. Bird Screening: Galvanized steel, 1/2-inch (13-mm) square mesh, 0.041-inch (1.04-mm) wire; or aluminum, 1/2-inch (13-mm) square mesh, 0.063-inch (1.6-mm) wire.
   c. Dampers: Spring-loaded, butterfly type; pull-chain operation; with pull chain of length required to reach within 36 inches (914 mm) of floor.

2. Continuous or Sectional-Ridge Type: Factory-engineered and -fabricated, continuous unit; Zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet, 0.018-inch (0.46-mm) nominal uncoated steel thickness, pre-painted with coil coating; finished to match metal roof panels. Fabricated in minimum 10-foot (3-m) long sections. Provide throat size and total length indicated, complete with side baffles, ventilator assembly, end caps, splice plates, and reinforcing diaphragms.

a. Bird Screening: Galvanized steel, 1/2-inch (13-mm) square mesh, 0.041-inch (1.04-mm) wire; or aluminum, 1/2-inch (13-mm) square mesh, 0.063-inch (1.6-mm) wire.
b. Dampers: Manually operated, spring-loaded, vertically rising type; chain and worm gear operator; with pull chain of length required to reach within 36 inches (914 mm) of floor.
c. Throat Size: 9 inches (229 mm) or 12 inches (305 mm), as standard with manufacturer, and as required to comply with ventilation requirements.

H. Roof Curbs: Zinc-coated (galvanized) or aluminum-zinc alloy-coated steel sheet, 0.048-inch (1.21-mm) nominal uncoated steel thickness pre-painted with coil coating; finished to match metal roof panels; with welded top box and bottom skirt, and integral full-length cricket; capable of withstanding loads of size and height indicated.

I. Pipe Flashing: Pre-molded, EPDM pipe collar with flexible aluminum ring bonded to base.

2.11 FABRICATION

A. General: Design components and field connections required for erection to permit easy assembly.

1. Mark each piece and part of the assembly to correspond with previously prepared erection drawings, diagrams, and instruction manuals.
2. Fabricate structural framing to produce clean, smooth cuts and bends. Punch holes of proper size, shape, and location. Members shall be free of cracks, tears, and ruptures.

B. Tolerances: Comply with MBMA's "Metal Building Systems Manual" for fabrication and erection tolerances.

C. Primary Framing: Shop fabricate framing components to indicated size and section, with baseplates, bearing plates, stiffeners, and other items required for erection welded into place. Cut, form, punch, drill, and weld framing for bolted field assembly.

D. Secondary Framing: Shop fabricate framing components to indicated size and section by roll forming or break forming, with baseplates, bearing plates, stiffeners, and other plates required for erection welded into place. Cut, form, punch, drill, and weld secondary framing for bolted field connections to primary framing.

E. Metal Panels: Fabricate and finish metal panels at the factory to greatest extent possible, by manufacturer's standard procedures and processes, as necessary to fulfill indicated performance requirements. Comply with indicated profiles and with dimensional and structural requirements.

1. Provide panel profile, including major ribs and intermediate stiffening ribs, if any, for full length of metal panel.

2.12 SOURCE QUALITY CONTROL

A. Special Inspection: Owner will engage a qualified special inspector to perform source quality control inspections and to submit reports.

1. Accredited Manufacturers: Special inspections will not be required if fabrication is performed by an IAS AC472-accredited manufacturer approved by authorities having jurisdiction to perform such Work without special inspection.

B. Product will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 ERECTION OF STRUCTURAL FRAMING

A. Erect metal building system according to manufacturer's written instructions and drawings.

B. Do not field cut, drill, or alter structural members without written approval from metal building system manufacturer's professional engineer.

C. Set structural framing accurately in locations and to elevations indicated, according to AISC specifications referenced in this Section. Maintain structural stability of frame during erection.

D. Base and Bearing Plates: Clean concrete- and masonry-bearing surfaces of bond-reducing materials, roughen surfaces prior to setting plates. Clean bottom surface of plates.

1. Set plates for structural members on wedges, shims, or setting nuts as required.
2. Tighten anchor rods after supported members have been positioned and plumbed. Do not remove wedges or shims but, if protruding, cut off flush with edge of plate before packing with grout.
3. Promptly pack grout solidly between bearing surfaces and plates so no voids remain. Neatly finish exposed surfaces; protect grout and allow to cure. Comply with manufacturer's written installation instructions for shrinkage-resistant grouts.

E. Align and adjust structural framing before permanently fastening. Before assembly, clean bearing surfaces and other surfaces that will be in permanent contact with framing. Perform necessary adjustments to compensate for discrepancies in elevations and alignment.

1. Level and plumb individual members of structure.
2. Make allowances for difference between temperature at time of erection and mean temperature when structure will be completed and in service.

F. Primary Framing and End Walls: Erect framing level, plumb, rigid, secure, and true to line. Level baseplates to a true even plane with full bearing to supporting structures, set with double-nutted anchor bolts. Use grout to obtain uniform bearing and to maintain a level base-line elevation. Moist-cure grout for not less than seven days after placement.

1. Make field connections using high-strength bolts installed according to RCSC's "Specification for Structural Joints Using High-Strength Bolts" for bolt type and joint type specified.

    a. Joint Type: Snug tightened or pretensioned as required by manufacturer.

G. Secondary Framing: Erect framing level, plumb, rigid, secure, and true to line. Field bolt secondary framing to clips attached to primary framing.

1. Provide rake or gable purlins with tight-fitting closure channels and fasciae.
2. Locate and space wall girts to suit openings such as doors and windows.
3. Provide supplemental framing at entire perimeter of openings, including doors, windows, ventilators, and other penetrations of roof and walls.

H. Steel Joists: Install joists and accessories plumb, square, and true to line; securely fasten to supporting construction according to SJI's "Standard Specifications and Load Tables for Steel Joists and Joist Girders," joist manufacturer's written instructions, and requirements in this Section.

1. Before installation, splice joists delivered to Project site in more than one piece.
2. Space, adjust, and align joists accurately in location before permanently fastening.
3. Install temporary bracing and erection bridging, connections, and anchors to ensure that joists are stabilized during construction.
4. Joist Installation: Bolt joists to supporting steel framework using carbon-steel bolts unless otherwise indicated.
5. Joist Installation: Bolt joists to supporting steel framework using high-strength structural bolts unless otherwise indicated. Comply with RCSC's "Specification for Structural Joints Using High-Strength Bolts" for high-strength structural bolt installation and tightening requirements.
6. Joist Installation: Weld joist seats to supporting steel framework.
7. Install and connect bridging concurrently with joist erection, before construction loads are applied. Anchor ends of bridging lines at top and bottom chords if terminating at walls or beams.

I. Bracing: Install bracing in roof and sidewalls where indicated on erection drawings.

1. Tighten rod and cable bracing to avoid sag.
2. Locate interior end-bay bracing only where indicated.

J. Framing for Openings: Provide shapes of proper design and size to reinforce openings and to carry loads and vibrations imposed, including equipment furnished under mechanical and electrical work. Securely attach to structural framing.

K. Erection Tolerances: Maintain erection tolerances of structural framing within AISC 303.

3.2 METAL PANEL INSTALLATION, GENERAL

A. General: Anchor metal panels and other components of the Work securely in place, with provisions for thermal and structural movement.

1. Field cut metal panels as required for doors, windows, and other openings. Cut openings as small as possible, neatly to size required, and without damage to adjacent metal panel finishes.

a. Field cutting of metal panels by torch is not permitted unless approved in writing by manufacturer.

2. Install metal panels perpendicular to structural supports unless otherwise indicated.
3. Flash and seal metal panels with weather closures at perimeter of openings and similar elements. Fasten with self-tapping screws.
4. Locate and space fastenings in uniform vertical and horizontal alignment.
5. Locate metal panel splices over structural supports with end laps in alignment.
6. Lap metal flashing over metal panels to allow moisture to run over and off the material.

B. Lap-Seam Metal Panels: Install screw fasteners using power tools with controlled torque adjusted to compress EPDM washers tightly without damage to washers, screw threads, or metal panels. Install screws in predrilled holes.

1. Arrange and nest side-lap joints so prevailing winds blow over, not into, lapped joints. Lap ribbed or fluted sheets one full rib corrugation. Apply metal panels and associated items for neat and weathertight enclosure. Avoid "panel creep" or application not true to line.

C. Metal Protection: Where dissimilar metals contact each other or corrosive substrates, protect against galvanic action by painting contact surfaces with corrosion-resistant coating, by applying rubberized-asphalt underlayment to each contact surface, or by other permanent separation as recommended by metal roof panel manufacturer.

D. Joint Sealers: Install gaskets, joint fillers, and sealants where indicated and where required for weatherproof performance of metal panel assemblies. Provide types of gaskets, fillers, and sealants indicated; or, if not indicated, provide types recommended by metal panel manufacturer.

1. Seal metal panel end laps with double beads of tape or sealant the full width of panel. Seal side joints where recommended by metal panel manufacturer.
2. Prepare joints and apply sealants to comply with requirements in Section 079200 "Joint Sealants."

3.3 METAL ROOF PANEL INSTALLATION

A. General: Provide metal roof panels of full length from eave to ridge unless otherwise indicated or restricted by shipping limitations.

1. Install ridge and hip caps as metal roof panel work proceeds.
2. Flash and seal metal roof panels with weather closures at eaves and rakes. Fasten with self-tapping screws.

B. Standing-Seam Metal Roof Panels: Fasten metal roof panels to supports with concealed clips at each standing-seam joint, at location and spacing and with fasteners recommended by manufacturer.

1. Install clips to supports with self-drilling or self-tapping fasteners.
2. Install pressure plates at locations indicated in manufacturer's written installation instructions.
3. Snap Joint: Nest standing seams and fasten together by interlocking and completely engaging factory-applied sealant.

4. Seamed Joint: Crimp standing seams with manufacturer-approved motorized seamer tool so that clip, metal roof panel, and factory-applied sealant are completely engaged.
5. Rigidly fasten eave end of metal roof panels and allow ridge end free movement for thermal expansion and contraction. Predrill panels for fasteners.
6. Provide metal closures at peaks, rake edges, rake walls and each side of ridge and hip caps.

C. Lap-Seam Metal Roof Panels: Fasten metal roof panels to supports with exposed fasteners at each lapped joint, at location and spacing recommended by manufacturer.

1. Provide metal-backed sealing washers under heads of exposed fasteners bearing on weather side of metal roof panels.
2. Provide sealant tape at lapped joints of metal roof panels and between panels and protruding equipment, vents, and accessories.
3. Apply a continuous ribbon of sealant tape to weather-side surface of fastenings on end laps and on side laps of nesting-type metal panels, on side laps of ribbed or fluted metal panels, and elsewhere as needed to make metal panels weatherproof to driving rains.
4. At metal panel splices, nest panels with minimum 6-inch (152-mm) end lap, sealed with butyl-rubber sealant and fastened together by interlocking clamping plates.

D. Metal Fascia Panels: Align bottom of metal panels and fasten with blind rivets, bolts, or self-drilling or self-tapping screws. Flash and seal metal panels with weather closures where fasciae meet soffits, along lower panel edges, and at perimeter of all openings.

3.4 METAL WALL PANEL INSTALLATION

A. General: Install metal wall panels in orientation, sizes, and locations indicated on Drawings. Install panels perpendicular to girts, extending full height of building, unless otherwise indicated. Anchor metal wall panels and other components of the Work securely in place, with provisions for thermal and structural movement.

1. Unless otherwise indicated, begin metal panel installation at corners with center of rib lined up with line of framing.
2. Shim or otherwise plumb substrates receiving metal wall panels.
3. When two rows of metal panels are required, lap panels 4 inches (102 mm) minimum.
4. When building height requires two rows of metal panels at gable ends, align lap of gable panels over metal wall panels at eave height.
5. Rigidly fasten base end of metal wall panels and allow eave end free movement for thermal expansion and contraction. Predrill panels.
6. Flash and seal metal wall panels with weather closures at eaves and rakes, and at perimeter of all openings. Fasten with self-tapping screws.
7. Install screw fasteners in predrilled holes.
8. Install flashing and trim as metal wall panel work proceeds.
9. Apply elastomeric sealant continuously between metal base channel (sill angle) and concrete, and elsewhere as indicated on Drawings; if not indicated, as necessary for waterproofing.
10. Align bottom of metal wall panels and fasten with blind rivets, bolts, or self-drilling or self-tapping screws.
11. Provide weatherproof escutcheons for pipe and conduit penetrating exterior walls.

B. Metal Wall Panels: Install metal wall panels on exterior side of girts. Attach metal wall panels to supports with fasteners as recommended by manufacturer.

3.5 METAL SOFFIT PANEL INSTALLATION

A. Provide metal soffit panels the full width of soffits. Install panels perpendicular to support framing.

B. Flash and seal metal soffit panels with weather closures where panels meet walls and at perimeter of all openings.

3.6 THERMAL INSULATION INSTALLATION

A. General: Install insulation concurrently with metal panel installation, in thickness indicated to cover entire surface, according to manufacturer's written instructions.

1. Set vapor-retarder-faced units with vapor retarder toward warm side of construction unless otherwise indicated. Do not obstruct ventilation spaces except for firestopping.
2. Tape joints and ruptures in vapor retarder, seal each continuous area of insulation to the surrounding construction to ensure airtight installation.
3. Install factory-laminated, vapor-retarder-faced blankets straight and true in one-piece lengths, with both sets of facing tabs sealed, to provide a complete vapor retarder.
4. Install blankets straight and true in one-piece lengths. Install vapor retarder over insulation, with both sets of facing tabs sealed, to provide a complete vapor retarder.

B. Blanket Roof Insulation: Comply with the following installation method:

1. Over-Framing Installation: Extend insulation and vapor retarder over and perpendicular to top flange of secondary framing. Hold in place by metal roof panels fastened to secondary framing.
2. Between-Purlin Installation: Extend insulation and vapor retarder between purlins. Carry vapor-retarder-facing tabs up and over purlin, overlapping adjoining facing of next insulation course and maintaining continuity of retarder. Hold in place with bands and crossbands below insulation.
3. Over-Purlin-with-Spacer-Block Installation: Extend insulation and vapor retarder over and perpendicular to top flange of secondary framing. Install layer of filler insulation over first layer to fill space formed by metal roof panel standoffs. Hold in place by panels fastened to standoffs.

    a. Thermal Spacer Blocks: Where metal roof panels attach directly to purlins, install thermal spacer blocks.

4. Two-Layers-between-Purlin-with-Spacer-Block Installation: Extend insulation and vapor retarder between purlins. Carry vapor-retarder-facing tabs up and over purlin, overlapping adjoining facing of next insulation course and maintaining continuity of retarder. Install layer of filler insulation over first layer to fill space between purlins formed by thermal spacer blocks. Hold in place with bands and crossbands below insulation.

a. Thermal Spacer Blocks: Where metal roof panels attach directly to purlins, install thermal spacer blocks.

5. Retainer Strips: Install retainer strips at each longitudinal insulation joint, straight and taut, nesting with secondary framing to hold insulation in place.

C. Blanket Wall Insulation: Extend insulation and vapor retarder over and perpendicular to top flange of secondary framing. Hold in place by metal wall panels fastened to secondary framing.

1. Retainer Strips: Install retainer strips at each longitudinal insulation joint, straight and taut, nesting with secondary framing to hold insulation in place.

3.7 DOOR AND FRAME INSTALLATION

A. General: Install doors and frames plumb, rigid, properly aligned, and securely fastened in place according to manufacturers' written instructions. Coordinate installation with wall flashings and other components. Seal perimeter of each door frame with elastomeric sealant used for metal wall panels.

B. Personnel Doors and Frames: Install doors and frames according to NAAMM-HMMA 840.

1. At fire-rated openings, install frames according to, and doors with clearances specified in, NFPA 80.

C. Field Glazing: Comply with installation requirements in Section 088000 "Glazing."

D. Door Hardware:

1. Install surface-mounted items after finishes have been completed at heights indicated in DHI's "Recommended Locations for Architectural Hardware for Standard Steel Doors and Frames."
2. Set units level, plumb, and true to line and location. Adjust and reinforce attachment substrates as necessary for proper installation and operation.
3. Drill and countersink units that are not factory prepared for anchorage fasteners. Space fasteners and anchors according to industry standards.
4. Set thresholds for exterior doors in full bed of sealant complying with requirements for concealed mastics specified in Section 079200 "Joint Sealants."

3.8 WINDOW INSTALLATION

A. General: Install windows plumb, rigid, properly aligned, without warp or rack of frames or sash, and securely fasten in place according to manufacturer's written instructions. Coordinate installation with wall flashings and other components. Seal perimeter of each window frame with elastomeric sealant used for metal wall panels.

1. Separate dissimilar materials from sources of corrosion or electrolytic action at points of contact with other materials by complying with requirements specified in AAMA/WDMA/CSA 101/I.S.2/A440.

B. Set sill members in bed of sealant or with gaskets, for weathertight construction.

C. Install windows and components to drain condensation, water penetrating joints, and moisture migrating within windows to the exterior.

D. Mount screens directly to frames with tapped screw clips.

3.9 ACCESSORY INSTALLATION

A. General: Install accessories with positive anchorage to building and weathertight mounting, provide for thermal expansion. Coordinate installation with flashings and other components.

1. Install components required for a complete metal roof panel assembly, including trim, copings, ridge closures, seam covers, flashings, sealants, gaskets, fillers, closure strips, and similar items.
2. Install components for a complete metal wall panel assembly, including trim, copings, corners, seam covers, flashings, sealants, gaskets, fillers, closure strips, and similar items.
3. Where dissimilar metals contact each other or corrosive substrates, protect against galvanic action by painting contact surfaces with corrosion-resistant coating, by applying rubberized-asphalt underlayment to each contact surface, or by other permanent separation as recommended by manufacturer.

B. Flashing and Trim: Comply with performance requirements, manufacturer's written installation instructions, and SMACNA's "Architectural Sheet Metal Manual." Provide concealed fasteners where possible, and set units true to line and level. Install work with laps, joints, and seams that will be permanently watertight and weather resistant.

1. Install exposed flashing and trim that is without excessive oil-canning, buckling, and tool marks and that is true to line and levels indicated, with exposed edges folded back to form hems. Install sheet metal flashing and trim to fit substrates and to result in waterproof and weather-resistant performance.
2. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim. Space movement joints at a maximum of 10 feet (3 m) with no joints allowed within 24 inches (600 mm) of corner or intersection. Where lapped or bayonet-type expansion provisions cannot be used or would not be sufficiently weather resistant and waterproof, form expansion joints of intermeshing hooked flanges, not less than 1 inch (25 mm) deep, filled with mastic sealant (concealed within joints).

C. Gutters: Join sections with riveted-and-soldered or lapped-and-sealed joints. Attach gutters to eaves with gutter hangers spaced as required for gutter size, but not more than 36 inches (914 mm) o.c. using manufacturer's standard fasteners. Provide end closures and seal watertight with sealant. Provide for thermal expansion.

D. Downspouts: Join sections with 1-1/2-inch (38-mm) telescoping joints. Provide fasteners designed to hold downspouts securely 1-inch (25 mm) away from walls; locate fasteners at top and bottom and at approximately 60 inches (1524 mm) o.c. in between.

1. Provide elbows at base of downspouts to direct water away from building.
2. Tie downspouts to underground drainage system indicated.

E. Circular Roof Ventilators: Set ventilators complete with necessary hardware, anchors, dampers, weather guards, rain caps, and equipment supports. Mount ventilators on flat level base. Install preformed filler strips at base to seal ventilator to metal roof panels.

F. Continuous Roof Ventilators: Set ventilators complete with necessary hardware, anchors, dampers, weather guards, rain caps, and equipment supports. Join sections with splice plates and end-cap skirt assemblies where required to achieve indicated length. Install preformed filler strips at base to seal ventilator to metal roof panels.

G. Roof Curbs: Install curbs at locations indicated on Drawings. Install flashing around bases where they meet metal roof panels.

H. Pipe Flashing: Form flashing around pipe penetration and metal roof panels. Fasten and seal to panel as recommended by manufacturer.

3.10 FIELD QUALITY CONTROL

A. Special Inspections: Owner will engage a qualified special inspector to perform field quality control special inspections and to submit reports.

B. Product will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 133419

SECTION 133423.16 - FABRICATED CONTROL BOOTHS.

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes fabricated steel control booths.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For control booths. Include plans, elevations, sections, details, accessories, and fastening and anchorage details, including mechanical fasteners. Submit anchor-bolt plans and templates.

C. Samples: For each type of exposed finish in manufacturer's standard sizes.

1.3 INFORMATIONAL SUBMITTALS

A. Sample warranties.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair finish or replace control booths that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Structural Performance: Control booths shall withstand the following loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Loads: As directed.

B. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change (Range): 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

C. Ballistic Resistance: Provide components, including windows, walls, and doors identical to those tested for compliance with requirements indicated, and as follows:

1. Listed and labeled as Level 1 – Level 8 as directed when tested according to UL 752.
2. Type I, Type IIA, Type II, Type IIIA, Type III or Type IV when tested according to NIJ STD-0108.01.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Safety Glazing Products: Category II materials complying with testing requirements in 16 CFR 1201.

1. Subject to compliance with requirements, obtain safety glazing products permanently marked with certification label of SGCC or another certification agency or manufacturer acceptable to authorities having jurisdiction.

F. Regulatory Requirements: Comply with applicable provisions in the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines and ICC A117.1

2.2 FABRICATED STEEL CONTROL BOOTHS

A. General: Fabricate control booths from an integrated set of mutually dependent components to form a completed assembly, ready for installation on Project site.

B. Building Style: As directed.

C. Structural Framework: Fabricated from 2-by-2-by-0.075-inch (50-by-50-by-1.90-mm) steel structural or mechanical tubing. Connect framework by welding.

D. Doors: As directed.

1. Sliding Door: Top suspended from aluminum track with ball-bearing rollers; 1-3/4 inches (44 mm) thick; tubular-frame design fabricated from clear-anodized aluminum or galvanized steel; with top half of door glazed. Equip door with deadlock, lock support, guide hardware, and full weather stripping.

a. Glazing: Fixed or Horizontal sliding unit with clear tempered float glass, clear insulating glass or ballistic-resistant glazing, UL 752, as directed.
b. Deadlock: Mortised, laminated-hook bolt type with removable cylinder capable of being master keyed.

2. Swinging Door: 1-3/4 inches (44 mm) thick; tubular-frame design fabricated from clear-anodized aluminum or galvanized steel; with top half of door glazed. Equip door with deadlock, three butt hinges, closer, and full weather stripping.

    a. Glazing: Fixed or Horizontal sliding unit with clear tempered float glass, clear insulating glass or ballistic-resistant glazing, UL 752 Level, as directed.
    b. Deadlock: Mortised, with lever handle and removable cylinder capable of being master keyed.

E. Windows: Extruded-aluminum sash frames glazed with clear tempered float glass, clear insulating glass or ballistic-resistant glazing, UL 752 Level, as directed.

1. Frame Finish: Manufacturer's standard mill or clear anodic.
2. Operable Windows: Equip windows with cam locks, weather stripping, and stainless-steel or nylon ball-bearing rollers.
3. Screens: Insect and security screens for each window.
4. Corner Shape: Square or Round.

F. Wall Panel Assembly: Assembly consisting of exterior face panel fabricated from 0.079-inch (2.01-mm) nominal-thickness, galvanized-steel sheet; and interior face panel fabricated from 0.064-inch (1.63-mm) or 0.052-inch (1.32-mm) nominal-thickness, galvanized-steel sheet; with 2-inch 51-mm) or 3-inch (76-mm) thick, rigid fiberglass or polystyrene board insulation in cavity between exterior and interior face panels.

G. Base/Floor Assembly: 4-inch (102-mm) or 3-inch (76-mm) high assembly consisting of perimeter frame welded to structural framework of booth. Fabricate frame from 2-by-4-inch (51-by-102-mm) galvanized-steel structural tubing; 0.108-inch (2.74-mm) nominal-thickness, C-shaped, galvanized-steel sheet channels; or galvanized structural-steel angles. Include anchor clips fabricated from 1/4-inch (6-mm) thick galvanized-steel plate, predrilled and welded to exterior of integral floor frame.

1. Finished Floor: 0.108-inch (2.74-mm) nominal-thickness, galvanized, rolled steel tread plate.
2. Subfloor and Finished Floor: Assembly consisting of 0.079-inch (2.01-mm) nominal-thickness, galvanized-steel sheet underside with rigid insulation core; covered by 0.125-inch- (3.18-mm-) thick, aluminum rolled tread plate; with overall assembly thickness of 2 inches (51 mm).
3. Subfloor and Finished Floor: Assembly consisting of one or two layer(s) of 3/4-inch (19-mm) thick plywood or oriented strand board with 0.125-inch (3.18-mm) thick, aluminum rolled tread plate, vinyl composition flooring or carpeting, as directed.

H. Base/Floor Assembly: No perimeter frame, with finished floor fabricated from 0.108-inch (2.74-mm) nominal-thickness, galvanized, rolled steel tread plate.

I. No perimeter frame, with surface of supporting concrete base as finished floor.

J. Flat Roof/Ceiling Assembly: Assembly consisting of exterior roof panels, interior ceiling panels, and insulation between exterior and interior panels; sloped to drain at booth perimeter.

1. Exterior Roof Panel: Fabricated from 0.079-inch (2.01-mm) or 0.064-inch (1.63-mm) nominal-thickness, galvanized-steel sheet; with painted finish or EPDM membrane, continuously welded seams, and full-perimeter gutter.
2. Interior Ceiling Panel: Fabricated from 0.079-inch (2.01-mm) nominal-thickness, galvanized-steel sheet; with fiberglass insulation in cavity between ceiling and roof.
3. Insulated Exterior/Interior Panel: Fabricated from 0.028-inch (0.71-mm) nominal-thickness, galvanized-steel sheet faces and expanded-foam insulation core.
4. Canopy Fascia: Fabricated from 0.079-inch (2.01-mm) nominal-thickness, galvanized-steel sheet, of manufacturer's standard design or custom design indicated on Drawings.

    a. Height: 6 inches (152 mm) or 8 inches (203 mm).
    b. Overhang: 3 inches (76 mm) beyond or Flush with face of walls below.

5. Downspouts: Integral, extending 3 inches (76 mm) beyond booth walls.
6. Roof scuppers.
7. Rooftop finial.

K. Work Counters: Full width of control booth, reinforced; with 16-inch (406-mm) wide storage or cash drawer below each counter and an access opening for electrical cords at each rear corner of counter.

1. Material: 0.078-inch (1.98-mm) thick, stainless-steel sheet 0.079-inch (2.01-mm) nominal-thickness, galvanized-steel sheet or 1/2-inch- (13-mm) thick particleboard with plastic-laminate finish.
2. Depth: 18 inches (457 mm), 20 inches (508 mm) or 22 inches (559 mm), as directed.

L. Electrical Power Service: 125-A, 120/240-V ac, single-phase, three-wire load center, with no fewer than four open circuits or service with 8-16 circuit-breaker panel; located under one end of work counter. Run copper wiring in 1/2-inch (13-mm) EMT conduit.

1. Provide one 120-V ground-fault circuit interrupter (GFCI) power receptacle(s).

M. Lighting Fixtures: One or two ceiling-mounted fluorescent lighting fixture(s), 48 inches (1219 mm) long, with acrylic lens and two 40-W lamps in each fixture. Provide single-pole switch mounted adjacent to door to control lighting fixture.

N. Heating Unit: Wall or roof mounted, thermostatically controlled, 110-V, 1500-W electric heater with fan-forced operation and with capacity of not less than 5000 Btu/h (1465 W). Enclose in enameled-steel cabinet and mount under work counter.

O. Cooling Unit: Wall or roof mounted, thermostatically controlled air conditioner with cooling capacity of not less than 13,500 Btu/h (3956 W). Enclose in enameled-steel cabinet.

P. Accessories: Provide the following for each control booth:

1. Through-wall transaction drawers and speaking apertures.
2. Antifatigue mats.
3. Exterior stainless-steel counter.
4. Floor or wall-mounted safe.
5. Signage: As directed.
6. Ventilation fan.

7. Intercom.
8. Traffic control lights.
9. Bollards.

Q. Anchorage: Cast-in-place anchor bolts or post-installed anchors fabricated from non-ferrous or corrosion-resistant materials, with allowable load or strength design greater than or equal to the design load as determined by testing conducted by a qualified testing agency.

R. Materials:

1. Zinc-Coated (Galvanized) Steel Sheet: ASTM A653/A653M, commercial quality, G90 (Z275) coating designation; mill phosphatized.
2. Galvanized, Rolled Steel Tread Plate: ASTM A786/A786M, rolled from steel plate complying with ASTM A572/A572M, Grade 55 (380); hot-dip galvanized according to ASTM A123/A123M.
3. Steel Structural Tubing: ASTM A500/A500M, Grade B.
4. Steel Plates, Shapes, and Bars: ASTM A36/A36M.
5. Steel Mechanical Tubing: ASTM A513, welded-steel mechanical tubing.
6. Zinc-Coated (Galvanized) Steel: Hot-dip galvanized according to ASTM A123/A123M.
7. Aluminum: Alloy and temper recommended by aluminum producer and manufacturer for type of use and finish indicated, and as follows:

    a. Sheet: ASTM B209 (ASTM B209M).
    b. Extruded Shapes: ASTM B221 (ASTM B221M).
    c. Rolled Tread Plate: ASTM B632/B632M, Alloy 6061-T4 or Alloy 6061-T6.

8. Stainless-Steel Sheet: ASTM A666, Type 304.
9. Plastic Laminate: NEMA LD 3, HGS or HGL grade.
10. Plywood: DOC PS 1, Exterior grade.
11. Particleboard: ANSI A208.1, Grade M-2.
12. Clear Tempered Float Glass: ASTM C1048, Kind FT, Condition A, Type I, Class 1, and Quality q3; 6 mm thick.
13. Clear Insulating Glass: ASTM E2190. Factory-assembled units consisting of two lites of 2.5-mm-thick clear float glass, ASTM C1036, Type I, Class 1, Quality q3, and dehydrated air space, with a total overall unit thickness of 1 inch (25 mm), 3/4 inch (19 mm) or 5/8 inch (16 mm), as directed and with manufacturer's standard dual seal.
14. Ballistic-Resistant Glazing: Tested to comply with bullet-resistant testing level indicated.

S. Finish: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.

1. Color and Gloss: As directed.

2.3 FABRICATION

A. Factory fabricate control booths completely.

B. Factory pre-glaze windows and doors.

C. Factory prewire control booths, ready for connection to service at Project site.

D. Fabricate control booths with forklift pockets in base of booth or removable lifting eye centered in roof.

E. Accessible Control Booths: Where indicated to be accessible, fabricate control booths as follows:

1. Provide service windows located no higher than 34 inches (865 mm) above exterior grade.
2. Provide door opening with minimum 32-inch (813-mm) clear width.
3. Provide minimum 60-inch (1525-mm) clear turning spacing within the booth.
4. Provide minimum 27-inch (685-mm) clearance beneath interior work surfaces. Locate work surfaces 28 inches (710 mm) minimum and 34 inches (865 mm) maximum above the floor.
5. Locate controls and operable parts no lower than 15 inches (381 mm) and no higher than 48 inches (1219 mm) above the floor where reach is unobstructed. Where side reach is obstructed, locate controls and operable parts no lower than 15 inches (381 mm) and no higher than 46 inches (1219 mm) above the floor.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install control booths according to manufacturer's written instructions.

B. Accessible Control Booths: Install with interior floor surface at same elevation as adjacent paved surfaces.

C. Set control booths plumb and aligned. Level baseplates true to plane with full bearing on concrete bases.

D. Fasten control booths securely to concrete base with anchorage indicated.

E. Connect to electrical power service and data systems.

F. Perform startup checks of heating and cooling units according to manufacturer's written instructions.

3.2 ADJUSTING

A. Adjust doors, operable windows, and hardware to operate smoothly, easily, properly, and without binding. Confirm that locks engage accurately and securely without forcing or binding.

B. Lubricate hardware and other moving parts.

C. After completing installation, inspect exposed finishes and repair damaged finishes.

END OF SECTION 133423.16

SECTION 134713 - CATHODIC PROTECTION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes passive cathodic protection systems that use magnesium anodes to protect iron and steel piping and tanks.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: For cathodic protection. Include plans, evaluations, sections, details, and attachments to other work.

1. Detail locations of cathodic protection equipment, devices, and outlets, with characteristics and cross-references to products.
2. Include calculations and details of anode designs.
3. Include labeling and identifying scheme for wires, cables, and test boxes.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Warranty: Sample of special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace permanent reference electrodes that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 15 or 30 years from date of Substantial Completion, as directed.

PART 2 - PRODUCTS

2.1 MAGNESIUM ANODES, TYPE II

A. Manufacturers and products listed in SpecAgent and MasterWorks Paragraph Builder are neither recommended nor endorsed by the AIA or AVITRU. Before inserting names, verify that manufacturers and products listed there comply with requirements retained or revised in descriptions and are both available and suitable for the intended applications. For definitions of terms and requirements for Contractor's product selection, see Section 016000 "Product Requirements."

B. Comply with ASTM B843.

C. Chemical composition as percent of weight shall be as follows:

1. Aluminum: 0.010 maximum.
2. Manganese: 0.50 to 1.3.
3. Zinc: 0.05 maximum.
4. Silicon: 0.50 maximum.
5. Copper: 0.02 maximum.
6. Nickel: 0.001 maximum.
7. Iron: 0.03 maximum.
8. Other Impurities: 0.05 each; 0.3 maximum total.
9. Magnesium: Remainder.

D. Anode Core: Galvanized steel with anode wire silver-soldered to the core. Connection shall be recessed and epoxy insulated for 600-V rating. Connection shall be covered with heat-shrinkable tubing, and insulation shall be extended over connection.

E. Anode Wires: Factory-installed cables, with copper conductors, suitable for direct burial; not less than No. 10 AWG with Type THWN insulation according to ASTM D1248 and NEMA WC 70/ICEA S-95-658; long enough to extend to accompanying junction box without splicing.

F. Anode Backfill: Backfill materials packaged in water-permeable fabric sack or cardboard container. Anodes shall be factory installed in packaged backfill using methods that result in dense packing of fill with factory-installed anode spacers to ensure centering of anode in packaged anode backfill. Backfill material shall have the following chemical composition by weight:

1. Hydrated Gypsum: 75 percent.
2. Bentonite Clay: 20 percent.
3. Anhydrous Sodium Sulfate: 5 percent.

2.2 PERMANENT REFERENCE ELECTRODES

A. Copper/copper sulfate (Cu/CuSO4), suitable for direct burial. Electrode shall be guaranteed by supplier for 15 - 30 years' service in the installed environment.

2.3 WIRE AND CABLE

A. Anode Header Cable: Single-conductor, Type HMWPE, insulated cable specifically designed for direct-buried dc service in cathodic protection installations.

1. Conductor: Stranded, annealed, uncoated copper, not less than No. 8 AWG, complying with ASTM B3 and ASTM B8.
2. Insulation: High-molecular-weight polyethylene, complying with NEMA WC 70/ICEA S-95-658.
3. Minimum Average Thickness of Insulation: 110 mils (2.8 mm) for Nos. 8 through 2 AWG, and 125 mils (3.2 mm) for Nos. 1 through 4/0 AWG; rated at 600 V.
4. Connectors: Copper compression type or exothermic welds.

B. Conductors and Cables: Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

1. Bonding Conductors for Joint and Continuity Bonds: Not less than No. 8 AWG, stranded, Type THWN copper conductors.
2. Flexible Pipe Coupling Bonds: Flexible copper straps with electrical resistance equal to No. 1/0 AWG stranded copper wire and with five holes for five exothermic welds to pipe.
3. Test Wires: No. 12 AWG, Type THWN copper conductors.
4. Resistance Wires: No. 16 or No. 22 AWG nickel-chromium wire.
5. Cables for Installation in Conduit: Type THWN copper conductors.

2.4 TEST STATIONS

A. Plastic Test Stations: Flush-mounted type, manufactured of high-impact-resistant PVC or polycarbonate with watertight conduit connections and cover and removable terminal board having at least five terminals.

B. Test Station Mounting Enclosures:

1. Non-Traffic-Area Boxes: Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."
2. Traffic-Area Boxes: Comply with requirements in Section 260543 "Underground Ducts and Raceways for Electrical Systems." Boxes shall have cast-iron covers with a welded bead legend "CP TEST."

2.5 SEALING, POTTING, AND DIELECTRIC COMPOUNDS

A. Sealing and Dielectric Insulating Compound: Comply with NACE RP0188. Black, rubber based, soft, permanently pliable, tacky, moldable, and unbacked; 0.125 inch (3 mm) or 0.5 inch (13 mm) thick.

B. Potting Compound: Comply with NACE RP0188. Cast-epoxy, two-package type; fabricated for this purpose and covered with heat-shrinkable tape.

C. Pressure-Sensitive, Vinyl-Plastic Electrical Tape: Comply with UL 510.

2.6 EXOTHERMIC WELDING MATERIALS

A. Exothermic Weld Kits: Specifically designed by manufacturer for welding materials and shapes required.

B. Exothermic Weld Caps: Dome of high-density polyethylene, 10-mil (0.254-mm) minimum thickness, filled with mastic and containing a tunnel portion to separate lead wire from exothermic weld.

2.7 COATING REPAIR MATERIALS

A. Touchup Coating Materials: Comply with requirements in Section 099600 "High-Performance Coatings" for coating systems for touchup of factory-applied coatings.

B. Adhesive-Applied Coating Materials: Coating materials shall be compatible with factory-applied coating system.

1. Nominal thickness of coating materials shall be not less than 8 mils (0.2 mm), 16 mils (0.4 mm), 24 mils (0.6 mm), 40 mils (1.0 mm) or 60 mils (1.5 mm), plus or minus 5 percent, as directed.
2. Coating materials shall be one of the following supplied by factory-applied coating system manufacturer:

    a. Polyvinyl-chloride, pressure-sensitive, adhesive tape.
    b. High-density polyethylene/bituminous rubber compound tape.
    c. Butyl rubber tape.
    d. Coal-tar epoxy.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

A. Comply with ANSI/IEEE C2 and NFPA 70.

B. Make connections to ferrous pipe and metal tanks using exothermic welding.

C. Coat welds with the coating repair material and apply an exothermic weld cap.

3.2 MAGNESIUM ANODE INSTALLATION

A. Install magnesium anodes at locations that clear obstructions. Install at least 36 inches (900 mm) and no more than 10 feet (3 m) from pipe or tank to be protected. Install in augered holes with top of anode 24 inches (600 mm) below pipe invert elevation or a minimum of 36 inches (900 mm) below finished grade. In soils that will collapse into augered holes, use casing of galvanized sheet steel.

B. Install anodes in a dry condition after plastic or waterproof protective covering has been completely removed from water-permeable permanent container that houses anode metal. Do

not use anode-connecting wire for lowering anode into hole. Backfill annular space around anode with fine earth in 6-inch (150-mm) layers; compact each layer using hand tools. Do not strike anode or connecting wire during backfilling and compacting. After backfilling and compacting to within 6 inches (150 mm) of finished grade, pour approximately 5 gal. (20 L) of water into each filled hole. After water has been absorbed by earth, complete backfilling to finished level.

C. If rock strata are encountered before achieving specified augured hole depth, install anodes horizontally at depth at least as deep as bottom of pipe to be protected.

D. Install anodes spaced as indicated, directly connected or connected through a test station to the pipeline, allowing slack in connecting wire to compensate for movement during backfill operation.

E. For tank protection, connect groups of anodes to collector cable. Make contact, through a test station, with tank to be protected.

F. Do not use resistance wires to reduce current output of individual or group anodes.

3.3 INSTALLATION OF REFERENCE ELECTRODES

A. Install directly beneath the buried metallic component being protected.

3.4 CABLE AND WIRE INSTALLATION

A. Install conductors, except anode wires, in PVC conduit with waterproof PVC junction boxes. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for conduit and its installation.

B. Anode Wire Installation: Cover trench bottom for the anode wire with 3-inch (76-mm) layer of sand or stone-free earth. Center wire on backfill layer and do not stretch or kink the conductor. Place backfill over wire in layers not exceeding 6 inches (150 mm) deep, compact each layer. Use clean fill, free from roots, vegetable matter, and refuse. Place cable underground-line warning tape within 18 inches (460 mm) of finished grade, above cable and conduit.

C. Bonding Conductors: Install conductors on metallic pipe and tanks, to and across buried flexible couplings, mechanical joints, and flanged joints except at places where insulating joints are specified. Welded and threaded joints are considered electrically continuous and do not require bonding.

1. Install at least two bonds between parts requiring bonding.
2. Bonding conductors must contain sufficient slack for anticipated movement between structures. Bonding conductors across pipe joints shall have not less than a 4-inch (100-mm) slack for pipe expansion, contraction, and soil stress.
3. Connect bonding conductors to pipe, coupling follower rings and coupling middle ring or sleeve. Connect bonding conductors with exothermic welds.

D. For wire splicing, use compression connectors or exothermic welds.

3.5 TEST STATIONS

A. Install test stations as follows:

1. At 1000-foot (300-m) intervals.
2. At insulating joints.
3. At both ends of casings when casing material is included in the cathodic protection system.
4. Where pipe crosses other metal pipes.
5. Where pipe connects to existing piping system.
6. Where pipe connects to dissimilar metal pipe.
7. At each tank component.

B. Install test stations on backfill complying with requirements for trench bottom fill for anode wires unless otherwise indicated.

C. Terminate test conductors on terminal boards and install a spare set of test leads at each testing location.

3.6 PIPE JOINTS

A. Insulating Flange Sets: Cover flanges with sealing and dielectric compound.

B. Insulating Unions: Install electrical isolation at each building entrance and at other locations indicated. Cover unions with sealing and dielectric compound.

3.7 INSULATING PIPE SLEEVES

A. Install insulating sleeves between metallic piping and metal buildings, hangers, supports, and other metal structures. Completely surround the metallic pipe for the full length of the steel contact and effectively prevent contact between the cathodically protected metallic pipe and other metallic structures. Support insulating sleeve to prevent damage to coating and to accommodate relative movement, vibrations, and temperature differentials.

3.8 COATINGS

A. Field Joints: Apply adhesive-applied coating system in a thickness to achieve corrosion protection equal to adjacent factory-applied coating.

3.9 FIELD QUALITY CONTROL

A. Comply with NACE RP0169 and NACE RP0285.

B. Testing Agency: Owner will engage or engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installation, including connections.

D. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

E. Tests and Inspections:

1. Static Pull Test: Choose, at random, one completed anode of each type for this destructive test. Demonstrate that anode wire connections have enough strength to withstand a minimum tensile load of 300 lb (136 kg). If test fails, replace all anodes and repeat test at another randomly selected anode.
2. Insulation Testing: Before anode system is connected to pipe and tank, test insulation at each insulating joint and fitting. Demonstrate that no metallic contact, or short circuit, exists between the two insulated sections of pipe and tank. Replace defective joints or fittings.
3. Bonding Tests: Test for electrical continuity across all bonded joints. Repair or add additional bonds until electrical continuity is achieved.
4. Baseline Potentials: After backfilling of pipe and pipe, tank, and anodes is completed, but before anodes are connected to pipe and tank, measure the static potential of pipe and tank to soil. Record initial measurements.
5. Anode Output: Measure electrical current as anodes or groups of anodes are connected to pipe and tank. Use a low-resistance ammeter. Record current, date, time, and location of each measurement.
6. Pipe and tank to-Reference Electrode Potential Measurements: On completion of installation of entire cathodic protection system, make electrode potential measurements according to NACE RP0169, using a copper/copper-sulfate reference electrode and a potentiometer-voltmeter, or a dc voltmeter with an internal resistance (sensitivity) of not less than 100,000 ohms per volt and a full scale of 1 or 2 V. Make measurements at same locations as those used for baseline potentials. Record voltage, date, time, and location of each measurement, using one of the following two methods:

    a. 0.85 V Negative Voltage: With cathodic system in operation, measure a negative voltage of at least minus 0.85 V between pipe or tank and a saturated copper/copper-sulfate reference electrode contacting the earth directly over pipe or tank.
    b. 100-mV Polarization Voltage: Determine polarization voltage shift by interrupting protective current and measuring polarization decay. An immediate voltage shift will occur if protective current is interrupted. Use voltage reading, after immediate shift, as base reading from which to measure polarization decay. Measure at least a minimum polarization voltage shift of 100 mV between pipe or tank and a saturated copper/copper-sulfate reference electrode contacting the earth directly over pipe or tank.

F. Location of Measurements for Piping: For coated piping or conduit, measure from reference electrode in contact with the earth directly over pipe. Measure at intervals not exceeding 400 feet (120 m). Make additional measurements at each distribution service riser, with reference electrode placed directly over service line.

G. Location of Measurements for Tanks: For underground tanks, measure from reference electrode located as follows:

1. Directly over center of tank.
2. At a point directly over tank and midway between each pair of anodes.
3. At each end of tank.

H. Inspect coatings; comply with NACE RP0188. Repair imperfections of factory-applied coatings as specified in "Coatings" Article.

1. Use electronic holiday detectors to detect coating imperfections.
2. All damage to the protective coating during transit and handling shall be repaired before installation.
3. Repair factory-applied coatings to have equal or better corrosion resistance than the factory-applied coating system. Field-repair material shall be of the type approved by, and shall be applied as recommended by, manufacturer of the coating material.

3.10 ADJUSTING

A. During the first year after Substantial Completion, test, inspect, and adjust cathodic protection system every three months to ensure its continued compliance with specified requirements.

3.11 DEMONSTRATION

A. Engage a factory-authorized service representative to train or train Owner's maintenance personnel to adjust, operate, and maintain cathodic protection system.

END OF SECTION 134713

SECTION 134900 - RADIATION PROTECTION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Lead sheet, strip, and plate.
2. Lead-lined gypsum board.
3. Lead glass.
4. Lead-lined, hollow-metal doors and door frames.
5. Lead-lined flush wood doors.
6. Lead-lined, observation-window frames.
7. Informational signs.

1.2 DEFINITIONS

A. Lead Equivalence: The thickness of lead that provides the same attenuation (reduction of radiation passing through) as the material in question under the specified conditions.

1. Lead equivalence specified for materials used in diagnostic x-ray rooms is as measured at 100 kV unless otherwise indicated.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference as directed.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: Show layout of radiation-protected areas. Indicate lead thickness or lead equivalence of components. Show components and installation conditions not fully dimensioned or detailed in product data.

1. Show ducts, pipes, conduit, and other objects that penetrate radiation protection; include details of penetrations.

D. Samples for Initial Selection: For units with factory-applied color finishes.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample Warranty: For warranty.

1.6 QUALITY ASSURANCE

1.7 WARRANTY

A. Warranty for Lead-Lined Flush Wood Doors: Comply with requirements in Section 081416 "Flush Wood Doors."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Provide materials and workmanship, including joints and fasteners, that maintain continuity of radiation protection at all points and in all directions equivalent to materials specified in thicknesses and locations indicated.

1. Materials, thicknesses, and configurations indicated are based on radiation protection design prepared by Owner's radiation health physicist. This design is available to Contractor on request.

B. Lead-Lined Assemblies: Unless otherwise indicated, provide lead thickness in doors, door frames, window frames, penetration shielding, joint strips, film transfer cabinets, and other items located in lead-lined assemblies not less than that indicated for assemblies in which they are installed.

C. Lead Glazing: Unless otherwise indicated, provide lead equivalence not less than that indicated for assembly in which glazing is installed.

D. Fire-Rated and Smoke-Control Door and Frame Assemblies: Comply with Section 081113 "Hollow Metal Doors and Frames" and Section 081416 "Flush Wood Doors", as directed.

2.2 MANUFACTURERS

A. Source Limitations: Obtain each type of radiation protection product from single source from single manufacturer unless otherwise indicated.

2.3 MATERIALS

A. Lead Sheet, Strip, and Plate: ASTM B749, Alloy UNS No. L51121 (chemical-copper lead).

B. Grout: ASTM C476, with a slump of 8 to 11 inches (200 to 280 mm) as measured according to ASTM C143/C143M.

1. For grouting frames of neutron-shielding doors, use coarse grout made with aggregate having a density not less than that used for concrete walls in which frames are installed.

C. Lead-Lined Gypsum Board: 1/2-inch (12.7-mm) or 5/8-inch (16-mm) thick gypsum board complying with Section 092613 "Gypsum Veneer Plastering," or Section 092900 "Gypsum Board," of width and length required for support spacing and to prevent cracking during handling, and with a single sheet of lead laminated to the back of the board.

1. Lead Sheet Lining: As directed.
2. Furnish 3-inch (75-mm) wide lead strips for wrapping metal stud flanges.
3. Furnish 2-inch (50-mm) wide lead strips for backing joints.
4. Furnish 5/16-inch (8-mm) or 5/8-inch (16-mm) lead disks for covering screw heads.
5. Furnish lead-headed nails for fastening gypsum board, accessories, and trim to wood members.
6. Furnish gypsum veneer plaster, accessories, and trim for lead-lined gypsum base complying with Section 092613 "Gypsum Veneer Plastering."
7. Furnish finishing materials, accessories, and trim for lead-lined gypsum board complying with Section 092900 "Gypsum Board."

D. Lead Glass: Lead-barium, polished glass containing not less than 60 percent heavy metal oxides, including not less than 48 percent lead oxide by weight.

1. Safety Glass: Tempered lead glass or Laminated glass.

a. Outer Ply: Clear float glass.
b. Interlayer: Clear polyvinyl butyral.
c. Inner Ply: Lead glass; thickness as needed to provide lead equivalence indicated.

E. Glazing Compounds, Gaskets, and Accessories: Comply with requirements in Section 088000 "Glazing."

F. Accessories and Fasteners: Manufacturer's standard fasteners and accessories as required for installation, maintaining same lead equivalence as rest of system.

G. Asphalt Coating: Cold-applied asphalt emulsion complying with ASTM D1187/D1187M.

H. Asphalt Felt: ASTM D226/D226M.

2.4 LEAD-LINED, HOLLOW-METAL DOORS

A. General: Steel doors complying with NAAMM-HMMA 861, except with a single continuous sheet of lead of thickness not less than that required for partition in which door is installed extending from top to bottom and edge to edge, installed either between back-to-back stiffeners or between stiffeners and stop face of door.

1. Line inverted channels at top and bottom of doors with lead sheet of same thickness used in door and close with filler channels to provide flush top and bottom edges.
2. Shield cutouts for locksets with lead sheet of same thickness used in door. Lap lining of cutouts with door lining 1 inch (25 mm).
3. Prepare doors to receive observation windows and louvers; cut and trim openings through doors in factory. Furnish removable stops for glazed openings.
4. Furnish lead-lined astragals for pairs of doors.
5. Factory fit doors to suit frame-opening sizes indicated with 1/16-inch (1.5-mm) clearance at heads and jambs and minimum clearance at bottom.
6. Finish: Apply manufacturer's standard primer immediately after cleaning and pretreating or factory-applied paint.

    a. Color and Gloss: As directed.

B. Lead Door Louvers: Louvers with 20 - 30 percent free area made from formed-lead sheet or lead extrusions of not less than lead thickness required for door in which louver is installed. Fabricate louvers to be lightproof with fixed maze-type blades that maintain required lead equivalence at all points and in all directions. Fit and assemble louvers in doors at factory.

2.5 LEAD-LINED, HOLLOW-METAL DOOR FRAMES

A. General: Steel door frames complying with NAAMM-HMMA 861, except 0.0667 inch (1.7 mm) thick, lined with lead sheet of thickness not less than that required for doors and walls where frames are used.
1. Furnish with additional reinforcements and internal supports to adequately carry the weight of lead-lined doors. Install reinforcements and supports before installing lead lining.
2. Form lead sheet to match frame contour, continuous in each jamb and across the head, lapping the stops. Form lead shields around areas prepared to receive hardware. Fabricate lead lining wide enough to maintain an effective lap with lead of adjacent shielding.
3. Finish: Apply manufacturer's standard primer immediately after cleaning and pretreating or factory-applied paint.

    a. Color and Gloss: As directed.

2.6 LEAD-LINED FLUSH WOOD DOORS

A. Lead-Lined Flush Wood Doors: Solid-core wood doors with lead lining, thickness not less than that required for partition in which door is installed or as directed.
1. Door Construction: Veneer face, five - seven ply, bonded core as directed.
2. Door Construction: Plastic-laminate face, three - five ply, bonded core, as directed.
3. Lead Lining: One or more continuous sheets of lead extending from top to bottom and edge to edge, constructed either in the core or between the core and faces, at manufacturer's option.
4. Lead Lining: One continuous sheet of lead extending from top to bottom and edge to edge, constructed in the core. Assemble lead lining and core with poured lead fasteners or steel bolts. Space fasteners not more than 1-1/2 inches (38 mm) from door edge and about 8 inches (200 mm) o.c. Countersink bolt heads and cover with lead.

5. Comply with Section 081416 "Flush Wood Doors" for grade, faces, veneer matching, performance grade, fabrication, finishing, and other requirements unless otherwise indicated.

B. Quality Standard: In addition to requirements specified, comply with AWI's, AWMAC's, and WI's "Architectural Woodwork Standards or WDMA I.S.1-A, "Architectural Wood Flush Doors."

1. Grade: As directed.
2. Face Veneer Species and Cut: As directed.

    a. Veneer Matching: Slip or book and running or balance match.
    b. Factory finish with stain and transparent catalyzed lacquer or conversion varnish.

3. Faces: Any closed-grain hardwood of mill option, for opaque finish.
4. Faces: Plastic laminate complying with NEMA LD 3, Grade HGS.

    a. Color, Patterns, and Finishes: As directed.

C. WDMA I.S.1-A Performance Grade: Extra Heavy Duty.

D. Lead Door Louvers: Louvers with 20 - 30 percent free area, made from formed-lead sheet or lead extrusions of not less than lead thickness required for door in which louver is installed. Fabricate louvers to be lightproof with fixed maze-type blades that maintain required lead equivalence at all points and in all directions. Fit and assemble louvers in doors at factory.

E. Prepare doors to receive observation windows and louvers; cut and trim openings through doors in factory. Provide removable wood stops for glazed openings.

F. Shield cutouts for locksets with lead sheet of same thickness used in door. Lap lining of cutouts with door lining.

G. Furnish lead-lined astragals for pairs of doors.

H. Factory fit doors to suit frame openings indicated with 1/16-inch (1.5-mm) clearance at heads and jambs and minimum clearance at bottom. Factory machine doors for hardware not surface applied.

2.7 LEAD-LINED, OBSERVATION-WINDOW FRAMES

A. General: Fabricate from 0.043-inch (1.1-mm) thick, formed-steel sheet or 0.064-inch (1.6-mm) thick aluminum extrusions with mitered corners, welded or bolted with concealed fasteners.

1. Line with lead sheet formed to match frame contour, continuous in each jamb and across head and sill, lapping the stops, and fabricated wide enough to maintain an effective lap with lead of adjoining assemblies.
2. Construct so lead lining overlaps glazing material perimeter by at least 3/8 inch (9.5 mm) and furnish removable stops.
3. Form sill with an opening for sound transmission. Offset sound passage to make opening lightproof and to maintain required lead equivalence at all points and in all directions.

2.8 INFORMATIONAL SIGNS

A. Informational Signs: Comply with Section 101423 "Panel Signage."

1. Color: As selected by Architect from manufacturer's full range of colors.
2. Provide copy indicated or as directed.
3. Indicate lead equivalence in millimeters and heights of radiation protection in inches (millimeters).

B. Informational Signs: High-pressure-laminate engraving stock with contrasting face and core, machine engraved from master templates for accurately formed letters, numbers, and symbols.

1. Color: As selected by Architect from manufacturer's full range of colors.
2. Provide copy indicated or as directed.
3. Indicate lead equivalence in millimeters and heights of radiation protection in inches (millimeters).

C. Rooms Where the Level of Protection Is Uniform Throughout: Provide one sign for each room indicating lead equivalence of partitions, ceilings, floors, doors, and other portions of radiation protection enclosure. Indicate height of radiation protection above floor or indicate that partitions are radiation protected to full height.

D. Rooms Where the Level of Protection Is Not Uniform Throughout: Provide one sign for each room with different lead equivalences in different locations. Indicate, in tabular form, lead equivalence of each wall, partition, ceiling, floor, door, and window. Indicate height of radiation protection above floor or indicate that partitions are radiation protected to full height. Indicate where lead equivalence changes or is not continuous.

E. Rooms Where Some Partitions Are without Radiation Protection: Provide one sign for each partition that contains radiation protection and indicate its lead equivalence. Indicate height of radiation protection above floor or indicate that partitions are radiation protected to full height.

F. Rooms Where Only the Door Has Radiation Protection: Provide one sign for each door indicating its lead equivalence.

2.9 DOOR AND DOOR FRAME FABRICATION

A. Hardware Preparation: Factory prepare doors and frames to receive templated mortised hardware; include cutouts, reinforcement, mortising, drilling, and tapping according to the Door Hardware Schedule and templates furnished as specified in Section 087100 "Door Hardware or Section 087111 "Door Hardware (Descriptive Specification)."

PART 3 - EXECUTION

3.1 EXAMINATION

3.2 INSTALLATION OF LEAD SHEETS IN CONCRETE FLOOR SLABS

A. Proceed with installation only after concrete surfaces are clean, dry, and free of depressions and sharp projections that could damage or penetrate lead sheet.

B. Apply a coat of asphalt mastic or paint to concrete surfaces before installing lead sheet.

C. Before installing floor lead sheet, place lead strips not less than 7 inches (175 mm) wide under the base of vertical wall protection. Extend lead strips approximately 3 inches (75 mm) into the shielded room area.

D. Lead Sheet, 1/8 Inch (3 mm) Thick or Less: Install in a single layer with a 2-inch (50-mm) minimum lap at joints.

E. Lead Sheet More Than 1/8 Inch (3 mm) Thick: Install in two or more layers with a 2-inch (50-mm) minimum lap at joints, or in a single layer with joints butted and covered with a 4-inch (100-mm) wide lead strip of same thickness.

F. Extend lead sheet at least 12 inches (300 mm) beyond radiation protection in walls of room.

G. In floor slabs above shielded rooms where lead sheet is indicated, extend lead sheet at least 12 inches (300 mm) beyond radiation protection in walls of room below.

H. At door openings, extend lead sheet at least 12 inches (300 mm) beyond radiation protection in walls and at least 12 inches (300 mm) beyond door opening on both sides except where lead-lined thresholds are provided.

I. After installation, apply a coat or two of asphalt coating on top surface of lead sheet and protect from damage until concrete topping is placed.

3.3 INSTALLATION OF LEAD-LINED GYPSUM BOARD

A. Install with long edge parallel to supports and lead lining facing supports. Provide blocking at end joints. Install using construction adhesive and supplementary fasteners.

B. Fastening to Metal Supports: Use steel drill screws spaced as recommended in writing by gypsum board manufacturer.

1. Install lead strips covering face of framing and wrap around flange to cover points of screws. Where possible, install lead-lined gypsum board before installing gypsum board on other side of partition, and do not fold lead strips back over inside of flange until after lead-lined gypsum board is applied. Apply lead disks recessed flush with surface of board over heads of screws securing trim.

2. Install lead strips, 2 inches (50 mm) wide and same thickness as lead lining, to face of supports and blocking where joints occur. Secure lead strips with construction adhesive. Provide shims at face of supports and blocking where joints do not occur.

C. Fastening to metal and wood Supports: Use steel drill screws spaced as recommended in writing by gypsum board manufacturer.

1. Install lead strips, 2 inches (50 mm) wide and same thickness as lead lining, to face of supports and blocking where joints occur. Secure lead strips with construction adhesive. Provide shims at face of supports and blocking where joints do not occur.
2. Apply lead disks recessed flush with surface of board over heads of screws securing gypsum board and trim.

D. Fastening to Wood Supports: Use lead-headed nails spaced as recommended in writing by gypsum board manufacturer. Drill pilot holes to prevent deforming nails or distorting board. Drive nail heads slightly below exposed surface.

1. Install lead strips, 2 inches (50 mm) wide and same thickness as lead lining, to face of supports and blocking where joints occur. Secure lead strips with construction adhesive. Provide shims at face of supports and blocking where joints do not occur.
2. Fasten accessories and trim to wood supports with lead-headed nails as specified above for fastening gypsum board.

E. Two-Layer System: Apply a facing sheet of gypsum board vertically over base sheet using laminating adhesive recommended in writing by gypsum board manufacturer. Offset joints in finish layer from joints in base layer and fasten at top and bottom of sheet to support finish panel until adhesive has set.

1. Locate fasteners above ceiling or behind wall base and cover fasteners with lead disks recessed flush with surface of board.

F. Openings: Extend lead-lined gypsum board into frames of openings, lapping lead lining with lead frames or frame linings at least 1 inch (25 mm). Arrange board around openings so neither horizontal nor vertical joints occur at corners of openings.

G. Install control and expansion joints where indicated, with appropriate trim accessories. Install lead strip on face of framing, extending across joint, and lap with lead lining of gypsum board.

H. Finish lead-lined gypsum board to comply with Section 092900 "Gypsum Board."

3.4 INSTALLATION OF LEAD-LINED DOORS AND DOOR FRAMES

A. Install lead-lined steel doors and door frames according to Section 081113 "Hollow Metal Doors and Frames."

1. Apply a coat of asphalt mastic or paint to lead lining in door frames where lead comes in contact with masonry or grout.

B. Install lead-lined wood doors according to Section 081416 "Flush Wood Doors."

C. Glazing: Comply with installation requirements in Section 088000 "Glazing" and with door manufacturer's written instructions.

D. Lap lead lining of frames over lining in walls at least 1 inch (25 mm).

E. Line astragals with lead sheet.

F. Hardware: Line covers, escutcheons, and plates to provide effective shielding at cutouts and penetrations of frames and doors. See Section 087100 "Door Hardware" for other installation requirements.

3.5 INSTALLATION OF LEAD-LINED OBSERVATION WINDOWS

A. Install observation windows according to manufacturer's written installation instructions.

1. Apply a coat of asphalt mastic or paint to lead lining in frames where lead comes in contact with masonry or grout.

B. Install windows level, plumb, square, true to line, and anchored securely in place to structural support.

C. Install leaded side of frame on radiation side of wall. Lap lead lining of frames over lining in walls at least 1 inch (25 mm).

D. Glazing: Comply with installation requirements in Section 088000 "Glazing" and with manufacturer's written instructions.

3.6 INSTALLATION OF PENETRATING ITEMS

A. At penetrations of lead linings, provide lead shields to maintain continuity of protection.

B. Provide lead linings, sleeves, shields, and other protection in thickness not less than that required in assembly being penetrated.

C. Secure shields at penetrations using adhesive or wire ties but not penetrating fasteners unless indicated on Drawings.

D. Outlet Boxes and Conduit: Cover or line with lead sheet lapped over adjacent lead lining at least 1 inch (25 mm). Wrap conduit with lead sheet for a distance of not less than 10 inches (250 mm) from box.

E. Duct Openings: Unless otherwise indicated, line or wrap ducts with lead sheet for distance from partition/ceiling equal to three times the largest opening dimension. Lap lead sheet with adjacent lead lining at least 1 inch (25 mm).

F. Piping: Unless otherwise indicated, wrap piping with lead sheet for a distance of not less than 10 inches (250 mm) from point of penetration.

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage or engage a qualified testing agency to perform tests and inspections after radiology equipment has been installed and placed in operating condition.

B. Correct deficiencies in or remove and replace radiation protection that inspection reports indicate does not comply with specified requirements.

C. Prepare test and inspection reports.

END OF SECTION 134900

SECTION 141000 - DUMBWAITERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes power dumbwaiters, power dumbwaiters with self-supporting dumbwaiter structures and hand dumbwaiters.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: For dumbwaiters.

1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.

D. Samples: For each exposed product and for each color and texture specified.

1.4 INFORMATIONAL SUBMITTALS

A. Product certificates.

B. Field quality-control reports.

C. Sample warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 WARRANTY

A. Manufacturer's Special Warranty: Manufacturer agrees to repair or replace components of dumbwaiters that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two, Five, years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Regulatory Requirements: Comply with ASME A17.1/CSA B44.

B. Fire-Rated Door and Frame Assemblies: Units complying with NFPA 80 that are listed and labeled by UL or another testing and inspecting agency acceptable to authorities having jurisdiction, for fire-protection ratings indicated, based on testing according to NFPA 252 or UL 10B.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 DUMBWAITERS

A. Power Dumbwaiter: Manufacturer's standard pre-engineered, electric-driving-machine dumbwaiter system.

1.
2. Car Platform Size: Minimum 16 inches (406 mm) wide by 16 inches (406 mm) deep, 18 inches (457 mm) wide by 26 inches (660 mm) deep, 24 inches (610 mm) wide by 24 inches (610 mm) deep, 36 inches (914 mm) wide by 36 inches (914 mm) deep, clear inside dimensions.
3. Car Inside Height: Manufacturer's standard, 24 inches (610 mm), 36 inches (914 mm), 48 inches (1220 mm), clear inside dimension to lowest point.
4. Rated Load: Minimum 50 lb (23 kg), 100 lb (45 kg), 200 lb (91 kg), 500 lb (227 kg).
5. Self-Supporting Structure: Structural-steel, self-supporting hoistway framing that supports vertical loads of unit only at base, with lateral support only at landing levels.
6. Rated Speed: 18 fpm (0.09 m/s), 25 fpm (0.13 m/s), 50 fpm (0.25 m/s), 75 fpm (0.38 m/s).
7. Electrical Characteristics:

    a. Horsepower: 1, 2, 5 hp.
    b. Voltage: 115-V ac, 208-V ac, 230-V ac, single phase, 60 Hz.
    c. Voltage: 208-V ac, 230-V ac, three phase, 60 Hz.

8. Car: Manufacturer's standard construction and as follows:

    a. Number of Shelves: One, Two, As indicated on Drawings.
    b. Light Fixture: Manufacturer's standard recessed light fixture, located in ceiling near front of car.

9. Car Entrance: Power, Manually, operated, vertically biparting doors, vertically sliding door or vertically sliding gate.

a. Automatic Hoistway-Door Operation: Equip car entrance with connecting linkages to operate hoistway doors at each landing when car is present.
b. Car-Door Vision Panel: Glazed port through car door aligning with vision panel in hoistway door.
c. Material and Finish: Match car-enclosure walls.

10. Hoistway Doors and Frames: See Equip door with linkages to allow opening only when car is present at landing.
11. Hoistway Doors and Frames: Power, Manually, operated, single-swing door vertically biparting doors or vertically sliding door equipped with linkages to allow opening only when car is present at landing.

a. Construction: Manufacturer's standard construction except as indicated on Drawings as selected by Architect from manufacturer's full range.
b. Fire Rating: 1 hour, 1-1/2 hours with 30-minute temperature rise of 450 deg F (250 deg C).
c. Hardware: As selected by Architect from manufacturer's full range. Equip fire-rated doors with fire-rated hardware and closers.
d. Vision Panel: Glazed port through door, sufficient for observation that car is at landing and aligning with vision panel in car door.

12. Steel Finish: Factory primed for field painting, Factory-applied, baked-enamel or powder-coat finish.

a. Color: As indicated by manufacturer's designations, Match Architect's sample as selected by Architect from manufacturer's full range.

13. Stainless-Steel Finish: Manufacturer's standard, No. 4 directional satin polish.
14. Plastic-Laminate Finish: As indicated by manufacturer's designations Match Architect's sample, As selected by Architect from manufacturer's full range.
15. Wood-Veneer Species and Finish: Species as indicated by manufacturer's designations, Match Architect's sample, as selected by Architect from manufacturer's full range, Birch, Red oak, White ash, and or as directed with transparent finish. transparent finish over stain. Wood finish as specified in Section 099300 "Staining and Transparent Finishing."

B. Hand Dumbwaiter: Manufacturer's standard pre-engineered, manually operated dumbwaiter system.
1. Car Platform Size: Minimum 18 inches (457 mm) wide by 16 inches (406 mm) deep, 24 inches (610 mm) wide by 20 inches (508 mm) deep, 36 inches (914 mm) wide by 36 inches (914 mm) deep, clear inside dimensions.
2. Car Inside Height: Manufacturer's standard, 30 inches (762 mm), 42 inches (1067 mm), clear inside dimension to lowest point.
3. Rated Load: Minimum 70 lb (32 kg), 100 lb (45 kg), 200 lb (91 kg).
4. Lifting Ratio: 3 to 4.5, 3.5 to 5, 5 to 7.5, 6 to 8.5.
5. Lifting Ratio: As required to operate car containing rated load with a manually applied, maximum force of 5 lbf (22 N), 10 lbf (44 N), 15 lbf (67 N).
6. Car: Manufacturer's standard construction except as indicated on Drawings as selected by Architect from manufacturer's full range.
7. Car Entrance: Manually operated, vertically bi-parting doors, vertically sliding door, horizontally collapsing gates or vertically sliding gate.

a. Car-Door Vision Panel: Glazed port through car door, aligning with vision panel in hoistway door.
b. Material and Finish: Match car-enclosure walls.

8. Hoistway Doors and Frames: See Equip door with linkages to allow opening only when car is present at landing.
9. Hoistway Doors and Frames: Manually operated, single-swing door, vertically bi-parting doors or vertically sliding door, equipped with linkages to allow opening only when car is present at landing.

    a. Construction: Manufacturer's standard construction except as indicated on Drawings as selected by Architect from manufacturer's full range.
    b. Fire Rating: 1 hour, 1-1/2 hours, with 30-minute temperature rise of 450 deg F (250 deg C).
    c. Hardware: As selected by Architect from manufacturer's full range. Equip fire-rated doors with fire-rated hardware and closers.
    d. Vision Panel: Glazed port through door, sufficient for observation that car is at landing and aligning with vision panel in car door.

10. Steel Finish: Factory primed for field painting, Factory-applied, baked-enamel or powder-coat finish.

    a. Color: As indicated by manufacturer's designations, Match Architect's sample, As selected by Architect from manufacturer's full range.

11. Stainless-Steel Finish: Manufacturer's standard, No. 4 directional satin polish.
12. Plastic-Laminate Finish: As indicated by manufacturer's designations, Match Architect's sample, As selected by Architect from manufacturer's full range.
13. Wood-Veneer Species and Finish: Species as indicated by manufacturer's designations, Match Architect's sample, As selected by Architect from manufacturer's full range, Birch, Red oak, White ash and or as directed, with transparent finish. Transparent finish over stain. Wood finish as specified in Section 099300 "Staining and Transparent Finishing."

2.3 OTHER COMPONENTS

A. Access Door and Frame: See Manufacture’s standard

B. Access Door and Frame: Manufacturer's standard, Flush hollow-metal swing door.

1. Fire Rating: 1 hour, 1-1/2 hours, with 30-minute temperature rise of 450 deg F (250 deg C).
2. Hardware: As selected by Architect from manufacturer's full range. Equip fire-rated doors with fire-rated hardware and closers.

C. Control System for Power Dumbwaiters: Manufacturer's standard, fully automatic, call-and-send control system that responds to momentary push-button signals at each landing.

D. Signal Equipment for Power Dumbwaiters: Manufacturer's standard signal equipment at each landing push-button station; include call button, send button for each landing served, and illuminated "car-in-use" light that flashes when car arrives at landing until door is opened.

Station recessed, set in wall adjacent to dumbwaiter, with surface-mounted, stainless-steel faceplate.

1. Power-Operated Door Buttons: Momentary-pressure "door open" and constant-pressure "door close" buttons.
2. Arrival Signal: Manufacturer's standard arrival lantern and gong system.
3. Audible Service Call Signal: Manufacturer's standard buzzer system, located on top of each car.

2.4 MATERIALS

A. Plywood: Manufacturer's standard plywood.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with ASME A17.1/CSA B44 and manufacturer's written instructions.

B. Alignment: Coordinate hoistway doors with dumbwaiter travel and car positioning for accurate alignment and required clearances between dumbwaiter components including car, hoistway doors, sills, and door frame at each landing.

C. Set sills flush with finished surface of landings. Fill space under sills solidly with non-shrink, nonmetallic grout.

D. Adjust car stops for accurate stopping at each landing, within required tolerances.

E. Lubricate operating parts of dumbwaiter, including wire ropes, guide rails, door tracks, and hardware.

3.2 FIELD QUALITY CONTROL

A. Acceptance Testing: On completion of installation and before permitting use of dumbwaiters, have Installer perform acceptance inspections and tests according to ASME A17.1/CSA B44 and authorities having jurisdiction.

B. Operating Test: Have Installer load dumbwaiters to rated load and operate continuously for 30 minutes between lowest and highest landings served. Readjust stops, signal equipment, and other devices for accurate stopping and operation of system.

C. Dumbwaiters will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.3 DEMONSTRATION

A. Engage a factory-authorized service representative to train, Train Owner's maintenance personnel to adjust, operate, and maintain dumbwaiters.

END OF SECTION 141000

SECTION 142100 - ELECTRIC TRACTION ELEVATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes electric traction passenger and service elevators.

1.2 ACTION SUBMITTALS

A. Product Data: Include capacities, sizes, performances, operations, safety features, finishes, and similar information.

B. Shop Drawings:

1. Include plans, elevations, sections, and large-scale details indicating service at each landing, coordination with building structure, relationships with other construction, and locations of equipment.
2. Indicate maximum dynamic and static loads imposed on building structure at points of support, and maximum and average power demands.

C. Samples: For finishes involving color selection.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For elevator equipment, accessories, and components, from manufacturer.

B. Manufacturer Certificates: Signed by elevator manufacturer certifying that hoistway, pit, and machine room layout and dimensions, as indicated on Drawings, and electrical service including standby power generator, as shown and specified, are adequate for elevator system being provided.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

B. Inspection and Acceptance Certificates and Operating Permits: As required by authorities having jurisdiction for normal, unrestricted elevator use.

C. Continuing Maintenance Proposal: Submit a continuing maintenance proposal from Installer to Owner, in the form of a standard one-year, two-year, five-year and or as directed. Maintenance agreement, starting on date initial maintenance service is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.

1.5 WARRANTY

A. Manufacturer's Special Warranty: Manufacturer agrees to repair, restore, or replace elevator work that fails in materials or workmanship within specified warranty period.

1. Warranty Period: As directed, year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 ELEVATOR MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Regulatory Requirements: Comply with ASME A17.1/CSA B44.

B. Accessibility Requirements: Comply with requirements for accessible elevators in the United States Access Board's ADA-ABA Accessibility Guidelines and with ICC A117.1.

C. Seismic Performance: Elevator system shall withstand the effects of earthquake motions determined according to ASCE/SEI 7 and shall comply with elevator seismic requirements in ASME A17.1/CSA B44.

1. Project Seismic Design Category: C, D, E, F.
2. Elevator Component Importance Factor: 1.5, 1.0.
3. Design earthquake spectral response acceleration short period (Sds) for Project is.
4. Provide earthquake equipment required by ASME A17.1/CSA B44.
5. Provide seismic switch required by ASCE/SEI 7.

2.3 ELEVATORS

A. Elevator System, General: Manufacturer's standard elevator systems. Unless otherwise indicated, manufacturer's standard components shall be used, as included in standard elevator systems and as required for complete system.

B. Elevator Description:

1. Group Number: Number for each group of elevators that share a group operation system.
2. Elevator Number(s): Elevator number(s) as indicated on Drawings.
3. Emergency Elevator Number(s): Elevator number(s) as indicated on Drawings.
4. Service Elevator Number(s): Elevator number(s) as indicated on Drawings.
5. Machine Type: Geared, Gearless traction.
6. Rated Load: 2000 lb (908 kg), 2100 lb (953 kg), 2500 lb (1135 kg), 3000 lb (1362 kg), 3500 lb (1589 kg), 4000 lb (1816 kg), 4500 lb (2043 kg), 5000 lb (2270 kg).
7. Freight Loading Class for Service Elevator(s): Class A.
8. Rated Speed: 200 fpm (1.0 m/s), 350 fpm (1.8 m/s), 400 fpm (2.0 m/s), 450 fpm (2.3 m/s), 500 fpm (2.5 m/s), 700 fpm (3.6 m/s), 800 fpm (4.1 m/s), 1000 fpm (5.1 m/s), 1200 fpm (6.1 m/s), 1400 fpm (7.1 m/s).

9. Operation System: Selective-collective automatic operation, Group automatic operation, Group automatic operation with demand-based dispatching, Destination-based group automatic operation.
10. Auxiliary Operations:

    a. Standby power operation.
    b. Battery-powered automatic evacuation.
    c. Automatic dispatching of loaded car.
    d. Nuisance-call cancel.
    e. Loaded-car bypass.
    f. Distributed parking.
    g. Off-peak operation.
    h. Automatic operation of lights and ventilation fans.
    i. Emergency hospital, Priority, service at all floors.
    j. Independent service for service elevator, one car in group, all cars in group.

11. Security Features: Card-reader operation, Key-switch operation.
12. Dual Car-Control Stations: Provide two car-control stations in each elevator; equip only one with required key-switches if any.
13. Car Enclosures:

    a. Inside Width: Not less than, 64 inches (1626 mm), 66 inches (1676 mm), 68 inches (1727 mm), 70 inches (1778 mm), 80 inches (2032 mm), 89-1/2 inches (2273 mm), 92 inches (2337 mm) from side wall to side wall.
    b. Inside Depth: Not less than, 51 inches (1295 mm), 53 inches (1346 mm), 56-1/2 inches (1435 mm), 60 inches (1524 mm), 64-1/2 inches (1638 mm), 66 inches (1676 mm), 68 inches (1727 mm), 88 inches (2235 mm), 89 inches (2261 mm), 90-1/2 inches (2298 mm), 93-1/2 inches (2375 mm), 95 inches (2413), 96-1/2 inches (2451 mm), 101 inches (2565 mm), 102 inches (2591 mm), 104 inches (2641 mm), 108 inches (2743 mm) from back wall to front wall (return panels).
    c. Inside Height: Not less than 93 inches (2362 mm), to underside of ceiling.
    d. Front Walls (Return Panels): Polished stainless steel, No. 8 finish, Satin stainless steel, No. 4 finish.
    e. Car Fixtures: Polished stainless steel, No. 8 finish, Satin stainless steel, No. 4 finish.
    f. Side and Rear Wall Panels: Enameled or powder-coated steel, Plastic laminate, Satin stainless steel, No. 4 finish.
    g. Door Faces (Interior): Enameled or powder-coated steel, Polished stainless steel, No. 8 finish, Satin stainless steel, No. 4 finish, Plastic laminate.
    h. Ceiling: Luminous ceiling, Enameled or powder-coated steel, Polished stainless steel, No. 8 finish, Satin stainless steel, No. 4 finish, Reflective metallic-finish, plastic-laminate, stainless steel, Reflective metallic-finish, plastic-laminate, bronze.
    i. Handrails: 1-1/2 inches (38 mm) round, 1/2 by 2 inches (13 by 50 mm) rectangular, anodized aluminum, mirror-polished stainless steel, No. 8 finish, satin stainless steel, No. 4 finish, at sides and rear of car.
    j. Floor prepared to receive carpet (specified in Section 096816 "Sheet Carpeting").
    k. Floor prepared to receive resilient flooring (specified in Section 096516 "Resilient Sheet Flooring").

14. Hoistway Entrances:

a. Width: 36 inches (914 mm), 42 inches (1067 mm), 48 inches (1219 mm), 54 inches (1372 mm).
b. Height: 84 inches (2134 mm).
c. Type: Single-speed side sliding, Two-speed side sliding, Single-speed center opening, Two-speed center opening.
d. Frames at First Floor, at Basement Floors: Enameled or powder-coated steel, Polished stainless steel, No. 8 finish, Satin stainless steel, No. 4 finish.
e. Frames at Other Floors: Enameled or powder-coated steel, Polished stainless steel, No. 8 finish, Satin stainless steel, No. 4 finish.
f. Doors and Transoms, at First Floor, at Basement Floors: Enameled or powder-coated steel, Polished stainless steel, No. 8 finish, Satin stainless steel, No. 4 finish, Plastic laminate.
g. Doors and Transoms, at Other Floors: Enameled or powder-coated steel, Polished stainless steel, No. 8 finish, Satin stainless steel, No. 4 finish, Plastic laminate.

15. Hall Fixtures at First Floor, at Basement Floors: Polished stainless steel, No. 8 finish, Satin stainless steel, No. 4 finish.
16. Hall Fixtures at Other Floors: Polished stainless steel, No. 8 finish, Satin stainless steel, No. 4 finish.
17. Additional Requirements:

a. Provide inspection certificate in each car, mounted under acrylic cover with frame made from polished stainless steel, No. 8 finish, satin stainless steel, No. 4 finish, polished bronze, lacquered, satin bronze, lacquered.
b. Provide hooks for protective pads in service car, all cars and one, two, complete set(s) of full-height protective pads.

2.4 TRACTION SYSTEMS

A. Elevator Machines: Variable-voltage, variable-frequency, ac-type hoisting machines or variable-voltage dc-type hoisting machines and solid-state power converters.

1. Provide regenerative system that complies with the IgCC.
2. Limit total harmonic distortion of regenerated power to 5 percent per IEEE 519.
3. Provide means for absorbing regenerated power when elevator system is operating on standby power.

B. Fluid for Hydraulic Buffers: Fire-resistant fluid.

C. Machine Beams: Provide steel framing to support elevator hoisting machine and deflector sheaves from the building structure. Comply with Section 055000 "Metal Fabrications" for materials and fabrication.

D. Guides: Roller guides or polymer-coated, nonlubricated sliding guides. Provide guides at top and bottom of car and counterweight frames.

2.5 OPERATION SYSTEMS

A. General: Provide manufacturer's standard microprocessor operation systems as required to provide type of operation indicated.

B. Group Automatic Operation with Demand-Based Dispatching: Provide reprogrammable group automatic system that assigns cars to hall calls based on a dispatching program designed to minimize passenger wait time. System automatically adjusts to demand changes for different traffic conditions including heavy incoming, heavy two-way, heavy outgoing, and light off-hours as variations of normal two-way traffic.

C. Auxiliary Operations:

1. Single-Car Standby Power Operation: On activation of standby power, car is returned to a designated floor and parked with doors open. Car can be manually put in service on standby power, either for return operation or for regular operation, by switches in control panel located at main lobby fire-command station. Manual operation causes automatic operation to cease.
2. Single-Car Battery-Powered Automatic Evacuation: If power fails and car is at a floor, it remains at that floor, opens its doors, and shuts down. If car is between floors, it moves to the next floor above or below, opens its doors, and shuts down. System includes rechargeable battery and automatic recharging system.
3. Group Standby Power Operation: On activation of standby power, cars are returned, one at a time, to a designated floor and parked with doors open. If a car cannot be returned, it is removed from the system. When all cars have been returned or removed from the system, one car can be put in service on standby power by a selector switch in control panel located at main lobby, fire-command station.
4. Group Battery-Powered Automatic Evacuation: If power fails, cars that are at a floor remain at that floor, open their doors, and shut down. Cars that are between floors are moved one at a time to the next floor above or below, open their doors, and shut down. System includes rechargeable battery and automatic recharging system.
5. Off-Peak Operation: During periods of low traffic, half of the elevators in a group shall be taken out of service and switched to low power mode.
6. Independent Service: Key-switch in car-control station removes car from group operation and allows it to respond only to car calls. Key cannot be removed from key-switch when car is in independent service. When in independent service, doors close only in response to door close button.
7. Emergency Hospital, Priority Service: Service is initiated by a key-switch, card reader, remote switch at designated floors. One elevator is removed from group operation and directed to the floor where service was initiated. Car is placed in operation by selecting a floor and pressing door close button or by operating keyswitch to put car in independent service. After responding to floor selected or being removed from independent service, car is returned to group operation.
8. Automatic Operation of Lights and Fan: When elevator is stopped and unoccupied with doors closed, lighting, ventilation fan, and cab displays are de-energized after five minutes and are re-energized before car doors open.

D. Security features shall not affect emergency firefighters' service.

1. Card-Reader Operation: System uses card readers at car-control stations to authorize calls. Security system determines which landings and at what times calls require

authorization by card reader. Allow space for card reader in car, Provide stripe-swipe card reader integral with each car-control station.

a. Security access system equipment is specified in Section 281500 "Access Control Hardware Devices." not in the Contract.

2. Key-switch Operation: Push buttons are activated and deactivated by security key-switches at car-control stations.

2.6 DOOR REOPENING DEVICES

A. Infrared Array: Provide door reopening device with uniform array of 36 or more microprocessor-controlled, infrared light beams projecting across car entrance. Interruption of one or more light beams shall cause doors to stop and reopen.

B. Nudging Feature: After car doors are prevented from closing for predetermined adjustable time, through activating door reopening device, a loud buzzer shall sound and doors shall begin to close at reduced kinetic energy.

2.7 CAR ENCLOSURES

A. General: Provide enameled or powder-coated steel car enclosures to receive removable, steel-framed car enclosures with nonremovable wall panels, with removable, car roof, access doors, power door operators, and ventilation.

1. Provide standard railings complying with ASME A17.1/CSA B44 on car tops where required by ASME A17.1/CSA B44.

B. Materials and Finishes: Manufacturer's standards, but not less than the following:

1. Enameled or Powder-Coated Steel Wall Panels: Flush, formed-metal construction; fabricated from cold-rolled steel sheet. Provide with factory-applied enamel or powder-coat finish; colors as selected by Architect from manufacturer's full range.
2. Stainless-Steel Wall Panels: Flush, formed-metal construction; fabricated from stainless-steel sheet.
3. Plastic-Laminate Wall Panels: Plastic laminate adhesively applied to 1/2-inch (13-mm) fire-retardant-treated particleboard, manufacturer's standard honeycomb core, manufacturer's standard formed metal panels with plastic-laminate panel backing and manufacturer's standard protective edge trim. Panels shall have a flame-spread index of 25, 75 or less, when tested according to ASTM E84. Plastic-laminate color, texture, and pattern as selected by Architect from plastic-laminate, elevator manufacturer's full range.
4. Enameled or Powder-Coated Steel Doors: Flush, hollow-metal construction; fabricated from cold-rolled steel sheet. Provide with factory-applied enamel or powder-coat finish; colors as selected by Architect from manufacturer's full range.
5. Primed or Powder-Coated Steel Doors: Flush, hollow-metal construction; fabricated from cold-rolled steel sheet, with factory-applied, rust-resistant primer or powder-coating for field painting.
6. Stainless-Steel Doors: Flush, hollow-metal construction; fabricated from stainless-steel sheet or by laminating stainless-steel sheet to exposed faces and edges of enameled or

powder-coated steel doors using adhesive that fully bonds metal to metal without telegraphing or oil-canning.

7. Plastic-Laminate Doors: Flush, hollow-metal construction; fabricated by laminating plastic laminate to exposed faces of enameled or powder-coated steel doors and covering edges with protective edge trim matching return panels. Plastic-laminate color, texture, and pattern as selected by Architect from plastic-laminate, elevator manufacturer's full range.
8. Sight Guards: Provide sight guards on car doors.
9. Sills: Extruded or machined metal, with grooved surface, 1/4 inch (6.4 mm) thick.
10. Luminous Ceiling: Fluorescent light fixtures and ceiling panels of translucent acrylic or other permanent rigid plastic.
11. Metal, Metallic-Finish, Plastic-Laminate Ceiling: Flush panels, with incandescent downlights in the center of, four low-voltage downlights in each panel. Align ceiling panel joints with joints between wall panels.
12. Light Fixture Efficiency: Not less than 35 lumens/W.
13. Ventilation Fan Efficiency: Not less than 3.0 cfm/W (1.4 L/s per W).

2.8 HOISTWAY ENTRANCES

A. Hoistway Entrance Assemblies: Manufacturer's standard horizontal-sliding, door-and-frame hoistway entrances complete with track systems, hardware, sills, and accessories. Frame size and profile shall accommodate hoistway wall construction.

1. Where gypsum board wall construction is indicated, frames shall be self-supporting with reinforced head sections.

B. Fire-Rated Hoistway Entrance Assemblies: Door and frame assemblies shall comply with NFPA 80 and be listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, based on testing at as close-to-neutral pressure as possible according to NFPA 252 or UL 10B.

1. Fire-Protection Rating: 1 hour, 1-1/2 hours, with 30-minute temperature rise of 450 deg F (250 deg C).

C. Materials and Fabrication: Manufacturer's standards, but not less than the following:

1. Enameled or Powder-Coated Steel Frames: Formed from cold- or hot-rolled steel sheet. Provide with factory-applied enamel or powder-coat finish; colors as selected by Architect from manufacturer's full range.
2. Stainless-Steel Frames: Formed from stainless-steel sheet.
3. Star of Life Symbol: Identify emergency elevators with star of life symbol, not less than 3 inches (76 mm) high, on both jambs of hoistway door frames.
4. Enameled or Powder-Coated Steel Doors and Transoms: Flush, hollow-metal construction; fabricated from cold-rolled steel sheet. Provide with factory-applied enamel or powder-coat finish; colors as selected by Architect from manufacturer's full range.
5. Stainless-Steel Doors and Transoms: Flush, hollow-metal construction; fabricated from stainless-steel sheet or by laminating stainless-steel sheet to exposed faces and edges of enameled or powder-coated steel doors using adhesive that fully bonds metal to metal without telegraphing or oil-canning.

6. Plastic-Laminate Doors and Transoms: Flush, hollow-metal construction; fabricated by laminating plastic laminate to exposed faces of enameled or powder-coated steel doors and covering edges with protective edge trim matching door frames. Plastic-laminate color, texture, and pattern as selected by Architect from plastic-laminate, elevator manufacturer's full range.
7. Sight Guards: Provide sight guards on doors matching door edges.
8. Sills: Extruded or machined metal, with grooved surface, 1/4 inch (6.4 mm) thick.
9. Non-shrink, Nonmetallic Grout: Factory-packaged, non-staining, noncorrosive, nongaseous grout complying with ASTM C1107/C1107M.

2.9 SIGNAL EQUIPMENT

A. General: Provide hall-call and car-call buttons that light when activated and remain lit until call has been fulfilled, signal equipment designed for destination-based system. Provide vandal-resistant buttons and lighted elements illuminated with LEDs.

B. Car-Control Stations: Provide manufacturer's standard recessed or semi-recessed car-control stations. Mount in return panel adjacent to car door unless otherwise indicated.

1. Provide "No Smoking" sign matching car-control station, either integral with car-control station or mounted adjacent to it, with text and graphics as required by authorities having jurisdiction.

C. Emergency Communication System: Two-way voice communication system, with visible signal, which dials preprogrammed number of monitoring station and does not require handset use. System is contained in flush-mounted cabinet, with identification, instructions for use, and battery backup power supply.

D. Firefighters' Two-Way Telephone Communication Service: Provide flush-mounted cabinet, telephone jack in each car and required conductors in traveling cable for firefighters' two-way telephone communication service specified in Section 284621.11 "Addressable Fire-Alarm Systems."Section 284621.13 "Conventional Fire-Alarm Systems."

E. Car Position Indicator: Provide illuminated, digital-type car position indicator, located above car door or above car-control station. Also, provide audible signal to indicate to passengers that car is either stopping at or passing each of the floors served. Include travel direction arrows if not provided in car-control station.

F. Hall Push-Button Stations: Provide one hall push-button station at each landing, Provide hall push-button stations at each landing as indicated.

1. Provide telephone jack in each unit for firefighters' two-way telephone communication service specified in Section 284621.11 "Addressable Fire-Alarm Systems." Section 284621.13 "Conventional Fire-Alarm Systems."

G. Hall Lanterns: Units with illuminated arrows; but provide single arrow at terminal landings. Provide one of the following:

1. Manufacturer's standard wall-mounted units, for mounting above entrance frames.
2. Units mounted in both jambs of entrance frame for each elevator.

H. Hall Annunciator: With each hall lantern, provide audible signals indicating car arrival and direction of travel. Signals sound once for up and twice for down.

1. At manufacturer's option, audible signals may be placed on cars.

I. Hall Position Indicators: Provide illuminated, digital-display-type position indicators, located above each hoistway entrance at ground floor. Provide units with flat faceplate and with body of unit recessed in wall.

1. Integrate ground-floor hall lanterns with hall position indicators.

J. Standby Power Elevator Selector Switches: Provide switches, as required by ASME A17.1/CSA B44, where indicated. Adjacent to switches, provide illuminated signal that indicates when normal power supply has failed. For each elevator, provide illuminated signals that indicate when they are operational and when they are at the designated emergency return level with doors open.

K. Fire-Command-Center Annunciator Panel: Provide panel containing illuminated position indicators for each elevator, clearly labeled with elevator designation; include illuminated signal that indicates when elevator is operational and when it is at the designated emergency return level with doors open. Provide standby power elevator selector switch(es), as required by ASME A17.1/CSA B44, adjacent to position indicators. Provide illuminated signal that indicates when normal power supply has failed.

L. Emergency Pictorial Signs: Fabricate from materials matching hall push-button stations, with text and graphics as required by authorities having jurisdiction, indicating that in case of fire, elevators are out of service and exits should be used instead. Provide one sign at each hall push-button station unless otherwise indicated.

2.10 FINISH MATERIALS

A. Cold-Rolled Steel Sheet: ASTM A1008/A1008M, commercial steel, Type B, exposed, matte finish.

B. Hot-Rolled Steel Sheet: ASTM A1011/A1011M, commercial steel, Type B, pickled.

C. Stainless-Steel Sheet: ASTM A240/A240M, Type 304.

D. Stainless-Steel Bars: ASTM A276, Type 304.

E. Stainless-Steel Tubing: ASTM A554, Grade MT 304.

F. Aluminum Extrusions: ASTM B221 (ASTM B221M), Alloy 6063.

G. Plastic Laminate: High-pressure type complying with NEMA LD 3, Type HGS or Type HGL.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Sound Isolation: Mount rotating and vibrating equipment on vibration-isolating mounts to minimize vibration transmission to structure and structure-borne noise due to elevator system.

B. Lubricate operating parts of systems, including ropes, as recommended by manufacturers.

C. Leveling Tolerance: 1/8 inch (3 mm), up or down, regardless of load and travel direction.

D. Set sills flush with finished floor surface at landing. Fill space under sill solidly with non-shrink, nonmetallic grout.

E. Locate hall signal equipment for elevators as follows unless otherwise indicated:

1. For groups of elevators, locate hall push-button stations between two elevators at center of group or at location most convenient for approaching passengers.
2. Place hall lanterns either above or beside each hoistway entrance.
3. Mount hall lanterns at a minimum of 72 inches (1829 mm) above finished floor.

3.2 FIELD QUALITY CONTROL

A. Acceptance Testing: On completion of elevator installation and before permitting elevator use (either temporary or permanent), perform acceptance tests as required and recommended by ASME A17.1/CSA B44 and by governing regulations and agencies.

3.3 PROTECTION

A. Temporary Use: Limit temporary use for construction purposes to one elevator. Comply with the following requirements for each elevator used for construction purposes:

1. Provide car with temporary enclosure, either within finished car or in place of finished car, to protect finishes from damage.
2. Provide other protective coverings, barriers, devices, signs, and procedures as needed to protect elevator and elevator equipment.
3. Engage elevator Installer to provide full maintenance service.
4. Engage elevator Installer to restore damaged work, if any, so no evidence remains of correction. Return items that cannot be refinished in the field to the shop, make required repairs and refinish entire unit, or provide new units as required.

3.4 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include months' full maintenance by skilled employees of elevator Installer. Include monthly preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper elevator operation at rated speed and capacity.

END OF SECTION 142100

SECTION 142113 - ELECTRIC TRACTION FREIGHT ELEVATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes electric traction freight elevators.

B. Related Requirements:

1. Section 051200 "Structural Steel Framing" for structural-steel frames and sills for hoistway entrances that are a part of steel frame.
2. Section 055000 "Metal Fabrications" for structural-steel frames and sills for hoistway entrances.

1.2 ACTION SUBMITTALS

A. Product Data: Include capacities, sizes, performances, operations, safety features, finishes, and similar information.

B. Shop Drawings:

1. Include plans, elevations, sections, and large-scale details indicating service at each landing, machine room layout, coordination with building structure, relationships with other construction, and locations of equipment.
2. Indicate maximum dynamic and static loads imposed on building structure at points of support, and maximum and average power demands.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For elevator equipment, accessories, and components, from manufacturer.

B. Manufacturer Certificates: Signed by elevator manufacturer certifying that hoistway, pit, and machine room, control closet, layout and dimensions, as shown on Drawings, and electrical service, including standby power generator, as shown and specified, are adequate for elevator system being provided.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

B. Inspection and Acceptance Certificates and Operating Permits: As required by authorities having jurisdiction for normal, unrestricted elevator use.

C. Continuing Maintenance Proposal: Submit a continuing maintenance proposal from Installer to Owner, in the form of a standard one-year, two-year, five-year and or as directed maintenance agreement, starting on date initial maintenance service is concluded.

1.5 WARRANTY

A. Manufacturer's Special Warranty: Manufacturer agrees to repair or replace elevator work that fails in materials or workmanship within specified warranty period.

1. Warranty Period: As directed, year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Regulatory Requirements: Comply with ASME A17.1/CSA B44.

B. Accessibility Requirements: Comply with Section 407 in the United States Access Board's ADA-ABA Accessibility Guidelines and with ICC A117.1.

C. Seismic Performance: Elevator system shall withstand the effects of earthquake motions determined according to ASCE/SEI 7 and shall comply with elevator seismic requirements in ASME A17.1/CSA B44.

1. Project Seismic Design Category: C, D, E, F.
2. Elevator Component Importance Factor: 1.5, 1.0.
3. Design earthquake spectral response acceleration short period (Sds) for Project is.
4. Provide earthquake equipment required by ASME A17.1/CSA B44.
5. Provide seismic switch required by ASCE/SEI 7.

2.3 FREIGHT ELEVATORS

A. Elevator System, General: Manufacturer's standard electric traction freight elevator systems. Unless otherwise indicated, manufacturer's standard components shall be used, as included in standard elevator systems and as required for complete system.

B. Elevator Description:

1. Elevator Number(s): Elevator number(s) as shown on Drawings.
2. Elevator Type: Geared, Gearless traction.
3. Machine Location: Machine room above hoistway, Hoistway; no machine room is provided.
4. Rated Load: 2000 lb (908 kg), 2500 lb (1135 kg), 3000 lb (1362 kg),4000 lb (1816 kg), 5000 lb (2270 kg), 6000 lb (2720 kg), 8000 lb (3632 kg), 10,000 lb (4540 kg).

5. Freight Loading Class: Class A, Class B, Class C1, Class C2, Class C3.
6. Rated Speed: 75 fpm (0.38 m/s), 100 fpm (0.51 m/s), 150 fpm (0.76 m/s), 200 fpm (1.0 m/s), 350 fpm (1.8 m/s).
7. Operation System: Single automatic, Car-switch automatic floor stop, Selective-collective automatic.
8. Auxiliary Operations:

    a. Earthquake Emergency Operation: Comply with requirements in ASME A17.1/CSA B44.
    b. Load-weighing device.
    c. Automatic operation of lights and ventilation fans.

9. Security Feature: Card-reader, Key-switch operation.
10. Auxiliary Car-Control Station: Provide additional car-control station mounted on side of car at height to facilitate operation by forklift-truck operator without leaving truck.
11. Car Enclosures:

    a. Platform Width: 64 inches (1626 mm), 76 inches (1930 mm), 88 inches (2235 mm), 100 inches (2540 mm).
    b. Platform Depth: 84 inches (2134 mm), 96 inches (2438 mm), 120 inches (3048 mm), 144 inches (3658 mm), 168 inches (4267 mm).
    c. Ceiling Height: 84 inches (2134 mm), 96 inches (2438 mm), 108 inches (2743 mm).
    d. Walls and Ceiling: Prime-painted or powder-coated steel, Prime-painted or powder-coated, metallic-coated steel, Satin stainless steel, No. 4 finish.
    e. Car Fixtures: Satin stainless steel, No. 4 finish.
    f. Floor: Rolled steel floor plate.
    g. Car Gate Type: Vertical biparting, Single-speed vertical lift, Two-speed vertical lift.
    h. Car Gate Operation: Manual, Power operated.
    i. Car Gate Material: Prime-painted or powder-coated steel, Satin stainless steel, No. 4 finish.
    j. Lighting: One, Two, Three, 48-inch (1219-mm), two-tube fluorescent light fixture(s).
    k. Light Fixture Efficiency: Not less than 35 lumens/W.
    l. Ventilation Fan Efficiency: Not less than 3.0 cfm/W (1.4 L/s per W).

12. Hoistway Entrances:

    a. Width: 56 inches (1422 mm), 60 inches (1524 mm), 72 inches (1829 mm), 96 inches (2438 mm).
    b. Height: 84 inches (2134 mm), 96 inches (2438 mm).
    c. Door Type: Vertical bi-parting, Single-speed vertical lift, Two-speed vertical lift.
    d. Fire-Protection Rating: 1 hour, 1-1/2 hours, with 30-minute temperature rise of 450 deg F (250 deg C).
    e. Door Operation: Manual, Power operated with door reopening device.
    f. Door Material: Prime-painted or powder-coated steel, Satin stainless steel, No. 4 finish.

13. Hall Fixtures: Satin stainless steel, No. 4 finish.

14. Auxiliary Hall Stations: Provide additional pendant-mounted, hall push-button stations where indicated, mounted at height to facilitate operation by forklift-truck operator without leaving truck.

2.4 TRACTION SYSTEMS

A. Elevator Machines: Variable-voltage, variable-frequency, ac-type hoisting machines or variable-voltage dc-type hoisting machines and solid-state power converters.

1. Provide regenerative system that complies with IgCC.
2. Limit total harmonic distortion of regenerated power to 5 percent per IEEE 519.

B. Fluid for Hydraulic Buffers: If using hydraulic buffers, use only fire-resistant fluid.

C. Machine Beams: Provide framing to support elevator hoisting machine and deflector sheaves from the building structure. Comply with Section 055000 "Metal Fabrications" for materials and fabrication.

D. Guides: Roller guides or polymer-coated, nonlubricated sliding guides. Provide guides at top and bottom of car and counterweight frames.

2.5 OPERATION SYSTEMS

A. General: Provide manufacturer's standard microprocessor operation systems as required to provide type of operation indicated.

B. Security Features: Security features shall not affect emergency firefighters' service.

1. Card-Reader Operation: System uses card readers at car-control stations to authorize calls. Security system determines which landings and at what times calls require authorization by card reader. Allow space as indicated for card reader in car, Provide stripe-swipe card reader integral with each car-control station.

a. Security access system equipment is specified in Section 281500 "Access Control Hardware Devices." not in the Contract.

2. Key-switch Operation: Push buttons are activated and deactivated by security key-switches at car-control stations.

2.6 DOOR REOPENING DEVICES

A. Infrared Array: Provide door reopening device with a uniform array of 36 or more microprocessor-controlled, infrared light beams projecting across car entrance. Interruption of one or more light beams shall cause doors to stop and reopen.

2.7 CAR ENCLOSURES

A. General: Provide car enclosures as indicated, including ventilation, lighting, finishes, access doors, thresholds, trim, and accessories. Fabricate with recesses and cutouts for signal equipment.

1. Provide power door operators with linkages for hoistway door operation.
2. Provide standard railings complying with ASME A17.1/CSA B44 on car tops where required by ASME A17.1/CSA B44.

B. Materials and Fabrication: Provide manufacturer's standard, flush panel, welded construction made from metal sheet, of metal indicated, not less than 0.067 inch (1.7 mm) and reinforced at 16-inch (406-mm) maximum spacing.

2.8 HOISTWAY ENTRANCES

A. Unless otherwise indicated, provide hoistway entrance doors of type indicated below, with truckable sill bars and resilient safety meeting-rail gaskets.

1. Equip for power operation by coordinated linkage with power-operated car door.

B. Fire-Rated Hoistway Entrance Assemblies: Door and frame assemblies shall comply with NFPA 80 and be listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire-protection ratings indicated, based on testing at as close-to-neutral pressure as possible according to NFPA 252 or UL 10B.

C. Materials and Fabrication: Provide manufacturer's standards, but not less than the following:

1. Metal Door Panels: Constructed of metal sheets, flush on room side, welded and reinforced in steel framing with vertical reinforcing spaced not more than 24 inches (610 mm) o.c. Fabricate panel faces from metal sheet, of metal indicated, not less than 0.097 inch (2.5 mm) thick.

2.9 SIGNAL EQUIPMENT

A. General: Provide hall-call and car-call buttons that light when activated and remain lit until call has been fulfilled. Fabricate lighted elements of acrylic or other permanent, non-yellowing translucent plastic.

B. Car-Control Stations: Provide manufacturer's standard car-control station. Mount adjacent to car door unless otherwise indicated.

C. Firefighters' Two-Way Telephone Communication Service: Provide flush-mounted cabinet, telephone jack in each car and required conductors in traveling cable for firefighters' two-way telephone communication service specified in Section 284621.11 "Addressable Fire-Alarm Systems." Section 284621.13 "Conventional Fire-Alarm Systems."

D. Hall Push-Button Stations: Provide hall push-button station at each landing as indicated.

1. Provide single-button stations with position, "in-use", indicator.

E. Provide telephone jack in each unit for firefighters' two-way telephone communication service specified in Section 284621.11 "Addressable Fire-Alarm Systems." Section 284621.13 "Conventional Fire-Alarm Systems."

2.10 FINISH MATERIALS

A. Cold-Rolled Steel Sheet: ASTM A1008/A1008M, commercial steel, Type B, exposed, matte finish.

B. Hot-Rolled Steel Sheet: ASTM A1011/A1011M, commercial steel, Type B, pickled.

C. Metallic-Coated Steel Sheet: ASTM A653/A653M, commercial steel, with G60 (Z180) zinc coating (galvanized) or A60 (ZF180) zinc-iron-alloy coating (galvannealed).

D. Stainless-Steel Sheet: ASTM A240/A240M, Type 304.

E. Rolled Steel Floor Plate: ASTM A786/A786M.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Sound Isolation: Mount rotating and vibrating equipment on vibration-isolating mounts to minimize vibration transmission to structure and structure-borne noise due to elevator system.

B. Lubricate operating parts of systems, including ropes, as recommended by manufacturers.

3.2 FIELD QUALITY CONTROL

A. Acceptance Testing: On completion of elevator installation and before permitting elevator use (either temporary or permanent), perform acceptance tests as required and recommended by ASME A17.1/CSA B44 and by governing regulations and agencies.

3.3 PROTECTION

A. Temporary Use: Limit temporary use for construction purposes to one elevator. Comply with the following requirements for each elevator used for construction purposes:

1. Engage elevator Installer to provide full maintenance service.
2. Engage elevator Installer to restore damaged work, if any, so no evidence remains of correction. Return items that cannot be refinished in the field to the shop, make required repairs and refinish entire unit, or provide new units as required.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to operate, adjust, and maintain elevator(s).

3.5 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include, as directed, months' full maintenance by skilled employees of elevator Installer. Include monthly preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper elevator operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

END OF SECTION 142113

SECTION 142123.16 – MACHINE ROOM-LESS ELECTRIC TRACTION PASSENGER ELEVATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes machine-room-less electric traction passenger and service elevators.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include Product Data for car enclosures, hoistway entrances, and operation, control, and signal systems.

B. Shop Drawings:

1. Include plans, elevations, sections, and large-scale details indicating service at each landing, coordination with building structure, relationships with other construction, and locations of equipment.
2. Indicate maximum dynamic and static loads imposed on building structure at points of support, and maximum and average power demands.

C. Samples: For each type of exposed finish involving color selection.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For elevator equipment, accessories, and components, from manufacturer.

B. Manufacturer Certificates: Signed by elevator manufacturer certifying that hoistway and pit layout and dimensions, as indicated on Drawings, and electrical service including standby power generator, as shown and specified, are adequate for elevator system being provided.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

B. Inspection and Acceptance Certificates and Operating Permits: As required by authorities having jurisdiction for normal, unrestricted elevator use.

C. Continuing Maintenance Proposal: Submit a continuing maintenance proposal from Installer to Owner, in the form of a standard one-year, two-year, five-year and or as directed, maintenance agreement, starting on date initial maintenance service is concluded.

1.5 WARRANTY

A. Manufacturer's Special Warranty: Manufacturer agrees to repair, restore, or replace elevator work that fails in materials or workmanship within specified warranty period.

1. Warranty Period: As directed, year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Regulatory Requirements: Comply with ASME A17.1/CSA B44.

B. Accessibility Requirements: Comply with requirements for accessible elevators in the United States Access Board's ADA-ABA Accessibility Guidelines and with ICC A117.1.

C. Seismic Performance: Elevator system shall withstand the effects of earthquake motions determined according to ASCE/SEI 7 and shall comply with elevator seismic requirements in ASME A17.1/CSA B44.

1. Project Seismic Design Category: C, D, E, F.
2. Elevator Component Importance Factor: 1.5, 1.0.
3. Design earthquake spectral response acceleration short period (Sds) for Project is.
4. Provide earthquake equipment required by ASME A17.1/CSA B44.
5. Provide seismic switch required by ASCE/SEI 7.

2.3 ELEVATORS

A. Elevator System, General: Manufacturer's standard elevator systems. Unless otherwise indicated, manufacturer's standard components shall be used, as included in standard elevator systems and as required for complete system.

B. Elevator Description:

1. Group Number: Number for each group of elevators that share a group operation system.
2. Elevator Number(s): Elevator number(s) as indicated on Drawings.
3. Emergency Elevator Number(s): Elevator number(s) as indicated on Drawings.
4. Service Elevator Number(s): Elevator number(s) as indicated on Drawings.
5. Rated Load: 2000 lb (908 kg), 2100 lb (953 kg), 2500 lb (1135 kg), 3000 lb (1362 kg), 3500 lb (1589 kg), 4000 lb (1816 kg), 4500 lb (2043 kg), 5000 lb (2270 kg).
6. Freight Loading Class for Service Elevator(s): Class A.
7. Rated Speed: 100 fpm (0.5 m/s), 150 fpm (0.75 m/s), 200 fpm (1.0 m/s), 350 fpm (1.8 m/s), 400 fpm (2.0 m/s), 450 fpm (2.3 m/s), 500 fpm (2.5 m/s).
8. Operation System: Selective-collective automatic operation, Group automatic operation, Group automatic operation with demand-based dispatching.
9. Auxiliary Operations:

a. Standby power operation.
b. Battery-powered automatic evacuation.
c. Earthquake Emergency Operation: Comply with requirements in ASME A17.1/CSA B44.
d. Automatic dispatching of loaded car.
e. Nuisance-call cancel.
f. Loaded-car bypass.
g. Distributed parking.
h. Off-peak operation.
i. Automatic operation of lights and ventilation fans.
j. Emergency hospital, Priority, service at, all, floors.
k. Independent service for service elevator, one car in group, all cars in group.

10. Security Features: Card-reader operation, Key-switch operation, Keypad operation, Car-to-lobby feature.
11. Dual Car-Control Stations: Provide two car-control stations in each elevator; equip only one with required key-switches if any.
12. Car Enclosures:

a. Inside Width: Not less than 64 inches (1626 mm), 66 inches (1676 mm), 68 inches (1727 mm), 70 inches (1778 mm), 80 inches (2032 mm), 89-1/2 inches (2273 mm), 92 inches (2337 mm), from side wall to side wall.
b. Inside Depth: Not less than 51 inches (1295 mm), 53 inches (1346 mm), 56-1/2 inches (1435 mm), 60 inches (1524 mm), 64-1/2 inches (1638 mm), 66 inches (1676 mm), 68 inches (1727 mm), 88 inches (2235 mm), 89 inches (2261 mm), 90-1/2 inches (2298 mm), 93-1/2 inches (2375 mm), 95 inches (2413), 96-1/2 inches (2451 mm), 101 inches (2565 mm), 102 inches (2591 mm), 104 inches (2641 mm), 108 inches (2743 mm), from back wall to front wall (return panels).
c. Inside Height: Not less than 93 inches (2362 mm), to underside of ceiling.
d. Front Walls (Return Panels): Polished stainless steel, No. 8 finish, Satin stainless steel, No. 4 finish, Polished bronze, lacquered, Satin bronze, lacquered.
e. Car Fixtures: Polished stainless steel, No. 8 finish, Satin stainless steel, No. 4 finish, Polished bronze, lacquered, Satin bronze, lacquered.
f. Side and Rear Wall Panels: Enameled or powder-coated steel, Plastic laminate, Satin stainless steel, No. 4 finish, textured stainless steel, Satin bronze, lacquered.
g. Reveals: Black, Enameled or powder-coated steel, Anodized aluminum, Polished stainless steel, No. 8 finish, Satin stainless steel, No. 4 finish, Polished bronze, lacquered, Satin bronze, lacquered.
h. Door Faces (Interior): Enameled or powder-coated steel, Primed or powder-coated steel, Polished stainless steel, No. 8 finish, Satin stainless steel, No. 4 finish, textured stainless steel, Polished bronze, lacquered, Satin bronze, lacquered, Plastic laminate.
i. Ceiling: Luminous ceiling, Enameled or powder-coated steel, Polished stainless steel, No. 8 finish, Satin stainless steel, No. 4 finish, Polished bronze, lacquered, Reflective metallic-finish, plastic-laminate, stainless steel, Reflective metallic-finish, plastic-laminate, bronze.
j. Handrails: 1-1/2 inches (38 mm) round, 1/2 by 2 inches (13 by 50 mm) rectangular, anodized aluminum, mirror-polished stainless steel, No. 8 finish, satin stainless steel, No. 4 finish, mirror-polished bronze, lacquered, satin bronze, lacquered, at, sides and rear of car.
k. Floor: Manufacturer's standard carpet.

l. Floor prepared to receive carpet (specified in Section 096816 "Sheet Carpeting").
m. Floor prepared to receive resilient flooring (specified in Section 096516 "Resilient Sheet Flooring").

13. Hoistway Entrances:

a. Width: 36 inches (914 mm), 42 inches (1067 mm), 48 inches (1219 mm), 54 inches (1372 mm).
b. Height: 84 inches (2134 mm).
c. Type: Single-speed side sliding, Two-speed side sliding, Single-speed center opening, Two-speed center opening.
d. Frames at First Floor, at Basement Floors: Enameled or powder-coated steel, Primed or powder-coated steel, Primed or powder-coated steel to receive stone, Polished stainless steel, No. 8 finish, Satin stainless steel, No. 4 finish, Polished bronze, lacquered, Satin bronze, lacquered, Steel subframes to receive stone.
e. Frames at Other Floors: Enameled or powder-coated steel, Primed or powder-coated steel, Polished stainless steel, No. 8 finish, Satin stainless steel, No. 4 finish, Polished bronze, lacquered, Satin bronze, lacquered.
f. Doors and Transoms, at First Floor, at Basement Floors: Enameled or powder-coated steel, Primed or powder-coated steel, Polished stainless steel, No. 8 finish, Satin stainless steel, No. 4 finish, textured stainless steel, Polished bronze, lacquered, Satin bronze, lacquered, Plastic laminate.
g. Doors and Transoms at Other Floors: Enameled or powder-coated steel, Primed or powder-coated steel, Polished stainless steel, No. 8 finish, Satin stainless steel, No. 4 finish, textured stainless steel, Polished bronze, lacquered, Satin bronze, lacquered, Plastic laminate.

14. Hall Fixtures at First Floor, at Basement Floors: Polished stainless steel, No. 8 finish, Satin stainless steel, No. 4 finish, Polished bronze, lacquered, Satin bronze, lacquered, Recessed type with no exposed-metal surfaces.
15. Hall Fixtures at Other Floors: Polished stainless steel, No. 8 finish, Satin stainless steel, No. 4 finish, Polished bronze, lacquered, Satin bronze, lacquered, Recessed type with no exposed-metal surfaces.
16. Additional Requirements:

a. Provide inspection certificate in each car, mounted under acrylic cover with frame made from polished stainless steel, No. 8 finish, satin stainless steel, No. 4 finish, polished bronze, lacquered, satin bronze, lacquered.
b. Provide hooks for protective pads in service car, all cars and one, two, complete set(s) of full-height protective pads.

2.4 TRACTION SYSTEMS

A. Elevator Machines: Permanent magnet, variable-voltage, variable-frequency, ac-type hoisting machines and solid-state power converters.

1. Provide regenerative or nonregenerative system.
2. Provide regenerative system that complies with the IgCC.
3. Limit total harmonic distortion of regenerated power to 5 percent per IEEE 519.

4. Provide means for absorbing regenerated power when elevator system is operating on standby power.
5. Provide line filters or chokes to prevent electrical peaks or spikes from feeding back into building power system.

B. Fluid for Hydraulic Buffers: Fire-resistant fluid.

C. Machine Beams: Provide steel framing to support elevator hoisting machine and deflector sheaves from the building structure. Comply with Section 055000 "Metal Fabrications" for materials and fabrication.

D. Guides: Roller guides or polymer-coated, nonlubricated sliding guides. Provide guides at top and bottom of car and counterweight frames.

2.5 OPERATION SYSTEMS

A. General: Provide manufacturer's standard microprocessor operation systems as required to provide type of operation indicated.

B. Group Automatic Operation with Demand-Based Dispatching: Provide reprogrammable, group automatic system that assigns cars to hall calls based on a dispatching program designed to minimize passenger wait time, time to destination. System automatically adjusts to demand changes for different traffic conditions including heavy incoming, heavy two-way, heavy outgoing, and light off-hours as variations of normal two-way traffic.

C. Auxiliary Operations:

1. Single-Car Standby Power Operation: On activation of standby power, car is returned to a designated floor and parked with doors open. Car can be manually put in service on standby power, either for return operation or for regular operation, by switches in control panel located at main lobby, fire-command station. Manual operation causes automatic operation to cease.
2. Single-Car Battery-Powered Automatic Evacuation: If power fails and car is at a floor, it remains at that floor, opens its doors, and shuts down. If car is between floors, it moves to the next floor above or below, opens its doors, and shuts down. System includes rechargeable battery and automatic recharging system.
3. Group Standby Power Operation: On activation of standby power, cars are returned, one at a time, to a designated floor and parked with doors open. If a car cannot be returned, it is removed from the system. When all cars have been returned or removed from the system, one car can be put in service on standby power by a selector switch in control panel located at main lobby, fire-command station.
4. Group Battery-Powered Automatic Evacuation: If power fails, cars that are at a floor remain at that floor, open their doors, and shut down. Cars that are between floors are moved one at a time to the next floor above or below, open their doors, and shut down. System includes rechargeable battery and automatic recharging system.
5. Off-Peak Operation: During periods of low traffic, half of the elevators in a group shall be taken out of service and switched to sleep, low power mode.
6. Automatic Operation of Lights and Fan: When elevator is stopped and unoccupied with doors closed, lighting, ventilation fan, and cab displays are de-energized after five minutes and are re-energized before car doors open.

7. Independent Service: Key-switch in car-control station removes car from group operation and allows it to respond only to car calls. Key cannot be removed from key-switch when car is in independent service. When in independent service, doors close only in response to door close button.
8. Emergency Hospital, Priority, Service: Service is initiated by a key-switch, card reader, remote switch at designated floors. One elevator is removed from group operation and directed to the floor where service was initiated. On arriving at the floor, elevator opens its doors and parks and a lighted sign directs passengers to exit elevator. Car is placed in operation by selecting a floor and pressing door close button or by operating key-switch to put car in independent service. After responding to floor selected or being removed from independent service, car is returned to group operation. If car is not placed in operation within a preset time after being called, it is returned to group operation.

D. Security features shall not affect emergency firefighters' service.

1. Card-Reader Operation: System uses card readers at car-control stations to authorize calls. Security system determines which landings and at what times calls require authorization by card reader. Allow space for card reader in car, Provide stripe-swipe card reader integral with each car-control station.

    a. Security access system equipment is specified in Section 281500 "Access Control Hardware Devices." not in the Contract.

2. Keyswitch Operation: Push buttons are activated and deactivated by security key-switches at car-control stations.

2.6 DOOR REOPENING DEVICES

A. Infrared Array: Provide door reopening device with uniform array of 36 or more microprocessor-controlled, infrared light beams projecting across car entrance. Interruption of one or more light beams shall cause doors to stop and reopen.

B. Nudging Feature: After car doors are prevented from closing for predetermined adjustable time, through activating door reopening device, a loud buzzer shall sound and doors shall begin to close at reduced kinetic energy.

2.7 CAR ENCLOSURES

A. General: Provide enameled or powder-coated steel car enclosures to receive removable, steel-framed car enclosures with nonremovable, wall panels, with removable, car roof, access doors, power door operators, and ventilation.

1. Provide standard railings complying with ASME A17.1/CSA B44 on car tops where required by ASME A17.1/CSA B44.

B. Materials and Finishes: Manufacturer's standards, but not less than the following:

1. Enameled or Powder-Coated Steel Wall Panels: Flush, formed-metal construction; fabricated from cold-rolled steel sheet. Provide with factory-applied enamel or powder-coat finish; colors as selected by Architect from manufacturer's full range.
2. Stainless-Steel Wall Panels: Flush, formed-metal construction; fabricated from stainless-steel sheet.
3. Plastic-Laminate Wall Panels: Plastic laminate adhesively applied to 1/2-inch (13-mm) fire-retardant-treated particleboard, manufacturer's standard honeycomb core, manufacturer's standard formed metal panels with plastic-laminate panel backing and manufacturer's standard protective edge trim. Panels shall have a flame-spread index of 25, 75 or less, when tested according to ASTM E84. Plastic-laminate color, texture, and pattern as selected by Architect from plastic-laminate, elevator manufacturer's full range.
4. Enameled or Powder-Coated Steel Doors: Flush, hollow-metal construction; fabricated from cold-rolled steel sheet. Provide with factory-applied enamel or powder-coat finish; colors as selected by Architect from manufacturer's full range.
5. Stainless-Steel Doors: Flush, hollow-metal construction; fabricated from stainless-steel sheet or by laminating stainless-steel sheet to exposed faces and edges of enameled or powder-coated steel doors using adhesive that fully bonds metal to metal without telegraphing or oil-canning.
6. Plastic-Laminate Doors: Flush, hollow-metal construction; fabricated by laminating plastic laminate to exposed faces of enameled or powder-coated steel doors and covering edges with protective edge trim matching return panels. Plastic-laminate color, texture, and pattern as selected by Architect from plastic-laminate, elevator, manufacturer's full range.
7. Sight Guards: Provide sight guards on car doors.
8. Sills: Extruded or machined metal, with grooved surface, 1/4 inch (6.4 mm) thick.
9. Luminous Ceiling: Fluorescent light fixtures and ceiling panels of translucent acrylic or other permanent rigid plastic.
10. Metal, Metallic-Finish, Plastic-Laminate Ceiling: Flush panels, with incandescent downlights in the center of four low-voltage downlights in each panel. Align ceiling panel joints with joints between wall panels.
11. Light Fixture Efficiency: Not less than 35 lumens/W.
12. Ventilation Fan Efficiency: Not less than 3.0 cfm/W (1.4 L/s per W).

2.8 HOISTWAY ENTRANCES

A. Hoistway Entrance Assemblies: Manufacturer's standard horizontal-sliding, door-and-frame hoistway entrances complete with track systems, hardware, sills, and accessories. Frame size and profile shall accommodate hoistway wall construction.

1. Where gypsum board wall construction is indicated, frames shall be self-supporting with reinforced head sections.

B. Fire-Rated Hoistway Entrance Assemblies: Door and frame assemblies shall comply with NFPA 80 and be listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction based on testing at as close-to-neutral pressure as possible according to NFPA 252 or UL 10B.

1. Fire-Protection Rating: 1 hour, 1-1/2 hours with 30-minute temperature rise of 450 deg F (250 deg C).

C. Materials and Fabrication: Manufacturer's standards, but not less than the following:

1. Enameled or Powder-Coated Steel Frames: Formed from cold- or hot-rolled steel sheet. Provide with factory-applied enamel or powder-coat finish; colors as selected by Architect from manufacturer's full range.
2. Stainless-Steel Frames: Formed from stainless-steel sheet.
3. Star of Life Symbol: Identify emergency elevators with star of life symbol, not less than 3 inches (76 mm) high, on both jambs of hoistway door frames.
4. Enameled or Powder-Coated Steel Doors and Transoms: Flush, hollow-metal construction; fabricated from cold-rolled steel sheet. Provide with factory-applied enamel or powder-coat finish; colors as selected by Architect from manufacturer's full range.
5. Stainless-Steel Doors and Transoms: Flush, hollow-metal construction; fabricated from stainless-steel sheet or by laminating stainless-steel sheet to exposed faces and edges of enameled or powder-coated steel doors using adhesive that fully bonds metal to metal without telegraphing or oil-canning.
6. Plastic-Laminate Doors and Transoms: Flush, hollow-metal construction; fabricated by laminating plastic laminate to exposed faces of enameled or powder-coated steel doors and covering edges with protective edge trim matching door frames. Plastic-laminate color, texture, and pattern as selected by Architect from plastic-laminate, elevator, manufacturer's full range.
7. Sight Guards: Provide sight guards on doors matching door edges.
8. Sills: Extruded or machined metal, with grooved surface, 1/4 inch (6.4 mm) thick.
9. Non-shrink, Nonmetallic Grout: Factory-packaged, non-staining, noncorrosive, nongaseous grout complying with ASTM C1107/C1107M.

2.9 SIGNAL EQUIPMENT

A. General: Provide hall-call and car-call buttons that light when activated and remain lit until call has been fulfilled. Provide vandal-resistant, buttons and lighted elements illuminated with LEDs.

B. Car-Control Stations: Provide manufacturer's standard recessed or semi-recessed, car-control stations. Mount in return panel adjacent to car door unless otherwise indicated.

1. Provide "No Smoking" sign matching car-control station, either integral with car-control station or mounted adjacent to it, with text and graphics as required by authorities having jurisdiction.

C. Emergency Communication System: Two-way voice communication system, with visible signal, which dials preprogrammed number of monitoring station and does not require handset use. System is contained in flush-mounted cabinet, with identification, instructions for use, and battery backup power supply.

D. Firefighters' Two-Way Telephone Communication Service: Provide flush-mounted cabinet, telephone jack in each car and required conductors in traveling cable for firefighters' two-way telephone communication service specified in Section 284621.11 "Addressable Fire-Alarm Systems." Section 284621.13 "Conventional Fire-Alarm Systems."

E. Car Position Indicator: Provide illuminated, digital-type car position indicator, located above car door or above car-control station. Also, provide audible signal to indicate to passengers that car is either stopping at or passing each of the floors served. Include travel direction arrows if not provided in car-control station.

F. Hall Push-Button Stations: Provide one hall push-button station at each landing, Provide one hall push-button station at each landing for each single elevator or group of elevators, but not less than one station for each four elevators in a group, Provide hall push-button stations at each landing as indicated.

G. Hall Lanterns: Units with illuminated arrows; but provide single arrow at terminal landings. Provide one of the following:

1. Manufacturer's standard wall-mounted units, for mounting above entrance frames.
2. Units mounted in both jambs of entrance frame for each elevator.

H. Hall Annunciator: With each hall lantern, provide audible signals indicating car arrival and direction of travel. Signals sound once for up and twice for down.

I. Standby Power Elevator Selector Switches: Provide switches, as required by ASME A17.1/CSA B44, where indicated. Adjacent to switches, provide illuminated signal that indicates when normal power supply has failed. For each elevator, provide illuminated signals that indicate when they are operational and when they are at the designated emergency return level with doors open.

J. Fire-Command-Center Annunciator Panel: Provide panel containing illuminated position indicators for each elevator, clearly labeled with elevator designation; include illuminated signal that indicates when elevator is operational and when it is at the designated emergency return level with doors open. Provide standby power elevator selector switch(es), as required by ASME A17.1/CSA B44, adjacent to position indicators. Provide illuminated signal that indicates when normal power supply has failed.

K. Emergency Pictorial Signs: Fabricate from materials matching hall push-button stations, with text and graphics as required by authorities having jurisdiction, indicating that in case of fire, elevators are out of service and exits should be used instead. Provide one sign at each hall push-button station unless otherwise indicated.

2.10 FINISH MATERIALS

A. Cold-Rolled Steel Sheet: ASTM A1008/A1008M, commercial steel, Type B, exposed, matte finish.

B. Hot-Rolled Steel Sheet: ASTM A1011/A1011M, commercial steel, Type B, pickled.

C. Stainless-Steel Sheet: ASTM A240/A240M, Type 304.

D. Stainless-Steel Bars: ASTM A276, Type 304.

E. Stainless-Steel Tubing: ASTM A554, Grade MT 304.

F. Aluminum Extrusions: ASTM B221 (ASTM B221M), Alloy 6063.

G. Plastic Laminate: High-pressure type complying with NEMA LD 3, Type HGS for flat applications, Type HGL for flat applications, Type HGP for post-formed applications and Type BKV for panel backing.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Sound Isolation: Mount rotating and vibrating equipment on vibration-isolating mounts to minimize vibration transmission to structure and structure-borne noise due to elevator system.

B. Lubricate operating parts of systems, including ropes, as recommended by manufacturers.

C. Leveling Tolerance: 1/8 inch (3 mm), up or down, regardless of load and travel direction.

D. Set sills flush with finished floor surface at landing. Fill space under sill solidly with non-shrink, nonmetallic grout.

E. Locate hall signal equipment for elevators as follows unless otherwise indicated:

1. For groups of elevators, locate hall push-button stations between two elevators at center of group or at location most convenient for approaching passengers.
2. Place hall lanterns either above or beside each hoistway entrance.
3. Mount hall lanterns at a minimum of 72 inches (1829 mm) above finished floor.

3.2 FIELD QUALITY CONTROL

A. Acceptance Testing: On completion of elevator installation and before permitting elevator use (either temporary or permanent), perform acceptance tests as required and recommended by ASME A17.1/CSA B44 and by governing regulations and agencies.

3.3 PROTECTION

A. Temporary Use: Limit temporary use for construction purposes to one elevator. Comply with the following requirements for each elevator used for construction purposes:

1. Provide car with temporary enclosure, either within finished car or in place of finished car, to protect finishes from damage.
2. Provide other protective coverings, barriers, devices, signs, and procedures as needed to protect elevator and elevator equipment.
3. Engage elevator Installer to provide full maintenance service.
4. Engage elevator Installer to restore damaged work, if any, so no evidence remains of correction. Return items that cannot be refinished in the field to the shop, make required repairs and refinish entire unit, or provide new units as required.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to operate, adjust, and maintain elevator(s).

3.5 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include months' full maintenance by skilled employees of elevator Installer. Include monthly preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper elevator operation at rated speed and capacity.

END OF SECTION 142123.16

SECTION 142400 - HYDRAULIC ELEVATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes hydraulic passenger and service elevators.

1.2 UNIT PRICES

A. Unit Prices: Rock excavation for cylinder well holes is paid for under the unit price indicated in the Contract and as specified in Section 012200 "Unit Prices."

1.3 ACTION SUBMITTALS

A. Product Data: Include capacities, sizes, performances, operations, safety features, finishes, and similar information.

B. Shop Drawings:

1. Include plans, elevations, sections, and large-scale details indicating service at each landing; machine room layout; coordination with building structure; relationships with other construction; and locations of equipment.
2. Indicate maximum dynamic and static loads imposed on building structure at points of support as well as maximum and average power demands.

C. Samples: For finishes involving color selection.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For elevator equipment, accessories, and components, from manufacturer.

B. Manufacturer Certificates: Signed by elevator manufacturer, certifying that hoistway, pit, and machine room layout and dimensions, as shown on Drawings, and electrical service, including standby-power generator, as shown and specified, are adequate for elevator system being provided.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For elevators to include in emergency, operation, and maintenance manuals.

B. Inspection and Acceptance Certificates and Operating Permits: As required by authorities having jurisdiction for normal, unrestricted elevator use.

C. Continuing Maintenance Proposal: Submit a continuing maintenance proposal from Installer to Owner, in the form of a standard one-year, two-year, five-year and or as directed, maintenance agreement, starting on date initial maintenance service is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.

1.6 WARRANTY

A. Manufacturer's Special Warranty: Manufacturer agrees to repair, restore, or replace elevator work that fails in materials or workmanship within specified warranty period.

1. Warranty Period: As directed, year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 HYDRAULIC ELEVATOR MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Regulatory Requirements: Comply with ASME A17.1/CSA B44.

B. Accessibility Requirements: Comply with Section 407 in the United States Access Board's ADA-ABA Accessibility Guidelines and with ICC A117.1.

C. Seismic Performance: Elevator system shall withstand the effects of earthquake motions determined according to ASCE/SEI 7 and shall comply with elevator seismic requirements in ASME A17.1/CSA B44.

1. Project Seismic Design Category: C, D, E, F.
2. Elevator Component Importance Factor: 1.5, 1.0.
3. Design earthquake spectral response acceleration short period (Sds) for Project is .
4. Provide earthquake equipment required by ASME A17.1/CSA B44.
5. Provide seismic switch required by ASCE/SEI 7.

2.3 ELEVATORS

A. Elevator System, General: Manufacturer's standard elevator systems. Unless otherwise indicated, manufacturers' standard components shall be used, as included in standard elevator systems and as required for complete system.

B. Elevator Description:

1. Group Number: Number for each group of elevators that share a group operation system.
2. Elevator Number(s): Number(s) as shown on Drawings.
3. Emergency Elevator Number(s): Number(s) as shown on Drawings.
4. Service Elevator Number(s): Elevator number(s) as shown on Drawings.
5. Type: Under-the-car single cylinder.

6. Type: Holeless, beside-the-car, single-acting, single, dual, cylinder.
7. Type: Holeless, beside-the-car, telescoping, single, dual, cylinder.
8. Type: Holeless, beside-the-car, roped hydraulic, single, dual, cylinder.
9. Rated Load: 2000 lb (908 kg), 2100 lb (953 kg), 2500 lb (1135 kg), 3000 lb (1362 kg), 3500 lb (1589 kg), 4000 lb (1816 kg), 4500 lb (2043 kg), 5000 lb (2270 kg).
10. Freight Loading Class for Service Elevators: Class A.
11. Rated Speed: 75 or 80 fpm (0.38 or 0.41 m/s), 100 fpm (0.51 m/s), 125 fpm (0.64 m/s), 150 fpm (0.76 m/s), 175 fpm (0.89 m/s), 200 fpm (1.0 m/s).
12. Operation System: Single automatic operation, Selective-collective automatic operation, Group automatic operation.
13. Auxiliary Operations:

    a. Standby-power operation.
    b. Battery-powered lowering.
    c. Automatic dispatching of loaded car.
    d. Nuisance call cancel.
    e. Loaded-car bypass.
    f. Off-peak operation
    g. Automatic operation of lights and ventilation fans.
    h. Emergency hospital, Priority, service at all, floor designations, floors.
    i. Independent service for service elevator, one car in group, all cars in group.

14. Security Features: Card-reader operation, Key-switch operation.
15. Dual Car-Control Stations: Provide two car-control stations in each elevator; equip only one with required key-switches if any.
16. Car Enclosures:

    a. Inside Width: Not less than, 64 inches (1626 mm), 66 inches (1676 mm), 68 inches (1727 mm), 70 inches (1778 mm), 80 inches (2032 mm), 89-1/2 inches (2273 mm), 92 inches (2337 mm) from side wall to side wall.
    b. Inside Depth: Not less than, 51 inches (1295 mm), 53 inches (1346 mm), 56-1/2 inches (1435 mm), 60 inches (1524 mm), 64-1/2 inches (1638 mm), 66 inches (1676 mm), 68 inches (1727 mm), 88 inches (2235 mm), 89 inches (2261 mm), 90-1/2 inches (2298 mm), 93-1/2 inches (2375 mm), 95 inches (2413), 96-1/2 inches (2451 mm), 101 inches (2565 mm), 102 inches (2591 mm), 104 inches (2641 mm), 108 inches (2743 mm) from back wall to front wall (return panels).
    c. Inside Height: Not less than 93 inches (2362 mm) to underside of ceiling.
    d. Front Walls (Return Panels): Polished stainless steel, No. 8 finish, Satin stainless steel, No. 4 finish with integral car door frames.
    e. Car Fixtures: Polished stainless steel, No. 8 finish, Satin stainless steel, No. 4 finish.
    f. Side and Rear Wall Panels: Enameled or powder-coated steel, Plastic laminate, Satin stainless steel, No. 4 finish.
    g. Door Faces (Interior): Enameled or powder-coated steel, Polished stainless steel, No. 8 finish, Satin stainless steel, No. 4 finish, Plastic laminate.
    h. Ceiling: Luminous ceiling, Enameled or powder-coated steel, Polished stainless steel, No. 8 finish, Satin stainless steel, No. 4 finish, Reflective metallic-finished plastic laminate, resembling stainless steel, Reflective metallic-finished plastic laminate, resembling bronze.

i. Handrails: 1-1/2 inches (38 mm) round, 1/2 by 2 inches (13 by 50 mm) rectangular, anodized aluminum, mirror-polished stainless steel, No. 8 finish, satin stainless steel, No. 4 finish, at sides and rear of car.
j. Floor: Manufacturer's standard carpet.
k. Floor prepared to receive carpet (specified in Section 096816 "Sheet Carpeting").
l. Floor prepared to receive resilient flooring (specified in Section 096500 "Resilient Flooring").

17. Hoistway Entrances:

a. Width: 36 inches (914 mm), 42 inches (1067 mm), 48 inches (1219 mm), 54 inches (1372 mm).
b. Height: 84 inches (2134 mm).
c. Type: Single-speed side sliding, Two-speed side sliding, Single-speed center opening, Two-speed center opening.
d. Frames at First Floor, at Basement Floors: Enameled or powder-coated steel, Polished stainless steel, No. 8 finish, Satin stainless steel, No. 4 finish.
e. Frames at Other Floors: Enameled or powder-coated steel, Polished stainless steel, No. 8 finish, Satin stainless steel, No. 4 finish.
f. Doors and Transoms, at First Floor, at Basement Floors: Enameled or powder-coated steel Polished stainless steel, No. 8 finish, Satin stainless steel, No. 4 finish, Plastic laminate.
g. Doors and Transoms at Other Floors: Enameled or powder-coated steel, Polished stainless steel, No. 8 finish, Satin stainless steel, No. 4 finish, Plastic laminate.

18. Hall Fixtures at First Floor, at Basement Floors: Polished stainless steel, No. 8 finish, Satin stainless steel, No. 4 finish.
19. Hall Fixtures at Other Floors: Polished stainless steel, No. 8 finish, Satin stainless steel, No. 4 finish.
20. Additional Requirements:

a. Provide inspection certificate in each car, mounted under acrylic cover with frame made from polished stainless steel, No. 8 finish, satin stainless steel, No. 4 finish, polished bronze, lacquered, satin bronze, lacquered.
b. Provide hooks for protective pads in service car, all cars and one, two, complete set(s) of full-height protective pads.

2.4 SYSTEMS AND COMPONENTS

A. Pump Units: Positive-displacement type with a maximum of 10 percent variation between no load and full load and with minimum pulsations.

1. Pump shall be submersible type with submersible squirrel-cage induction motor, and shall be suspended inside oil tank from vibration isolation mounts or shall be tank-top-mounted type with fan-cooled, squirrel-cage induction motor, and shall be mounted on oil tank with vibration isolation mounts and enclosed in prime-painted steel enclosure lined with 1-inch- (25-mm-) thick, glass-fiber insulation board.
2. Motor shall have wye-delta or solid-state starting.
3. Motor shall have variable-voltage, variable-frequency control.

B. Hydraulic Silencers: System shall have hydraulic silencer containing pulsation-absorbing material in blowout-proof housing at pump unit.

C. Piping: Size, type, and weight of piping as recommended by elevator manufacturer, with flexible connectors to minimize sound and vibration transmissions from power unit.

1. Cylinder units shall be connected with dielectric couplings.
2. Casing for Underground Piping: Schedule 40 PVC pipe complying with ASTM D1785, joined with PVC fittings complying with ASTM D2466 and solvent cement complying with ASTM D2564.

D. Hydraulic Fluid: Elevator manufacturer's standard fire-resistant fluid with additives as needed to prevent oxidation of fluid, corrosion of cylinder and other components, and other adverse effects.

E. Hydraulic Fluid: Nontoxic, biodegradable, fire-resistant fluid, made from vegetable oil with antioxidant, anticorrosive, antifoaming, and metal-passivating additives, that is approved by elevator manufacturer for use with elevator equipment.

F. Protective Cylinder Casing: PVC or HDPE pipe casing complying with ASME A17.1/CSA B44, of sufficient size to provide not less than 1-inch (25-mm) clearance from cylinder and extending above pit floor. Casing shall have means of monitoring effectiveness to comply with ASME A17.1/CSA B44.

G. Guides: Roller guides, Polymer-coated, nonlubricated sliding guides or sliding guides with guide-rail lubricators. Provide guides at top and bottom of car frame.

2.5 OPERATION SYSTEMS

A. General: Provide manufacturer's standard microprocessor operation system as required to provide type of operation indicated.

B. Auxiliary Operations:

1. Single-Car Standby-Power Operation: On activation of standby power, car is returned to a designated floor and parked with doors open. Car can be manually put in service on standby power, either for return operation or for regular operation, by switches in control panel located at main lobby or fire command station as directed. Manual operation causes automatic operation to cease.
2. Single-Car Battery-Powered Lowering: When power fails, car is lowered to the lowest floor, opens its doors, and shuts down. System includes rechargeable battery and automatic recharging system.
3. Group Standby-Power Operation: On activation of standby power, cars are returned to lowest floor and parked with doors open. If a car cannot be returned, it is removed from the system. One car is selected for service on standby power by a switch located at main lobby, fire command station.
4. Group Battery-Powered Lowering: When power fails, cars are lowered to the lowest floor, open their doors, and shut down. System includes rechargeable battery and automatic recharging system.

5. Off-Peak Operation: During periods of low traffic, half of the elevators in a group shall be taken out of service and switched to low-power mode.
6. Independent Service: Key-switch in car-control station removes car from group operation and allows it to respond only to car calls.
7. Emergency Hospital, Priority Service: Service is initiated by a key-switch, card reader, remote switch, at designated floors. One elevator is removed from group operation and directed to the floor where service was initiated. Car is placed in operation by selecting a floor and pressing door close button or by operating key-switch to put car in independent service. After responding to floor selected or being removed from independent service, car returns to group operation.
8. Automatic Operation of Lights and Fan: When elevator is stopped and unoccupied with doors closed, lighting, ventilation fan, and cab displays are de-energized after 5 minutes and are re-energized before car doors open.

C. Security Features: Security features shall not affect emergency firefighters' service.

1. Card-Reader Operation: System uses card readers at car-control stations to authorize calls. Security system determines which landings and at what times calls require authorization by card reader. Allow space for card reader in car, Provide stripe-swipe card reader integral with each car-control station.

    a. Security access system equipment is specified in Section 281500 "Access Control Hardware Devices." not in the Contract.

2. Key-switch Operation: Push buttons are activated and deactivated by security key-switches at car-control stations.

2.6 DOOR-REOPENING DEVICES

A. Infrared Array: Provide door-reopening device with uniform array of 36 or more microprocessor-controlled, infrared light beams projecting across car entrance. Interruption of one or more light beams shall cause doors to stop and reopen.

B. Nudging Feature: After car doors are prevented from closing for predetermined adjustable time, through activating door-reopening device, a loud buzzer shall sound and doors shall begin to close at reduced kinetic energy.

2.7 CAR ENCLOSURES

A. General: Provide enameled- or powder-coated-steel car enclosures to receive removable, steel-framed car enclosures with nonremovable wall panels, with removable car roof, access doors, power door operators, and ventilation.

1. Provide standard railings complying with ASME A17.1/CSA B44 on car tops where required by ASME A17.1/CSA B44.

B. Materials and Finishes: Manufacturer's standards, but not less than the following:

1. Enameled- or Powder-Coated-Steel Wall Panels: Flush, formed-metal construction; fabricated from cold-rolled steel sheet. Provide with factory-applied enamel or powder-coat finish; colors as selected by Architect from manufacturer's full range.
2. Stainless-Steel Wall Panels: Flush, formed-metal construction; fabricated from stainless-steel sheet.
3. Plastic-Laminate Wall Panels: Plastic laminate adhesively applied to 1/2-inch (13-mm) fire-retardant-treated particleboard, manufacturer's standard honeycomb core, manufacturer's standard formed metal panels with plastic-laminate panel backing and manufacturer's standard protective edge trim. Panels have a flame-spread index of 25, 75, or less, when tested according to ASTM E84. Plastic-laminate color, texture, and pattern as selected by Architect from plastic-laminate, elevator manufacturer's full range.
4. Enameled- or Powder-Coated-Steel Doors: Flush, hollow-metal construction; fabricated from cold-rolled steel sheet. Provide with factory-applied enamel or powder-coat finish; colors as selected by Architect from manufacturer's full range.
5. Stainless-Steel Doors: Flush, hollow-metal construction; fabricated from stainless-steel sheet or by laminating stainless-steel sheet to exposed faces and edges of enameled- or powder-coated-steel doors using adhesive that fully bonds metal to metal without telegraphing or oil-canning.
6. Plastic-Laminate Doors: Flush, hollow-metal construction; fabricated by laminating plastic laminate to exposed faces of enameled- or powder-coated-steel doors and covering edges with protective edge trim matching return panels. Plastic-laminate color, texture, and pattern as selected by Architect from plastic-laminate, elevator, manufacturer's full range.
7. Sight Guards: Provide sight guards on car doors.
8. Sills: Extruded or machined metal, with grooved surface, 1/4 inch (6.4 mm) thick.
9. Luminous Ceiling: Fluorescent light fixtures and ceiling panels of translucent acrylic or other permanent rigid plastic.
10. Metal, Metallic-Finish, Plastic-Laminate, Ceiling: Flush panels, with incandescent downlights in the center of four low-voltage downlights in each panel. Align ceiling panel joints with joints between wall panels.
11. Light Fixture Efficiency: Not less than 35 lumens/W.
12. Ventilation Fan Efficiency: Not less than 3.0 cfm/W (1.4 L/s per W).

2.8 HOISTWAY ENTRANCES

A. Hoistway Entrance Assemblies: Manufacturer's standard horizontal-sliding, door-and-frame hoistway entrances complete with track systems, hardware, sills, and accessories. Frame size and profile shall accommodate hoistway wall construction.

1. Where gypsum board wall construction is indicated, frames shall be self-supporting with reinforced head sections.

B. Fire-Rated Hoistway Entrance Assemblies: Door-and-frame assemblies shall comply with NFPA 80 and be listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction based on testing at as close-to-neutral pressure as possible according to NFPA 252 or UL 10B.

1. Fire-Protection Rating: 1 hour, 1-1/2 hours with 30-minute temperature rise of 450 deg F (250 deg C).

C. Materials and Fabrication: Manufacturer's standards, but not less than the following:

1. Enameled- or Powder-Coated-Steel Frames: Formed from cold- or hot-rolled steel sheet. Provide with factory-applied enamel or powder-coat finish; colors as selected by Architect from manufacturer's full range.
2. Stainless-Steel Frames: Formed from stainless-steel sheet.
3. Star of Life Symbol: Identify emergency elevators with star of life symbol, not less than 3 inches (76 mm) high, on both jambs of hoistway door frames.
4. Enameled- or Powder-Coated-Steel Doors and Transoms: Flush, hollow-metal construction; fabricated from cold-rolled steel sheet. Provide with factory-applied enamel or powder-coat finish; colors as selected by Architect from manufacturer's full range.
5. Stainless-Steel Doors and Transoms: Flush, hollow-metal construction; fabricated from stainless-steel sheet or by laminating stainless-steel sheet to exposed faces and edges of enameled- or powder-coated-steel doors using adhesive that fully bonds metal to metal without telegraphing or oil-canning.
6. Plastic-Laminate Doors and Transoms: Flush, hollow-metal construction; fabricated by laminating plastic laminate to exposed faces of enameled- or powder-coated-steel doors and covering edges with protective edge trim matching door frames. Plastic-laminate color, texture, and pattern as selected by Architect from plastic-laminate, elevator manufacturer's full range.
7. Sight Guards: Provide sight guards on doors matching door edges.
8. Sills: Extruded or machined metal, with grooved surface, 1/4 inch (6.4 mm) thick.
9. Non-shrink, Nonmetallic Grout: Factory-packaged, non-staining, noncorrosive, nongaseous grout complying with ASTM C1107/C1107M.

2.9 SIGNAL EQUIPMENT

A. General: Provide hall-call and car-call buttons that light when activated and remain lit until call has been fulfilled. Provide vandal-resistant, buttons and lighted elements illuminated with LEDs.

B. Car-Control Stations: Provide manufacturer's standard recessed or semi-recessed car-control stations. Mount in return panel adjacent to car door unless otherwise indicated.

1. Provide "No Smoking" sign matching car-control station, either integral with car-control station or mounted adjacent to it, with text and graphics as required by authorities having jurisdiction.

C. Emergency Communication System: Two-way voice communication system, with visible signal, which dials preprogrammed number of monitoring station and does not require handset use. System is contained in flush-mounted cabinet, with identification, instructions for use, and battery backup power supply.

D. Firefighters' Two-Way Telephone Communication Service: Provide flush-mounted cabinet, telephone jack in each car and required conductors in traveling cable for firefighters' two-way telephone communication service specified in Section 284621.11 "Addressable Fire-Alarm Systems." Section 284621.13 "Conventional Fire-Alarm Systems."

E. Car Position Indicator: Provide illuminated, digital-type car position indicator, located above car door or above car-control station. Also, provide audible signal to indicate to passengers that car is either stopping at or passing each of the floors served. Include travel direction arrows if not provided in car-control station.

F. Hall Push-Button Stations: Provide hall push-button station at each landing as indicated.

G. Hall Lanterns: Units with illuminated arrows; however, provide single arrow at terminal landings. Provide one, of the following:

1. Manufacturer's standard wall-mounted units, for mounting above entrance frames.
2. Units mounted in both jambs of entrance frame for each elevator.

H. Hall Annunciator: With each hall lantern, provide audible signals indicating car arrival and direction of travel. Signals sound once for up and twice for down.

I. Standby-Power Elevator Selector Switches: Provide switches, as required by ASME A17.1/CSA B44, where indicated. Adjacent to switches, provide illuminated signal that indicates when normal power supply has failed. For each elevator, provide illuminated signals that indicate when they are operational and when they are at the designated emergency return level with doors open.

J. Fire-Command-Center Annunciator Panel: Provide panel containing illuminated position indicators for each elevator, clearly labeled with elevator designation; include illuminated signal that indicates when elevator is operational and when it is at the designated emergency return level with doors open. Provide standby-power elevator selector switch(es), as required by ASME A17.1/CSA B44, adjacent to position indicators. Provide illuminated signal that indicates when normal power supply has failed.

K. Emergency Pictorial Signs: Fabricate from materials matching hall push-button stations, with text and graphics as required by authorities having jurisdiction, indicating that in case of fire, elevators are out of service and exits should be used instead. Provide one sign at each hall push-button station unless otherwise indicated.

2.10 FINISH MATERIALS

A. Cold-Rolled Steel Sheet: ASTM A1008/A1008M, commercial steel, Type B, exposed, matte finish.

B. Hot-Rolled Steel Sheet: ASTM A1011/A1011M, commercial steel, Type B, pickled.

C. Stainless-Steel Sheet: ASTM A240/A240M, Type 304.

D. Stainless-Steel Bars: ASTM A276, Type 304.

E. Stainless-Steel Tubing: ASTM A554, Grade MT 304.

F. Aluminum Extrusions: ASTM B221 (ASTM B221M), Alloy 6063.

G. Plastic Laminate: High-pressure type complying with NEMA LD 3, Type HGS or Type HGL.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Excavation for Cylinder: Drill well hole in each elevator pit to accommodate installation of cylinder; comply with applicable requirements in Section 312000 "Earth Moving."

B. Provide, waterproof well casing, as necessary to retain well-hole walls.

C. Install cylinder in protective casing within well hole. Before installing protective casing, remove water and debris from well hole and provide permanent waterproof seal at bottom of well casing.

1. Align cylinder and fill space around protective casing with fine sand.

D. Install cylinder plumb and accurately centered for elevator car position and travel. Anchor securely in place, supported at pit floor. Seal between well or protective casing and pit floor with 4 inches (100 mm) of non-shrink, nonmetallic grout.

E. Install cylinder plumb and accurately centered for elevator car position and travel. Anchor securely in place, supported at pit floor and braced at intervals as needed to maintain alignment. Anchor cylinder guides at spacing needed to maintain alignment and avoid overstressing guides.

F. Sound Isolation: Mount rotating and vibrating equipment on vibration-isolating mounts to minimize vibration transmission to structure and structure-borne noise due to elevator system.

G. Lubricate operating parts of systems as recommended by manufacturers.

H. Leveling Tolerance: 1/4 inch (6 mm), up or down, regardless of load and travel direction.

I. Set sills flush with finished floor surface at landing. Fill space under sill solidly with nonshrink, nonmetallic grout.

J. Locate hall signal equipment for elevators as follows unless otherwise indicated:

1. For groups of elevators, locate hall push-button stations between two elevators at center of group or at location most convenient for approaching passengers.
2. Place hall lanterns either above or beside each hoistway entrance.
3. Mount hall lanterns at a minimum of 72 inches (1829 mm) above finished floor.

3.2 FIELD QUALITY CONTROL

A. Acceptance Testing: On completion of elevator installation and before permitting elevator use (either temporary or permanent), perform acceptance tests as required and recommended by ASME A17.1/CSA B44 and by governing regulations and agencies.

3.3 PROTECTION

A. Temporary Use: Limit temporary use for construction purposes to one elevator. Comply with the following requirements for each elevator used for construction purposes:

1. Provide car with temporary enclosure, either within finished car or in place of finished car, to protect finishes from damage.
2. Provide other protective coverings, barriers, devices, signs, and procedures as needed to protect elevator and elevator equipment.
3. Engage elevator Installer to provide full maintenance service.
4. Engage elevator Installer to restore damaged work, if any, so no evidence remains of correction. Return items that cannot be refinished in the field to the shop, make required repairs and refinish entire unit, or provide new units as required.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to operate, adjust, and maintain elevator(s).

3.5 MAINTENANCE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include, as directed, months' full maintenance by skilled employees of elevator Installer. Include monthly preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper elevator operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

END OF SECTION 142400

SECTION 142413 - HYDRAULIC FREIGHT ELEVATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes hydraulic freight elevators.

B. Related Requirements:

1. Section 051200 "Structural Steel Framing" for structural-steel frames and sills for hoistway entrances that are a part of steel frame.
2. Section 055000 "Metal Fabrications" for structural-steel frames and sills for hoistway entrances.

1.2 ACTION SUBMITTALS

A. Product Data: Include capacities, sizes, performances, operations, safety features, finishes, and similar information.

B. Shop Drawings:

1. Include plans, elevations, sections, and large-scale details indicating service at each landing, machine room layout, coordination with building structure, relationships with other construction, and locations of equipment.
2. Indicate maximum dynamic and static loads imposed on building structure at points of support, and maximum and average power demands.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For elevator equipment, accessories, and components, from manufacturer.

B. Manufacturer Certificates: Signed by elevator manufacturer certifying that hoistway, pit, and machine room layout and dimensions, as shown on Drawings, and electrical service including standby power generator, as shown and specified, are adequate for elevator system being provided.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

B. Inspection and Acceptance Certificates and Operating Permits: As required by authorities having jurisdiction for normal, unrestricted elevator use.

C. Continuing Maintenance Proposal: Submit a continuing maintenance proposal from Installer to Owner, in the form of a standard one-year, two-year, five-year, and or as directed, maintenance agreement, starting on date initial maintenance service is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.

1.5 WARRANTY

A. Manufacturer's Special Warranty: Manufacturer agrees to repair or replace elevator work that fails in materials or workmanship within specified warranty period.

1. Warranty Period: As directed, year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Regulatory Requirements: Comply with ASME A17.1/CSA B44.

B. Accessibility Requirements: Comply with Section 407 in the United States Access Board's ADA-ABA Accessibility Guidelines and with ICC A117.1.

C. Seismic Performance: Elevator system shall withstand the effects of earthquake motions determined according to ASCE/SEI 7 and shall comply with elevator seismic requirements in ASME A17.1/CSA B44.

1. Project Seismic Design Category: C, D, E, F.
2. Elevator Component Importance Factor: 1.5, 1.0.
3. Design earthquake spectral response acceleration short period (Sds) for Project is.

2.3 FREIGHT ELEVATORS

A. Elevator System, General: Manufacturer's standard hydraulic freight elevator systems. Unless otherwise indicated, manufacturer's standard components shall be used, as included in standard elevator systems and as required for complete system.

B. Elevator Description:

1. Elevator Number(s): Elevator number(s) as shown on Drawings.
2. Type: Under-the-car single or dual cylinder.
3. Type: Holeless, beside-the-car, single-acting, single, dual cylinder.
4. Type: Holeless, beside-the-car, telescoping, single, dual cylinder.
5. Type: Holeless, beside-the-car, roped hydraulic, single, dual cylinder.
6. Rated Load: 2000 lb (908 kg), 2500 lb (1135 kg), 3000 lb (1362 kg), 4000 lb (1816 kg), 5000 lb (2270 kg), 6000 lb (2720 kg), 8000 lb (3632 kg), 10,000 lb (4540 kg).

7. Freight Loading Class: Class A, Class B, Class C1, Class C2, Class C3.
8. Rated Speed (Up): 50 fpm (0.25 m/s), 75 or 80 fpm (0.38 or 0.41 m/s), 100 fpm (0.51 m/s).
9. Operation System: Single automatic, Car-switch automatic floor stop, Selective-collective automatic.
10. Auxiliary Operations:

    a. Battery-powered lowering.
    b. Load-weighing device.
    c. Automatic operation of lights and ventilation fans.

11. Security Features: Card-reader, Key-switch operation.
12. Auxiliary Car-Control Station: Provide additional car-control station mounted on side of car at height to facilitate operation by forklift-truck operator without leaving truck.
13. Car Enclosures:

    a. Platform Width: 60 inches (1524 mm), 64 inches (1626 mm), 66 inches (1676 mm), 76 inches (1930 mm), 78 inches (1981 mm), 88 inches (2235 mm), 100 inches (2540 mm), 102 inches (2591 mm), 124 inches (3150 mm), 126 inches (3200 mm).
    b. Platform Depth: 72 inches (1829 mm), 84 inches (2134 mm), 96 inches (2438 mm), 120 inches (3048 mm), 144 inches (3658 mm), 168 inches (4267 mm).
    c. Ceiling Height: 84 inches (2134 mm), 96 inches (2438 mm), 108 inches (2743 mm).
    d. Walls and Ceiling: Prime-painted or powder-coated steel, Prime-painted or powder-coated, metallic-coated steel, Satin stainless steel, ASTM A480/A480M, No. 4 finish.
    e. Car Fixtures: Satin stainless steel, ASTM A480/A480M, No. 4 finish.
    f. Floor: Rolled steel floor plate.
    g. Car Gate Type: Vertical bi-parting, Single-speed vertical lift, Two-speed vertical lift.
    h. Car Gate Operation: Manual, Power operated.
    i. Car Gate Material: Prime-painted or powder-coated steel, Satin stainless steel, ASTM A480/A480M, No. 4 finish.
    j. Lighting: One, Two, Three, 48-inch (1219-mm), two-tube fluorescent light fixture(s).
    k. Light Fixture Efficiency: Not less than 35 lumens/W.
    l. Ventilation Fan Efficiency: Not less than 3.0 cfm/W (1.4 L/s per W).

14. Hoistway Entrances:

    a. Width: 56 inches (1422 mm), 60 inches (1524 mm), 62 inches (1575 mm), 72 inches (1829 mm), 96 inches (2438 mm), 98 inches (2489 mm), 120 inches (3048 mm), 122 inches (3099 mm).
    b. Height: 84 inches (2134 mm), 96 inches (2438 mm).
    c. Door Type: Vertical bi-parting, Single-speed vertical lift, Two-speed vertical lift.
    d. Fire-Protection Rating: 1 hour, 1-1/2 hours, with 30-minute temperature rise of 450 deg F (250 deg C).
    e. Door Operation: Manual, Power operated with door reopening device.
    f. Door Material: Prime-painted or powder-coated steel, Satin stainless steel, ASTM A480/A480M, No. 4 finish.

15. Hall Fixtures: Satin stainless steel, ASTM A480/A480M, No. 4 finish.
16. Auxiliary Hall Stations: Provide additional pendant-mounted, hall push-button stations where indicated mounted at height to facilitate operation by forklift-truck operator without leaving truck.

2.4 SYSTEMS AND COMPONENTS

A. Pump Units: Positive-displacement type with a maximum of 10 percent variation between no load and full load and with minimum pulsations.

1. Pump shall be submersible type with submersible squirrel-cage induction motor, shall be suspended inside oil tank from vibration isolation mounts or tank-top-mounted type with fan-cooled, squirrel-cage induction motor and shall be mounted on oil tank with vibration isolation mounts and enclosed in prime-painted steel enclosure lined with 1-inch- (25-mm-) thick, glass-fiber insulation board.
2. Motor shall have wye-delta or solid-state starting.

B. Hydraulic Silencers: System shall have hydraulic silencer containing pulsation-absorbing material in blowout-proof housing at pump unit.

C. Hydraulic Fluid: Elevator manufacturer's standard fire-resistant fluid with additives as needed to prevent oxidation of fluid, corrosion of cylinder and other components, and other adverse effects.

D. Hydraulic Fluid: Nontoxic, bio-degradable, fire-resistant fluid made from vegetable oil with antioxidant, anticorrosive, antifoaming, and metal-passivating additives and approved by elevator manufacturer for use with elevator equipment.

1. Product: Subject to compliance with requirements, provide "Hydro Safe" by Hydro Safe Oil Division, Inc.

E. Protective Cylinder Casing: PVC or HDPE pipe casing complying with ASME A17.1/CSA B44, of sufficient size to provide not less than 1-inch (25-mm) clearance from cylinder and extending above pit floor. Casing shall have method of monitoring effectiveness of complying with ASME A17.1/CSA B44.

F. Guides: Roller guides, Polymer-coated, nonlubricated sliding guides or sliding guides with guide-rail lubricators. Provide guides at top and bottom of car and counterweight frames.

2.5 OPERATION SYSTEMS

A. General: Provide manufacturer's standard microprocessor operation system as required to provide type of operation indicated.

B. Battery-Powered Lowering: When power fails, car is lowered to the lowest floor, opens its doors, and shuts down. System includes rechargeable battery and automatic recharging system.

C. Security Features: Security features shall not affect emergency firefighters' service.

1. Card-Reader Operation: System uses card readers at car-control stations to authorize calls. Security system determines which landings and at what times calls require authorization by card reader. Allow space for card reader in car, Provide stripe-swipe card reader integral with each car-control station.

    a. Security access system equipment is specified in Section 281500 "Access Control Hardware Devices." not in the Contract.

2. Key-switch Operation: Push buttons are activated and deactivated by security key-switches at car-control stations.

2.6 DOOR REOPENING DEVICES

A. Infrared Array: Provide door reopening devices with uniform array of 36 or more microprocessor-controlled, infrared light beams projecting across car entrance. Interruption of one or more light beams shall cause doors to stop and reopen.

2.7 CAR ENCLOSURES

A. General: Provide car enclosures as indicated, including ventilation, lighting, finishes, access doors, thresholds, trim, and accessories. Fabricate with recesses and cutouts for signal equipment.

1. Provide power door operators with linkages for hoistway door operation.
2. Provide standard railings complying with ASME A17.1/CSA B44 on car tops where required by ASME A17.1/CSA B44.

B. Materials and Fabrication: Provide manufacturer's standard, flush panel, welded construction made from metal sheet, of metal indicated, not less than 0.067 inch (1.7 mm) and reinforced at 16-inch (406-mm) maximum spacing.

2.8 HOISTWAY ENTRANCES

A. Unless otherwise indicated, provide hoistway entrance doors of type indicated below, with truckable sill bars and resilient safety meeting-rail gaskets.

1. Equip for power operation by coordinated linkage with power-operated car door.

B. Fire-Rated Hoistway Entrance Assemblies: Door and frame assemblies shall comply with NFPA 80 and be listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire-protection ratings indicated, based on testing at as-close-to-neutral pressure as possible according to NFPA 252 or UL 10B.

C. Materials and Fabrication: Provide manufacturer's standards, but not less than the following:

1. Metal Door Panels: Constructed of metal sheets, flush on room side, welded and reinforced in steel framing with vertical reinforcing spaced not more than 24 inches (610 mm) o.c. Fabricate panel faces from metal sheet, of metal indicated, not less than 0.097 inch (2.5 mm) thick.

2.9 SIGNAL EQUIPMENT

A. General: Provide hall-call and car-call buttons that light when activated and remain lit until call has been fulfilled. Fabricate lighted elements with LEDs or of acrylic or other permanent, nonyellowing translucent plastic.

B. Car-Control Stations: Provide manufacturer's standard car-control station. Mount adjacent to car door unless otherwise indicated.

C. Firefighters' Two-Way Telephone Communication Service: Provide flush-mounted cabinet, telephone jack in each car and required conductors in traveling cable for firefighters' two-way telephone communication service specified in Section 284621.11 "Addressable Fire-Alarm Systems." Section 284621.13 "Conventional Fire-Alarm Systems."

D. Hall Push-Button Stations: Provide hall push-button stations at each landing as indicated.

1. Provide single-button stations with position, "in-use", indicator.
2. Provide telephone jack in each unit for firefighters' two-way telephone communication service specified in Section 284621.11 "Addressable Fire-Alarm Systems." Section 284621.13 "Conventional Fire-Alarm Systems."

2.10 FINISH MATERIALS

A. Cold-Rolled Steel Sheet: ASTM A1008/A1008M, commercial steel, Type B, exposed, matte finish.

B. Hot-Rolled Steel Sheet: ASTM A1011/A1011M, commercial steel, Type B, pickled.

C. Metallic-Coated Steel Sheet: ASTM A653/A653M, commercial steel, with G60 (Z180) zinc coating (galvanized) or A60 (ZF180) zinc-iron-alloy coating (galvannealed).

D. Stainless Steel Sheet: ASTM A240/A240M, Type 304.

E. Rolled Steel Floor Plate: ASTM A786/A786M.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Excavation for Cylinder: Drill well hole in each, elevator pit to accommodate installation of cylinder; comply with applicable requirements in Section 312000 "Earth Moving."

B. Provide waterproof, well casing, as necessary, to retain well-hole walls.

C. Install cylinder in protective casing within well hole. Before installing protective casing, remove water and debris from well hole, and provide permanent waterproof seal at bottom of well casing.

1. Align cylinders and fill space around protective casing with fine sand.

D. Install cylinder plumb and accurately centered for elevator car position and travel. Anchor securely in place, supported at pit floor. Seal between well, protective, casing and pit floor with 4 inches (100 mm) of non-shrink, nonmetallic grout.

E. Install cylinder plumb and accurately centered for elevator car position and travel. Anchor securely in place, supported at pit floor and braced at intervals as needed to maintain alignment. Anchor cylinder guides at spacing needed to maintain alignment and avoid overstressing guides.

F. Sound Isolation: Mount rotating and vibrating equipment on vibration-isolating mounts to minimize vibration transmission to structure and structure-borne noise due to elevator system.

G. Lubricate operating parts of systems as recommended by manufacturers.

3.2 FIELD QUALITY CONTROL

A. Acceptance Testing: On completion of elevator installation and before permitting elevator use (either temporary or permanent), perform acceptance tests as required and recommended by ASME A17.1/CSA B44 and by governing regulations and agencies.

3.3 PROTECTION

A. Temporary Use: Limit temporary use for construction purposes to one elevator. Comply with the following requirements for each elevator used for construction purposes:

1. Engage elevator Installer to provide full maintenance service.
2. Engage elevator Installer to restore damaged work, if any, so no evidence remains of correction. Return items that cannot be refinished in the field to the shop, make required repairs and refinish entire unit, or provide new units as required.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to operate, adjust, and maintain elevator(s).

3.5 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include, as directed, months' full maintenance by skilled employees of elevator Installer. Include monthly preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper elevator operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

END OF SECTION 142413

SECTION 142600 - LIMITED-USE/LIMITED-APPLICATION ELEVATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes limited-use/limited-application (LU/LA) elevators.

1.2 ACTION SUBMITTALS

A. Product Data: Include capacities, sizes, performances, operations, safety features, finishes, and similar information. Include Product Data for car enclosures, hoistway entrances, and operation, control, and signal equipment.

B. Shop Drawings:

1. Include plans, elevations, sections, and large-scale details indicating service at each landing, machine room layout, coordination with building structure, relationships with other construction, and locations of equipment.
2. Indicate loads imposed on building structure at points of support and power requirements.

C. Samples: For finishes involving color selection.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Seismic Qualification Certificates: For elevator equipment, accessories, and components, from manufacturer.

C. Manufacturer Certificates: Signed by elevator manufacturer certifying that hoistway, pit, and machine room layout and dimensions, as shown on Drawings, and electrical service, as shown and specified, are adequate for elevator being provided.

D. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

B. Inspection and Acceptance Certificates and Operating Permits: As required by authorities having jurisdiction, for normal, unrestricted elevator use.

C. Continuing Maintenance Proposal: Provide a continuing maintenance proposal from Installer to Owner, in the form of a standard one-year, two-year, five-year, and or as directed, maintenance agreement, starting on date initial maintenance service is concluded.

1.5 WARRANTY

A. Manufacturer's Special Warranty: Manufacturer agrees to repair or replace elevator work that fails in materials or workmanship within specified warranty period.

1. Warranty Period: As directed, year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Regulatory Requirements: Comply with ASME A17.1/CSA B44.

B. Accessibility Requirements: Comply with requirements for LU/LA elevators in the United States Access Board's ADA-ABA Accessibility Guidelines and with ICC A117.1.

C. Seismic Performance: Elevator system shall withstand the effects of earthquake motions determined according to ASCE/SEI 7 and shall comply with elevator seismic requirements in ASME A17.1/CSA B44.

1. Project Seismic Design Category: C, D, E, F.
2. Elevator Component Importance Factor: 1.5, 1.0.
3. Design earthquake spectral response acceleration short period (Sds) for Project.

2.3 SYSTEMS AND COMPONENTS

A. Elevator System, General: Manufacturer's standard LU/LA elevator. Unless otherwise indicated, manufacturers' standard components shall be used, as included in standard LU/LA elevators and as required for complete system.

1. Rated Load: 1400 lb (635 kg).
2. Rated Speed: 25 to 30 fpm (0.13 to 0.15 m/s).

B. Machine Type: Hydraulic, holeless, beside the car; direct-acting hydraulic or roped hydraulic.

C. Pump Units: Positive-displacement type with a maximum of 10 percent variation between no load and full load and with minimum pulsations.

1. Pump shall be submersible type, with submersible squirrel-cage induction motor, suspended inside oil tank from vibration isolation mounts.
2. Motor shall have solid-state starting, variable-voltage, variable-frequency motor control.
3. System shall have hydraulic silencer and flexible piping connectors at pump unit.

D. Hydraulic Fluid: Elevator manufacturer's standard fire-resistant fluid with additives as needed to prevent oxidation of fluid, corrosion of cylinder and other components, and other adverse effects.

2.4 OPERATION SYSTEMS

A. General: Provide manufacturer's standard, microprocessor, operation system for single automatic operation, selective-collective automatic operation.

B. Battery-Powered Lowering: When power fails, car is lowered to the lowest floor, opens its car and hoistway doors, and shuts down. System includes rechargeable battery and automatic recharging system.

C. Provide automatic operation of lights and ventilation fans.

D. Emergency Operation: None required, Phase I emergency recall operation, Phase I emergency recall operation and Phase II emergency in-car operation.

2.5 CAR ENCLOSURES

A. General: Provide steel-framed car enclosures with wall panels, car roof, access doors, power door operators, and ventilation. Provide finished car including materials and finishes specified below.

B. Clear Inside Dimensions:

1. Inside Width: 36 inches (915 mm), 42 inches (1065 mm), 48 inches (1219 mm) from sidewall to sidewall.
2. Inside Depth: 48 inches (1219 mm), 54 inches (1370 mm), 60 inches (1524 mm) from back wall to front wall (return panels).
3. Inside Height: 84 inches (2134 mm) to underside of ceiling.

C. Materials and Finishes: Manufacturer's standards, but not less than the following:

1. Floor Finish: Elevator manufacturer's standard level-loop nylon carpet; color as selected by Architect from manufacturer's full range.
2. Enameled or Powder-Coated Steel Wall Panels: Flush, formed-metal construction; fabricated from cold-rolled steel sheet. Provide with factory-applied enamel or powder-coat finish; colors as selected by Architect from manufacturer's full range.
3. Plastic-Laminate Wall Panels: Plastic laminate adhesively applied to manufacturer's standard core, metal panels with plastic-laminate panel backing and manufacturer's standard protective edge trim. Panels shall have a flame-spread index of 25, 75 or less, when tested according to ASTM E84. Plastic-laminate color, texture, and pattern as selected by Architect from plastic-laminate, elevator manufacturer's full range.
4. Metal Ceiling: Flush panels, fabricated from cold-rolled steel sheet. Provide panels with factory-applied enamel or powder-coat finish; colors as selected by Architect from manufacturer's full range.
5. Lighting: Not less than two downlights. Provide battery backup power source with automatic charging.

    a. Light Fixture Efficiency: Not less than 35 lumens/watt.

6. Handrail: Manufacturer's standard.

D. Car Doors: Manufacturer's standard units complete with track systems, hardware, sills, and accessories.

1. Operation: Manual, Power-operated, automatic.
2. Type: Horizontal sliding, Horizontally, operated, folding.
3. Clear Opening Width: 32 inches (815 mm), 36 inches (915 mm).
4. Door Height: 80 inches (2032 mm), 84 inches (2134 mm).
5. Enameled or Powder-Coated Steel Doors: Flush, hollow-metal construction; fabricated from cold-rolled steel sheet. Provide with factory-applied enamel or powder-coat finish; colors as selected by Architect from manufacturer's full range.
6. Primed-Steel Doors: Flush, hollow-metal construction; fabricated from cold-rolled steel sheet. Provide with factory-applied, corrosion-resistant primer or powder-coating for field painting.
7. Plastic-Laminate Doors: Flush, hollow-metal construction; fabricated by laminating plastic laminate to exposed faces of enameled cold-rolled steel doors and covering edges with protective edge trim. Plastic-laminate color, texture, and pattern as selected by Architect from plastic-laminate, elevator manufacturer's full range.
8. Aluminum Folding Doors: Aluminum extrusions with edges forming full-height hinges connected by stainless-steel rod.

2.6 HOISTWAY ENTRANCES

A. General: Provide manufacturer's standard door-and-frame hoistway entrances, same size as car doors, complete with track systems, hardware, sills, and accessories.

1. Operation: Manual, Power-operated, automatic.
2. Type: Horizontal sliding, Side hinged.

B. Coordinate frame size and profile with hoistway wall construction.

1. Where gypsum board wall construction is indicated, provide self-supporting frames with reinforced head sections.

C. Materials and Fabrication: Manufacturer's standards, but not less than the following:

1. Enameled or Powder-Coated Steel Frames: Formed from cold- or hot-rolled steel sheet. Provide with factory-applied enamel or powder-coat finish; colors as selected by Architect from manufacturer's full range.
2. Primed-Steel Frames: Formed from cold- or hot-rolled steel sheet. Provide with factory-applied, corrosion-resistant primer or powder-coating for field painting.
3. Enameled or Powder-Coated Steel Doors: Flush, hollow-metal construction; fabricated from cold-rolled steel sheet. Provide with factory-applied enamel or powder-coat finish; colors as selected by Architect from manufacturer's full range.
4. Primed-Steel Doors: Flush, hollow-metal construction; fabricated from cold-rolled steel sheet. Provide with factory-applied, corrosion-resistant primer or powder-coating for field painting.
5. Plastic-Laminate Doors: Flush, hollow-metal construction; fabricated by laminating plastic laminate to exposed faces of enameled cold-rolled steel doors and covering edges with protective edge trim. Plastic-laminate color, texture, and pattern as selected by Architect from plastic-laminate, elevator, manufacturer's full range.

D. Fire-Rated Hoistway Entrance Assemblies: Door and frame assemblies shall comply with NFPA 80 and be listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction based on testing at as-close-to-neutral pressure as possible according to NFPA 252 or UL 10B as directed.

1. Fire-Protection Rating: 1 hour, 1-1/2 hours, with 30-minute temperature rise of 450 deg F (250 deg C).

2.7 SIGNAL EQUIPMENT

A. General: Provide hall-call and car-call buttons that light when activated and remain lit until call has been fulfilled. Provide vandal-resistant buttons and lighted elements illuminated with light-emitting diodes.

1. Finish: Polished stainless steel, No. 8 finish, Satin stainless steel, No. 4 finish.

B. Car-Control Stations: Provide manufacturer's standard car-control stations. Mount in side panel adjacent to car door unless otherwise indicated.

1. Mark buttons and switches for function. Use both tactile symbols and Braille.
2. Provide "No Smoking" sign matching car-control station, either integral with car-control station or mounted adjacent to it, with text and graphics as required by authorities having jurisdiction.

C. Emergency Communication System: Two-way voice communication system, with visible signal, which dials preprogrammed number of monitoring station and does not require handset use. System is contained in flush-mounted cabinet, with identification, instructions for use, and battery backup power supply.

D. Car Position Indicator: Provide digital-type position indicator in elevator car. Also, provide audible signal to indicate to passengers that car is either stopping at or passing each of the floors served. Include travel direction arrows if not provided in car-control station.

E. Hall Push-Button Stations: Wall-mounted or jamb-mounted units equipped with buttons for calling elevator and for indicating desired direction of travel where applicable.

F. Hall Lanterns: Wall-mounted or jamb-mounted units with illuminated arrows; but provide single arrow at terminal landings.

G. Hall Annunciator: Provide audible signals indicating car arrival and direction of travel.

H. Emergency Pictorial Signs: Fabricate from materials matching hall push-button stations, with text and graphics as required by authorities having jurisdiction, indicating that in case of fire, elevators are out of service and exits should be used instead. Provide one sign at each hall push-button station unless otherwise indicated.

2.8 FINISH MATERIALS

A. Cold-Rolled Steel Sheet: ASTM A1008/A1008M, commercial steel, Type B, exposed, matte finish.

B. Hot-Rolled Steel Sheet: ASTM A1011/A1011M, commercial steel, Type B, pickled.

C. Stainless-Steel Sheet: ASTM A240/A240M, Type 304.

D. Aluminum Extrusions: ASTM B221 (ASTM B221M), Alloy 6063.

E. Plastic Laminate: High-pressure type complying with NEMA LD 3, Type HGS for flat applications, Type HGL for flat applications and Type BKV for panel backing.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install cylinder plumb and accurately located for elevator car position and travel. Anchor securely in place, supported at pit floor and braced at intervals as needed to maintain alignment. Anchor cylinder guides at spacing needed to maintain alignment and avoid overstressing guides.

B. Sound Isolation: Mount rotating and vibrating equipment on vibration-isolating mounts to minimize vibration transmission to structure and structure-borne noise from elevator system.

C. Lubricate operating parts of systems as recommended by manufacturers.

D. Alignment: Coordinate installation of hoistway entrances with installation of elevator guide rails for accurate alignment of entrances with car. Reduce clearances to minimum, safe, workable dimension at each landing.

E. Leveling Tolerance: 1/4 inch (6 mm), up or down, regardless of load and direction of travel.

F. Set sills flush with finished floor surface at landing.

G. Locate hall lanterns either above or beside hoistway entrance at a minimum of 72 inches (1829 mm) above finished floor unless hall lanterns are built into entrance frames.

3.2 FIELD QUALITY CONTROL

A. Acceptance Testing: On completion of elevator installation and before permitting elevator use, perform acceptance tests as required and recommended by ASME A17.1/CSA B44 and by authorities having jurisdiction.

3.3 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include, as directed, months' full maintenance by skilled employees of elevator Installer. Include monthly preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper elevator operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

END OF SECTION 142600

SECTION 143100 - ESCALATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes escalators.

1.2 ACTION SUBMITTALS

A. Product Data: Include capacities, sizes, performances, safety features, finishes, and similar information.

B. Shop Drawings:

1. Include plans, elevations, sections, and details indicating coordination with building structure and relationships with other construction.
2. Indicate maximum loads imposed on building structure at points of support and power requirements.
3. Indicate access and ventilation for escalator machine space.

C. Samples: For exposed escalator finishes.

D. Delegated-Design Submittal: For escalators.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For escalator equipment, accessories, and components, from manufacturer.

B. Manufacturer Certificates: Signed by manufacturer, certifying that escalator layout and dimensions, as shown on Drawings, and electrical service, as shown and specified, are adequate for escalator system being provided.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For escalators to include in emergency, operation, and maintenance manuals.

B. Inspection and Acceptance Certificates and Operating Permits: As required by authorities having jurisdiction for normal, unrestricted escalator use.

1.5 WARRANTY

A. Manufacturer's Special Warranty: Manufacturer agrees to repair, restore, or replace escalator work that fails in materials or workmanship within specified warranty period.

1. Warranty Period: As directed, year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Regulatory Requirements: Comply with ASME A17.1/CSA B44.

B. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design escalators.

C. Drive System Energy Performance: Provide regenerative drive system and motor that complies with requirements of the International Green Construction Code (IgCC).

D. Step/Skirt Performance Index: Not more than 0.15.

E. Seismic Performance: Escalators shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. Design earthquake spectral response acceleration short period (Sds) for Project is.
2. Project's Seismic Design Category: A, B, C, D, E, F.
3. Escalator Component Importance Factor: 1.0.

F. Structural Performance of Balustrades, Deck Barricades, and Handrails: Provide components and assemblies capable of withstanding the effects of loads indicated in ASCE/SEI 7 for handrail assemblies and guardrail systems.

2.3 MATERIALS

A. Stainless Steel: ASTM A240/A240M, Type 304.

1. Satin Finish: No. 4 directional satin.

B. Clear Tempered Glass: ASTM C1048, Condition A (uncoated surfaces), Type 1 (transparent glass, flat), Class 1 (clear), Quality q3 (glazing, select), Kind FT (fully tempered), 10.0, 12.0, mm thick.

C. Tinted Tempered Glass: ASTM C1048, Condition A (uncoated surfaces), Type 1 (transparent glass, flat), Class 2 (tinted), Quality q3 (glazing, select), Kind FT (fully tempered), 10.0, 12.0, mm thick.

1. Color: Bronze, Gray, Green and or as directed.

2.4 ESCALATORS

A. Escalators, General: Manufacturer's standard escalators complying with requirements. Unless otherwise indicated, manufacturer's standard components shall be used as included in standard escalator systems and as required for complete system.

B. Rated Speed: 90 fpm (0.46 m/s) or 100 fpm (0.5 m/s).

2.5 COMPONENTS

A. Opaque Balustrades: Manufacturer's standard profile or arrangement of moving handrails on fully paneled guide rail, with interior balustrade panels, deck covers, skirts, trim, and accessories. Prepare for exterior finish (specified in another Section) below the deck covers.

B. Transparent Balustrades: Manufacturer's standard profile or arrangement of moving handrails on guide rail that is supported by tempered glass panels, with deck covers, skirts, trim, and accessories. Prepare for exterior finish (specified in another Section) below the deck covers.

C. Direction Indicator Lights: Provide red and green indicator lights at least 2 inches (50 mm) in diameter in right-hand, both balustrade newels at both upper and lower landings. Green light indicates entrance end, and red light indicates exit end. When escalator is stopped, red lights are illuminated at both ends.

D. Handrails: Smooth, jointless, reinforced black neoprene.

E. Deck Covers and Trim: Satin stainless steel.

F. Balustrade Interior Panels: Satin stainless steel.

G. Balustrade Exterior Panels and Escalator Soffits: Satin stainless steel.

H. Skirt Panels, if Applicable: Manufacturer's standard low-friction material.

I. Steps: One piece made of die-cast aluminum with demarcation grooves at front and rear of tread surface.

1. Finish: Powder-coated gray, black.
2. Step Demarcation: Yellow stripe at sides and backs of step treads.

J. Combs: Integrally colored structural plastic, Cast aluminum, Cast aluminum with powder-coated finish.

1. Comb Color: Yellow.

K. Combplate Lights: Provide recessed light fixtures with flush lenses mounted in skirt panels at each side of combplates to illuminate combplate steps.

L. Floor Plates: Cast or extruded aluminum with grooved or patterned surface.

2.6 FEATURES

A. Fault Indicator: Provide escalators with a microprocessor unit that monitors safety devices, motor temperature, and escalator speed and records in nonvolatile memory the date, time, and device identification if a safety device is activated or escalator malfunctions.

1. Provide built-in or plug-in unit to display recorded information.

B. Standby Speed Feature: Provide variable-speed controls that comply with ASME A17.1/CSA B44 and the following:

1. Controls decelerate the escalator to a speed of no more than 20 fpm (0.10 m/s) after the escalator is unoccupied and no passengers are approaching escalator for a predetermined time interval.
2. Controls detect approaching passengers and accelerate the escalator to rated speed by the time passengers reach the combplate.

C. Oil Drip Pan: Provide metal pan under full width and length of escalator to collect and hold oil and grease drippings from lubricated components.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Set escalators true to line and level, properly support, and anchor to building structure. Use established benchmarks, lines, and levels to ensure dimensional coordination of the Work.

B. Adjust installed components for smooth, efficient operation, complying with required tolerances and ensuring they are free of hazardous conditions. Lubricate operating parts, including bearings, tracks, chains, guides, and hardware. Test operating devices, equipment, signals, controls, and safety devices. Install oil drip pans and verify that no oil drips outside of pans.

C. Repair damaged finishes so no evidence remains of correction work. Return items to the shop that cannot be refinished in the field, make required repairs, and refinish entire unit, or provide new units as required.

3.2 FIELD QUALITY CONTROL

A. Acceptance Testing: On completion of escalator installation and before permitting escalator use, perform acceptance tests as required and recommended by ASME A17.1/CSA B44 and by authorities having jurisdiction.

3.3 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include, as directed, months' full maintenance by skilled employees of escalator Installer. Include monthly preventive maintenance, repair or replacement of worn or defective

components, lubrication, cleaning, and adjusting as required for proper escalator operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to operate, adjust, and maintain escalators.

END OF SECTION 143100

SECTION 143200 - MOVING WALKS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes moving walks.

1.2 ACTION SUBMITTALS

A. Product Data: Include capacities, sizes, performances, safety features, finishes, and similar information.

B. Shop Drawings:

1. Include plans, elevations, sections, and details indicating coordination with building structure and relationships with other construction.
2. Indicate maximum loads imposed on building structure at points of support, and power requirements.
3. Indicate access and ventilation for moving walk machine space.

C. Samples: For exposed finishes.

1.3 INFORMATIONAL SUBMITTALS

A. Manufacturer certificates.

B. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

B. Inspection and Acceptance Certificates and Operating Permits: As required by authorities having jurisdiction for normal, unrestricted use of moving walks.

C. Continuing Maintenance Proposal: Provide a continuing maintenance proposal from Installer to Owner, in the form of a standard one-year, two-year or five-year maintenance agreement as directed, starting on date initial maintenance service is concluded.

1.5 WARRANTY

A. Manufacturer's Special Warranty: Manufacturer agrees to repair, restore, or replace moving walk work that fails in materials or workmanship within specified warranty period.

1. Warranty Period: Number of year(s) as directed from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Regulatory Requirements: Comply with ASME A17.1/CSA B44.

B. Drive System Energy Performance: Provide drive system and motor that complies with requirements of the ICC's International Green Construction Code (IgCC).

C. Structural Performance of Balustrades, Deck Barricades, and Handrails: Provide components and assemblies capable of withstanding the effects of loads indicated in ASCE/SEI 7 for handrail assemblies and guardrail systems.

2.3 MOVING WALKS

A. Moving Walks, General: Unless otherwise indicated, manufacturer's standard components shall be used as included in standard moving walk systems and as required for complete system.

B. Design and equip moving walks to run in either direction.

C. Rated Speed: As directed 90 fpm (0.45 m/s), 100 fpm (0.5 m/s), 120 fpm (0.6 m/s), 130 fpm (0.66 m/s) or 150 fpm (0.76 m/s).

2.4 COMPONENTS

A. Opaque Balustrades: Manufacturer's standard profile or arrangement of moving handrails on fully paneled guide rail with interior balustrade panels, deck covers, skirts, trim, and accessories. Prepared for exterior finish below the deck covers; exterior finish specified in another Section.

B. Transparent Balustrades: Manufacturer's standard profile or arrangement of moving handrails on guide rail that is supported by clear or tinted tempered glass panels as directed, with deck covers, skirts, trim, and accessories. Prepared for exterior finish below the deck covers; exterior finish specified in another Section.

C. Direction Indicator Lights: Provide red and green indicator lights at least 2 inches (50 mm) in diameter in right-hand or both balustrade newels at both landings as directed. Green light indicates entrance end, and red light indicates exit end. When moving walk is stopped, red lights are illuminated at both ends.

D. Handrails: Smooth, jointless, reinforced neoprene.

E. Deck Covers and Trim: Satin stainless steel.

F. Balustrade Interior Panels: Satin stainless steel.

G. Balustrade Exterior Panels: Satin stainless steel.

H. Skirt Panels, if Applicable: Manufacturer's standard low-friction material.

1. Clearance between skirt panels or overhanging balustrade panels and treadway shall not exceed 1/16 inch (1.6 mm).

I. Combs: As directed Integrally colored structural plastic or Cast aluminum with powder-coated finish.

1. Comb Color: Yellow.

J. Combplate Lights: Provide recessed light fixtures with flush lenses mounted in interior balustrade panels at each side of combplates, designed to illuminate treadway at combplate.

K. Floor Plates: Cast or extruded aluminum.

2.5 FEATURES

A. Operational Control: Provide key-operated starter switches and key-operated switches for directional control located on exterior deck above newel base at both ends of moving walks.

B. Fault Indicator: Provide moving walks with a microprocessor unit that monitors safety devices, motor temperature, and moving walk speed and records in nonvolatile memory date, time, and device identification if a safety device is activated or moving walk malfunctions.

1. Provide built-in or plug-in unit to display recorded information.

C. Standby Speed Feature: Provide variable-speed controls that comply with ASME A17.1/CSA B44 and the following:

1. Controls decelerate the moving walk to a speed of no more than 30 fpm (0.15 m/s) after the moving walk is unoccupied and no passengers are approaching the moving walk for a predetermined time interval.
2. Controls detect approaching passengers and accelerate the moving walk to rated speed by the time passengers reach the combplate.

D. Equip pallet drive mechanism with automatic pallet drive-chain lubricators.

E. Oil Drip Pan: Provide metal pan under full width and length of moving walks to collect and hold oil and grease drippings from lubricated components. Design and fabricate drip pan to sustain a load of 250 lbf (1.1 kN) on a 1.0-sq. ft. (0.09-sq. m) area at any location without permanent deflection.

F. Comb-Step Impact Device: Activated if a horizontal force in direction of travel is applied exceeding 400 lbf (1780 N) at either side or exceeding 800 lbf (3560 N) at center of front edge

of combplate, or a resultant force in upward direction is applied exceeding 150 lbf (688 N) at center of front edge of combplate.

G. Comb-Step Impact Device: Activated if a horizontal force in direction of travel is applied exceeding 112 lbf (500 N) at either side or exceeding 225 lbf (1000 N) at center of front edge of combplate, or a resultant force in upward direction is applied exceeding 150 lbf (688 N) at center of front edge of combplate.

2.6 MATERIALS

A. Stainless Steel: ASTM A240/A240M, Type 304.

1. Satin Finish: No. 4 directional satin.

B. Clear Tempered Glass: ASTM C1048, Condition A (uncoated surfaces), Type 1 (transparent glass, flat), Class 1 (clear), Quality q3 (glazing, select), Kind FT (fully tempered), 10.0 or 12.0 mm thick as directed.

C. Tinted Tempered Glass: ASTM C1048, Condition A (uncoated surfaces), Type 1 (transparent glass, flat), Class 2 (tinted), Quality q3 (glazing, select), Kind FT (fully tempered), 10.0 or 12.0 mm thick as directed.

1. Color: As directed Bronze, Gray or Green.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Set moving walks true to line and level, or to indicated slope, properly supported, and anchored to building structure. Use established benchmarks, lines, and levels to ensure dimensional coordination of the Work.

B. Adjust installed components for smooth, efficient operation, complying with required tolerances and free of hazardous conditions. Lubricate operating parts, including bearings, tracks, chains, guides, and hardware. Test operating devices, equipment, signals, controls, and safety devices. Install oil drip pans and verify that no oil drips outside of pans.

C. Repair damaged finishes so no evidence remains of correction work. Return items to the shop that cannot be refinished in the field, make required repairs and refinish entire unit, or provide new units as required.

3.2 FIELD QUALITY CONTROL

A. Acceptance Testing: On completion of moving walk installation and before permitting moving walk use, perform acceptance tests as required and recommended by ASME A17.1/CSA B44 and by authorities having jurisdiction.

3.3 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to operate, adjust, and maintain moving walks.

3.4 MAINTENANCE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include the number of months' full maintenance as directed by skilled employees of moving walk Installer. Include monthly preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper moving walk operation at rated speed and capacity. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

END OF SECTION 143200

SECTION 144119 - STAIRWAY CHAIRLIFTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes inclined, private-residence, inclined, stairway chairlifts.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For each lift.

1. Include plans, elevations, sections, attachment details, and required clearances.
2. Indicate dimensions, weights, loads, and points of load to building structure.
3. Include diagrams for power, signal, and control wiring.

C. Samples: For each exposed product and for each color and texture specified.

1.3 INFORMATIONAL SUBMITTALS

A. Product certificates.

B. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

B. Inspection and acceptance certificates and operating permits.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of lifts that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two, Three, Five, and or as directed, years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Standard: Comply with ASME A18.1, "Safety Standard for Platform Lifts and Stairway Chairlifts."

2.2 INCLINED STAIRWAY CHAIRLIFT

A. Private-Residence, Inclined Stairway Chairlift, General: Preengineered lift system.

B. Rated Capacity: Minimum 250 lb (115 kg).

C. Rated Speed: 20 fpm (0.10 m/s).

D. Electrical Characteristics:

1. Horsepower: ¼,1/3, ½, 3/4 and or as directed
2. Voltage: 115-V ac, 208-V ac, 230-V ac, single phase, 60 Hz.
3. Voltage: 24-V dc battery with 115-V ac, 60-Hz, single-phase charger.

E. Emergency Operation:

1. Battery Operation: Provide battery-operated drive with automatic charging system.
2. Manual Lowering: Provide means to manually lower units in case of malfunction or power loss.

F. Folding Units: When not in use, units shall be capable of manually folding up against wall to minimize projection into stairway.

G. Support to Structure: Provide brackets to support vertical loads from floor or stair treads and to support lateral loads from walls. Fabricate brackets from steel plates, shapes, or bars.

H. Accessories: Provide units with the following accessories:

1. Tubular-steel, manually operated safety arms designed to restrain and provide grab bar for occupant.
2. Retractable seatbelt.
3. Seat with back and two handgrips or arms.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Wiring Method: Conceal conductors and cables within housings of units or building construction.

B. Adjust stops for accurate stopping at each landing.

C. Lubricate operating parts of lift, including drive mechanism, guide rails, hinges, safety devices, and hardware.

D. Test safety devices and verify smoothness of required protective enclosures and other surfaces.

3.2 FIELD QUALITY CONTROL

A. Acceptance Testing: On completion of lift installation and before permitting use of lifts, perform acceptance tests as required and recommended by ASME A18.1 and authorities having jurisdiction.

B. Operating Test: In addition to acceptance testing, load lifts to rated capacity and operate continuously for 30 minutes between lowest and highest landings served. Readjust stops, signal equipment, and other devices for accurate stopping and operation of system.

3.3 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lifts. Include a review of emergency systems and emergency procedures to be followed at time of operational failure and other building emergencies.

B. Check operation of lifts with Owner's personnel present and before date of Substantial Completion. Determine that operating systems and devices are functioning properly.

C. Check operation of lifts with Owner's personnel present not more than one month before end of warranty period. Determine that operating systems and devices are functioning properly.

END OF SECTION 144119

SECTION 144200 - WHEELCHAIR LIFTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Vertical platform lifts.
2. Inclined platform lifts.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For each lift.

1. Include plans, elevations, sections, attachment details, and required clearances.
2. Indicate dimensions, weights, loads, and points of load to building structure.
3. Include diagrams for power, signal, and control wiring.

C. Samples: For each exposed product and for each color and texture specified.

1.3 INFORMATIONAL SUBMITTALS

A. Product certificates.

B. Research reports.

C. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

B. Inspection and acceptance certificates and operating permits.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of lifts that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two, Three, Five and or as directed, years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Accessibility Standard: Comply with applicable provisions in the USDOJ's "2010 ADA Standards for Accessible Design", the ABA standards of the Federal agency having jurisdiction and ICC A117.1.

B. Regulatory Requirements: Comply with ASME A18.1, "Safety Standard for Platform Lifts and Stairway Chairlifts."

2.2 VERTICAL PLATFORM LIFT

A. Vertical Platform Lift, General: Pre-engineered lift system.

B. Platform Size: 34 by 54 inches (864 by 1372 mm), 35 by 48 inches (889 by 1220 mm), 35 by 51 inches (889 by 1295 mm), 36 by 56 inches (914 by 1422 mm), 36 by 60 inches (914 by 1524 mm).

C. Door Operation and Clear Opening Width: Low-energy, power-operated doors that remain open for 20 seconds minimum; end door with minimum 32-inch (815-mm) and side door with minimum 42-inch (1065-mm) clear opening width.

D. Rated Speed: 8 fpm (0.04 m/s), 10 fpm (0.05 m/s), 17 fpm (0.09 m/s), 20 fpm (0.10 m/s), 30 fpm (0.15 m/s).

E. Power Supply: Electric, Hydraulic.

1. Electrical Characteristics:

a. Horsepower: ½, 1, 2, 3.
b. Voltage: 115-V ac, 230-V ac, single phase, 60 Hz.
c. Voltage: 208-V ac, three phase, 60 Hz.
d. Voltage: 24-V dc battery with 115-V ac, 60-Hz, single-phase charger.

F. Emergency Operation: Provide manual operation and battery power system connection to indicated standby (emergency) power to raise or lower unit to a landing in case of malfunction or power loss.

G. Self-Supporting Unit: Support vertical loads of unit only at base, with lateral support only at landing levels.

H. Partial Runway Enclosure: Manufacturer's standard enclosure assembly.

1. Runway Enclosure: Rectangular, hot-dip-galvanized, steel, steel-tube frame with flush galvanized-steel-sheet, steel-sheet panels.
2. Runway Enclosure: Extruded-aluminum frame with flush galvanized-steel, aluminum-sheet panels.
3. Runway-Enclosure Doors: Rectangular steel-tube frame with flush steel-sheet panels.
4. Runway-Enclosure Doors: Rectangular steel-tube frame glazed with 6.0-mm-thick, clear, bronze-tinted, acrylic glazing and with 12-inch- (300-mm-) high, steel kick panels.
5. Runway-Enclosure Doors: Wide-stile aluminum entrance doors glazed with clear, bronze-tinted, tempered safety glass, 6.0 mm thick.

I. Platform: Steel sheet or galvanized-steel sheet with manufacturer's standard black rubber flooring.

J. Platform: Stainless-steel floor plate with checkered texture.

K. Platform: Aluminum floor plate with nonskid, surface texture.

L. Platform Enclosure and Door: Rectangular, hot-dip-galvanized, steel-tube frame with flush galvanized-steel-sheet panels.

M. Platform Enclosure and Door: Extruded-aluminum frame with flush galvanized-steel-sheet panels.

N. Ramp: Fixed ramp matching platform to provide transition from floor to lift platform at bottom landing, Retractable ramp matching platform to provide transition from lower floor to lift platform. Ramp lowers to floor automatically when lifts reach lower landing and door opens. Ramp rises automatically when lift control is activated for lift to leave lower landing.

1. Ramp Size: End ramps a minimum of 32 inches (815 mm) and side ramps a minimum of 42 inches (1065 mm) wide; length as required for slope.
2. Ramp Slope: As indicated, Maximum 1:12.
3. Ramp Finish: Finish ramps to match lift platform, As indicated on Drawings.

O. Accessories: Provide units with the following accessories:

1. Fold-down seat with seatbelt.
2. Lighting system within lift enclosures as indicated on Drawings selected by Architect from manufacturer's available products.

2.3 INCLINED PLATFORM LIFT

A. Inclined Platform Lift, General: Pre-engineered lift system.

B. Platform Size: 29 by 33 inches (737 by 838 mm), 28 by 35 inches (711 by 889 mm), 30 by 35 inches (760 by 889 mm), 30 by 36 inches (760 by 914 mm), 31 by 39 inches (787 by 991 mm), 30 by 41 inches (760 by 1041 mm), 30 by 42 inches (760 by 1067 mm), 31 by 43 inches (787 by 1092 mm), 30 by 48 inches (760 by 1220 mm).

C. Door Operation and Clear Opening Width: Low-energy, power-operated doors that remain open for 20 seconds minimum; end door with minimum 32-inch (815-mm) and side door with minimum 42-inch (1065-mm) clear opening width.

D. Rated Speed: 12 fpm (0.06 m/s), 15 fpm (0.08 m/s), 20 fpm (0.10 m/s), 30 fpm (0.15 m/s).

E. Electrical Characteristics:

1. Horsepower: ¾, 1, 2, 3.
2. Voltage: 115-V ac, 208-V ac, 230-V ac, single phase, 60 Hz.
3. Voltage: 24-V dc battery with 115-V ac, 60-Hz, single-phase charger.

F. Emergency Operation: Provide manual operation and battery power system connection to indicated standby (emergency) power to raise or lower units to a landing in case of malfunction or power loss.

G. Platform: Steel sheet or galvanized-steel sheet with manufacturer's standard black rubber flooring.

H. Platform: Stainless-steel floor plate with checkered.

I. Platform: Aluminum floor plate with nonskid surface texture.

J. Automatic Folding Platforms: When not in use, platforms shall automatically fold up against wall to minimize projection into stairway.

K. Manual Folding Platforms: When not in use, platforms shall be capable of manually folding up against wall to minimize projection into stairway.

L. Platform Guarding: Guard platform with passenger-restraining arms.

1. Passenger-Restraining Arms: Steel, Galvanized-steel, Stainless-steel tubing, manually, power, operated.
2. Platform Enclosure (Side Walls and Self-Closing Door): Rectangular steel-tube frame with flush steel-sheet panels.

M. Ramp: Fixed ramp matching platform to provide transition from floor to lift platform at bottom landing, Retractable ramp matching platform to provide transition from floor to lift platform. Ramp lowers to floor automatically when lifts reach landing and enclosure door opens. Ramp rises automatically when lift control is activated for lift to leave landing.

1. Ramp Size: End ramps a minimum of 32 inches (815 mm) and side ramps a minimum of 42 inches (1065 mm) wide; length as required for slope.
2. Ramp Slope: As indicated, Maximum 1:12.
3. Ramp Finish: Finish ramps to match lift platform, As indicated on Drawings.

N. Support to Structure: Provide framing and brackets to support vertical loads from floor or stair treads and only lateral loads from walls. Fabricate framing and brackets from steel, stainless-steel rectangular tubing, plates, shapes, and bars.

O. Guide Rails: Fabricate from steel or stainless-steel tubing.

P. Accessories: Provide units with the following accessories:

1. Fold-down seat with seatbelt.
2. Caution sign as required by ASME A18.1.

2.4 MATERIALS

A. Steel Plates, Shapes, and Bars: ASTM A36/A36M.

B. Steel Tubing: ASTM A500/A500M.

C. Steel Pipe: ASTM A53/A53M; standard weight (Schedule 40) unless otherwise indicated or required by loads.

D. Steel Sheet: ASTM A1008/A1008M, cold-rolled commercial steel (CS) or ASTM A1011/A1011M hot-rolled, commercial steel (CS); as required for each use.

E. Galvanized-Steel Sheet: ASTM A653/A653M, G90 (Z275) zinc coating.

F. Galvanizing: Hot-dip galvanize items complying with the following:

1. ASTM A123/A123M, for galvanizing steel and iron products.
2. ASTM A153/A153M, for galvanizing steel and iron hardware.

G. Aluminum: Alloy and temper recommended by aluminum producer and finisher for type of use, corrosion resistance, and finish indicated; manufacturer's standard strengths and thicknesses for type of use.

1. Extruded Aluminum: ASTM B221 (ASTM B221M).
2. Aluminum Sheet and Plate: ASTM B209 (ASTM B209M).

H. Stainless-Steel Bars and Shapes: ASTM A276/A276M, Type 304.

I. Stainless-Steel Tubing: ASTM A554, Grade MT-304.

J. Stainless-Steel Sheet, Strip, and Plate: ASTM A240/A240M or ASTM A666, Type 304.

K. Stainless-Steel Floor Plate: ASTM A793.

L. Glass: Comply with requirements in Section 088000 "Glazing."

M. Glass: As indicated by manufacturer's designations, Match Architect's sample, As selected by Architect from manufacturer's full range and complying with ASME A18.1.

N. Acrylic Glazing: ASTM D4802, Category A-1 (cell-cast) or Category A-2 (continuous cast), Finish 1 (smooth or polished), clear or tinted as indicated.

O. Inserts: Furnish required concrete and masonry inserts and similar anchorage devices for installing structural members, guide rails, machines, and other lift components where installation of devices is specified in another Section.

P. Non-shrink, Nonmetallic Grout: Factory-packaged, non-staining, noncorrosive, nongaseous grout complying with ASTM C1107/C1107M. Provide grout specifically recommended by manufacturer for interior and exterior applications.

2.5 FASTENERS

A. Post-Installed Anchors: Fastener systems with an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC01, ICC-ES AC193, ICC-ES AC58 or ICC-ES AC308 as appropriate for the substrate.

1. Material for Interior Locations: Carbon-steel components zinc-plated to comply with ASTM B633 or ASTM F1941 (ASTM F1941M), Class Fe/Zn 5, unless otherwise indicated.
2. Material for Exterior Locations and Where Stainless Steel Is Indicated: Alloy Group 1 (A1), Alloy Group 2 (A4) stainless-steel bolts, ASTM F593 (ASTM F738M), and nuts, ASTM F594 (ASTM F836M).

B. Power-Actuated Fasteners: Fastener systems with an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC70, do not use power-actuated fasteners.

2.6 FINISHES

A. Steel and Galvanized-Steel Factory Finish: Manufacturer's standard baked-enamel or powder-coat finish.

1. Color and Gloss: As indicated by manufacturer's designations, Match Architect's sample As selected by Architect from manufacturer's full range and or as directed.

B. Stainless-Steel Finishes:

1. Floor Plate Finish: Mill, Abrasive blasted.
2. Grab Rail Finish: As selected by Architect from manufacturer's full range, Directional satin finish No. 4.

C. Aluminum Finishes:

1. Clear Anodic Finish: AAMA 611, AA-M12C22A41, Class I, 0.018 mm, AA-M12C22A31, Class II, 0.010 mm or thicker.
2. Color Anodic Finish: AAMA 611, AA-M12C22A42/A44, Class I, 0.018 mm, AA-M12C22A32/A34, Class II, 0.010 mm or thicker.

    a. Color: Light bronze, Medium bronze, Dark bronze, Black.
    b. Color: Match Architect's sample, As selected by Architect from full range of industry colors and color densities.

3. Baked-Enamel or Powder-Coat Finish: AAMA 2603 except with a minimum dry film thickness of 1.5 mils (0.04 mm). Comply with coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.

a. Color and Gloss: As indicated by manufacturer's designations, Match Architect's sample, As selected by Architect from manufacturer's full range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Minimum Headroom Clearance: Verify that installed lift will have a minimum headroom of 80 inches (2032 mm) above any point on platform floor at any point of travel.

B. Minimum Headroom Clearance: Verify that installed lift will have a minimum headroom of 79 inches (2000 mm) at any point during travel, 60 inches (1500 mm) at any point during travel and minimum of 79 inches (2000 mm) where the platform is positioned for boarding.

3.2 INSTALLATION

A. General: Comply with ASME A18.1 and manufacturer's written instructions for installation of lifts unless otherwise indicated.

B. Wiring Method: Conceal conductors and cables within housings of units or building construction. Do not install conduit exposed to view in finished spaces.

C. Coordinate runway doors with platform travel and positioning, for accurate alignment and minimum clearance between platforms, runway doors, sills, and door frames.

D. Position sills accurately and fill space under sills solidly with nonshrink, nonmetallic grout.

E. Coordinate platform doors with platform travel and positioning.

F. Adjust stops for accurate stopping at each landing.

G. Adjust retractable ramps to meet maximum allowable slope and change-in-elevation requirements, and to lie fully against landing surfaces.

H. Lubricate operating parts of lift, including drive mechanism, guide rails, hinges, safety devices, and hardware.

3.3 FIELD QUALITY CONTROL

A. Acceptance Testing: On completion of lift installation and before permitting use of lifts, perform acceptance tests as required and recommended by ASME A18.1 and authorities having jurisdiction.

B. Operating Test: In addition to acceptance testing, load lifts to rated capacity and operate continuously for 30 minutes between lowest and highest landings served. Readjust stops, signal equipment, and other devices for accurate stopping and operation of system.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lifts. Include a review of emergency systems and emergency procedures to be followed at time of operational failure and other building emergencies.

B. Check operation of lifts with Owner's personnel present and before date of Substantial Completion. Determine that operating systems and devices are functioning properly.

C. Check operation of lifts with Owner's personnel present not more than one month before end of warranty period. Determine that operating systems and devices are functioning properly.

END OF SECTION 144200

SECTION 149133 - LAUNDRY AND LINEN CHUTES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes laundry and linen chutes.

1.2 DEFINITIONS

A. Access Door: Door other than an intake or discharge door that penetrates the chase wall for service access to devices in the chase.

B. Chase: The shaft that encloses a chute.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include diagrams for power, signal and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan(s) and other details drawn to scale and coordinated with each other, using input from installers of the items involved.

B. Product Certificates: For each type of chute.

C. Field quality control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Accessibility Standard: Comply with applicable provisions in the USDOJ's "2010 ADA Standards for Accessible Design", the ABA standards of the Federal agency having jurisdiction and ICC A117.1.

B. Fire-Rated Door Assemblies: Assemblies complying with NFPA 80 that are listed and labeled by a qualified testing and inspecting agency, for fire-protection ratings indicated.

1. Test Pressure: Test at atmospheric (neutral) pressure according to NFPA 252 or UL 10B.
2. Intake Doors: Labeled, 1, 1-1/2-hour fire-resistance rated with 30-minute temperature rise of 250 deg F (140 deg C).
3. Discharge Doors: Labeled, 1, 1-1/2-hour fire-resistance rated with 30-minute temperature rise of 250 deg F (140 deg C).
4. Access Doors: Labeled, 1, 1-1/2-hour fire-resistance rated with 30-minute temperature rise of 250 deg F (140 deg C).

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Standard: Provide chutes complying with NFPA 82 unless otherwise indicated.

2.3 LAUNDRY AND LINEN CHUTES

A. Chute Metal: Aluminum-coated, cold-rolled, commercial steel sheet; ASTM A463/A463M, Type 1, with not less than T1-40 (T1M-120) coating, Type 430 stainless steel, ASTM A240/A240M, Type 304 stainless steel, ASTM A240/A240M.

1. Thickness: 0.060 inch (1.6 mm), 0.075 inch (1.9 mm).

B. Chute Size: 24-inch (610-mm) diameter, As indicated on Drawings.

2.4 LAUNDRY AND LINEN CHUTE DOORS

A. Intake-Door Assemblies: ASTM A240/A240M, Type 304, stainless-steel self-closing units with positive latch and latch handle, with stainless-steel trim; constructed as required for performance requirements indicated; and with frame suitable for the enclosing chase construction.

1. Door Type: Side hinged, 180-degree swing, square, Type as indicated on Drawings.
2. Size: Manufacturer's standard size for door type, chute type, and diameter indicated.
3. Finish: Manufacturer's standard satin or No. 3 directional polish.
4. Lockset: T-handle-type, Lever-handle-type, cylinder lock that releases latch with key that is removable only when cylinder is locked.

    a. Lock Cylinder: Cylinders specified in Section 087100 "Door Hardware." specified in Section 087111 "Door Hardware (Descriptive Specification)." standard with manufacturer.
    b. Keying: For each chute, key cylinders alike, differently for each floor, to master key system.
    c. Keys: Two, Three, for each cylinder.

5. Latchset: T-handle type that unlatches door, Lever-handle type that unlatches door, Foot-operated type that unlatches and opens door when foot pedal is depressed.
6. Accessible Automatic Door Operating System: Manufacturer's standard system complying with applicable provisions of the cited accessibility standard.
7. Mechanical Interlocks: Interlock system for system servicing, operated from discharge door to automatically lock intake doors.
8. Electrical Interlocks: Interlock system that is energized by opening one intake door; remaining intake doors automatically lock when system is energized.

B. Discharge-Door Assemblies: Aluminum-coated-steel doors; horizontal-discharge, top-hinged, self-closing and latching, hopper-type door; constructed as required for performance requirements indicated; equipped with 165 deg F (74 deg C), fusible links that cause doors to close in the event of fire; with floor-mounted leg brace designed to absorb impact of material dropping against chute; and with minimum NPS 2 (DN 50) drain pipe connection.

C. Detector System: Heat and smoke, detecting interlock system with temperature-rise elements that locks chute doors when temperature in chute reaches a predetermined, adjustable temperature.

1. Locate smoke detector outside discharge door with solenoid to close discharge door.

D. Access-Door Assemblies: Manufacturer's standard ASTM A240/A240M, Type 302/304, stainless-steel doors with trim; constructed as required for performance requirements indicated; with frame suitable for the enclosing chase construction; in satin or No. 3 directional polish finish; equipped with cylinder locks that release latch with keys that are removable only when cylinder is locked.

1. Lock Cylinder: Cylinders specified in Section 087100 "Door Hardware." Specified in Section 087111 "Door Hardware (Descriptive Specification)." Standard with manufacturer.
2. Keying: Key access-door cylinders, alike, to master key system.
3. Keys: Two or three for each cylinder, as directed.

E. Manual Control System: Control system with manual switches that lock chute doors during shutdown hours and service operations.

2.5 ACCESSORIES

A. Chute Fire Sprinklers: NFPA 13; manufacturer's standard, recessed, automatic, NPS 1/2 (DN 13) sprinklers; ready for piping connections.

B. Flushing Spray Unit: NPS 3/4 (DN 19) spray-head unit located in chute above highest intake door, ready for hot-water piping connection, and with access door for spray-head and piping maintenance.

C. Sanitizing Unit: NPS 3/4 (DN 19) disinfecting and sanitizing spray-head unit located in chute above highest intake door, including 1-gal. (3.8-L) tank and adjustable proportioning valve with bypass for manual control of sanitizing and flushing operation, ready for hot-water piping connection, and with access door for spray-head and piping maintenance.

2.6 FABRICATION

A. Factory-assemble chutes to greatest extent practicable.

B. Roof Vent: Extend vent to height above roofing surface as indicated on Drawings. Equip vent with full insect screening and metal explosion-release cap. Fabricate with roof-deck flange, counterflashing, and clamping ring of nonferrous metal compatible with chute metal.

C. Chute Fire Sprinklers: Install internally within chute, recessed out of the chute area through which material travels, and according to NFPA 13.

D. Equipment Access: Fabricate chutes with access for maintaining equipment located within the chute, such as flushing and sanitizing units, fire sprinklers, and plumbing and electrical connections.

PART 3 - EXECUTION

3.1 INSTALLATION OF LAUNDRY AND LINEN CHUTES

A. Install and test chutes before installing enclosing chase construction.

B. Install chutes according to NFPA 82 and manufacturer's written instructions.

C. Install chutes plumb, without obstructions that might prevent materials from free falling within chutes.

D. Anchor flanges of chute vents to roof curbs before installing roofing and flashing. Install chute-vent counterflashing after roofing and roof-penetration flashing are installed.

E. Interconnect sanitizer control with door interlock system.

F. Electrical Interlock System: Install according to applicable NECA 1 recommendations.

G. Test and adjust chute components after installation. Operate doors, locks, and interlock systems to demonstrate that hardware operates properly and smoothly and electrical wiring is connected correctly.

H. Test heat- and smoke-sensing devices for proper operation.

I. Operate sanitizing unit through one complete cycle of chute use and cleanup and replenish chemicals or cleaning fluids in unit containers.

J. Do not remove labels of testing and inspecting agencies.

3.2 DEMONSTRATION

A. Engage a factory-authorized service representative to train, Train, Owner's maintenance personnel to adjust, operate, and maintain each chute and related equipment.

END OF SECTION 149133

SECTION 149182 - TRASH CHUTES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes waste chutes.

1.2 DEFINITIONS

A. Access Door: Door other than an intake or discharge door that penetrates the chase wall for service access to devices in the chase.

B. Chase: The shaft that encloses a chute.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include diagrams for power, signal and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan(s) and other details, drawn to scale and coordinated with each other, using input from installers of the items involved.

B. Product Certificates: For each type of chute.

C. Field quality control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Accessibility Standard: Comply with applicable provisions in the USDOJ's "2010 ADA Standards for Accessible Design" the ABA standards of the Federal agency having jurisdiction and ICC A117.1.

B. Fire-Rated Door Assemblies: Assemblies complying with NFPA 80 that are listed and labeled by a qualified testing and inspecting agency, for fire-protection ratings indicated.

1. Test Pressure: Test at atmospheric (neutral) pressure according to NFPA 252 or UL 10B.
2. Intake Doors: Labeled, 1, 1-1/2-hour fire-resistance rated with 30-minute temperature rise of 250 deg F (140 deg C).
3. Access Doors: Labeled, 1, 1-1/2-hour fire-resistance rated with 30-minute temperature rise of 250 deg F (140 deg C).

C. Discharge-Door Assemblies: Fire-resistive door construction, Labeled, 1-hour fire-resistance rated, Labeled, 1-1/2-hour fire-resistance rated according to NFPA 252 or UL 10B requirements for fire-rated door assemblies.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Standard: Provide chutes complying with NFPA 82.

2.3 LAUNDRY AND LINEN CHUTES

A. Chute Metal: Aluminum-coated, cold-rolled, commercial steel sheet; ASTM A463/A463M, Type 1, with not less than T1-40 (T1M-120) coating, Type 430 stainless steel, ASTM A240/A240M, Type 304 stainless steel, ASTM A240/A240M.

1. Thickness: 0.060 inch (1.6 mm), 0.075 inch (1.9 mm).

B. Chute Size: 24-inch (610-mm) diameter, As indicated on Drawings.

2.4 LAUNDRY AND LINEN CHUTE DOORS

A. Intake-Door Assemblies: ASTM A240/A240M, Type 304, stainless-steel self-closing units with positive latch and latch handle, with stainless-steel trim; constructed as required for

performance requirements indicated; and with frame suitable for the enclosing chase construction.

1. Door Type: Hopper, Type as indicated on Drawings.
2. Size: Manufacturer's standard size for door type, chute type, and diameter indicated.
3. Finish: Manufacturer's standard satin or No. 3 directional polish.
4. Lockset: T-handle-type, Lever-handle-type cylinder lock that releases latch with key that is removable only when cylinder is locked.

    a. Lock Cylinder: Cylinders specified in Section 087100 "Door Hardware." Specified in Section 087111 "Door Hardware (Descriptive Specification)." Standard with manufacturer.
    b. Keying: For each chute, key cylinders alike, differently for each floor to master key system.
    c. Keys: Two, or Three, for each cylinder as directed.

5. Latchset: T-handle type that unlatches door, Lever-handle type that unlatches door, Foot-operated type that unlatches and opens door when foot pedal is depressed.
6. Accessible Automatic Door Operating System: Manufacturer's standard system complying with applicable provisions of the cited accessibility standard.
7. Mechanical Interlocks: Interlock system for system servicing, operated from discharge door to automatically lock intake doors.
8. Electrical Interlocks: Interlock system that is energized by opening one intake door; remaining intake doors automatically lock when system is energized.
9. Baffles: Rubber backdraft baffles at each intake.

B. Discharge-Door Assemblies: Aluminum-coated steel; direct vertical-discharge type, inclined, and horizontally closing and latching; constructed as required for performance requirements indicated; and equipped with 165 deg F (74 deg C) fusible links that cause doors to close in the event of fire.

C. Detector System: Heat-and smoke-detecting interlock system with temperature-rise elements that locks chute doors when temperature in chute reaches a predetermined, adjustable temperature.

1. Locate smoke detector outside discharge door with solenoid to close discharge door.

D. Access-Door Assemblies: Manufacturer's standard ASTM A240/A240M, Type 302/304, stainless-steel doors with trim; constructed as required for performance requirements indicated; with frame suitable for the enclosing chase construction; in satin or No. 3 directional polish finish; equipped with cylinder locks that release latch with keys that are removable only when cylinder is locked.

1. Lock Cylinder: Cylinders specified in Section 087100 "Door Hardware." Specified in Section 087111 "Door Hardware (Descriptive Specification)." Standard with manufacturer.
2. Keying: Key access-door cylinders alike to master key system.
3. Keys: Two or Three, for each cylinder, as directed.

E. Manual Control System: Control system with manual switches that lock chute doors during shutdown hours and service operations.

2.5 ACCESSORIES

A. Chute Fire Sprinklers: NFPA 13; manufacturer's standard, recessed, automatic, NPS 1/2 (DN 13) sprinklers; ready for piping connections.

B. Flushing Spray Unit: NPS 3/4 (DN 19) spray-head unit located in chute above highest intake door, ready for hot-water piping connection, and with access door for spray-head and piping maintenance.

C. Sanitizing Unit: NPS 3/4 (DN 19) disinfecting and sanitizing spray-head unit located in chute above highest intake door, including 1-gal. (3.8-L) tank and adjustable proportioning valve with bypass for manual control of sanitizing and flushing operation, ready for hot-water piping connection, and with access door for spray-head and piping maintenance.

D. Intake-Door Baffles: Rubber baffles, 1/8 inch (3 mm) thick.

2.6 FABRICATION

A. Factory-assemble chutes to greatest extent practicable.

B. Roof Vent: Extend vent to height above roofing surface as indicated on Drawings. Equip vent with full insect screening and metal explosion-release cap. Fabricate with roof-deck flange, counterflashing, and clamping ring of nonferrous metal compatible with chute metal.

C. Chute Fire Sprinklers: Install internally within chute, recessed out of the chute area through which material travels, and according to NFPA 13.

D. Equipment Access: Fabricate chutes with access for maintaining equipment located within the chute, such as flushing and sanitizing units, fire sprinklers, and plumbing and electrical connections.

PART 3 - EXECUTION

3.1 INSTALLATION OF TRASH CHUTES

A. Install and test chutes before installing enclosing chase construction.

B. Install chutes according to NFPA 82 and manufacturer's written instructions.

C. Install chutes plumb, without obstructions that might prevent materials from free falling within chutes.

D. Anchor flanges of chute vents to roof curbs before installing roofing and flashing. Install chute-vent counterflashing after roofing and roof-penetration flashing are installed.

E. Interconnect sanitizer control with door interlock system.

F. Electrical Interlock System: Install according to applicable NECA 1 recommendations.

G. Test and adjust chute components after installation. Operate doors, locks, and interlock systems to demonstrate that hardware operates properly and smoothly and electrical wiring is connected correctly.

H. Test heat-and smoke-sensing devices for proper operation.

I. Operate sanitizing unit through one complete cycle of chute use and cleanup and replenish chemicals or cleaning fluids in unit containers.

3.2 DEMONSTRATION

A. Engage a factory-authorized service representative to train, Train, Owner's maintenance personnel to adjust, operate, and maintain each chute and related equipment.

END OF SECTION 149182

SECTION 210513 - COMMON MOTOR REQUIREMENTS FOR FIRE SUPPRESSION EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on alternating-current power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.2 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.
4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with requirements in this Section except when stricter requirements are specified in equipment schedules or Sections.

B. Comply with NEMA MG 1 unless otherwise indicated.

C. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet (1000 m) above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Premium efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.

1. For motors with 2:1 speed ratio, consequent pole, single winding.
2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Rotor: Random-wound, squirrel cage.

F. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

G. Temperature Rise: Match insulation rating.

H. Insulation: Class F.

I. Code Letter Designation:

1. Motors 15, HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller Than 15, HP: Manufacturer's standard starting characteristic.

J. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 ADDITIONAL REQUIREMENTS FOR POLYPHASE MOTORS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable-Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width-modulated inverters.
2. Premium-Efficient Motors: Class B temperature rise; Class F insulation.
3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

2.5 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Split phase.
3. Capacitor start, inductor run.
4. Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Pre-lubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 210513

SECTION 210517 - SLEEVES AND SLEEVE SEALS FOR FIRE-SUPPRESSION PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Sleeves.
2. Sleeve-seal systems.
3. Grout.
4. Silicone sealants.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop.

B. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, anticorrosion coated or galvanized, with plain ends and integral welded waterstop collar.

C. Galvanized-Steel Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

D. PVC Pipe Sleeves: ASTM D1785, Schedule 40.

2.2 SLEEVE-SEAL SYSTEMS

A. Description:

1. Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.

2. Designed to form a hydrostatic seal of 20 psig (137 kPa) minimum.
3. Sealing Elements: EPDM-rubber, High-temperature-silicone, Nitrile (Buna N) interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size.
4. Pressure Plates: As directed Carbon steel, Composite plastic, Stainless steel or Stainless steel Type 316.
5. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, ASTM B633, Stainless steel, Stainless steel Type 316, of length required to secure pressure plates to sealing elements.

2.3 GROUT

A. Description: Non-shrink, for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.4 SILICONE SEALANTS

A. Silicone, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant, ASTM C920, Type S, Grade NS, Class 25, Use NT.

B. Silicone, S, P, 25, T, NT: Single-component, pourable, plus 25 percent and minus 25 percent movement capability, traffic- and nontraffic-use, neutral-curing silicone joint sealant; ASTM C920, Type S, Grade P, Class 25, Uses T and NT. Grade P Pourable (self-leveling) formulation is for opening in floors and other horizontal surfaces that are not fire rated.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch (25-mm) annular clear space between piping and concrete slabs and walls.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

1. Cut sleeves to length for mounting flush with both surfaces.

a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level.

2. Using grout or silicone sealant, seal space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint.

E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 078413 "Penetration Firestopping."

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.

B. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.4 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls above Grade:

a. Piping Smaller Than NPS 6 (DN 150): Cast-iron pipe sleeves, Steel pipe sleeves.

b. Piping NPS 6 (DN 150) and Larger: Cast-iron pipe sleeves, Steel pipe sleeves.

2. Exterior Concrete Walls below Grade:

a. Piping Smaller Than NPS 6 (DN 150): Cast-iron pipe sleeves with sleeve-seal system, Steel pipe sleeves with sleeve-seal system.

1) Select sleeve size to allow for 1-inch (25-mm), annular clear space between piping and sleeve for installing sleeve-seal system.

b. Piping NPS 6 (DN 150) and Larger: Cast-iron pipe sleeves with sleeve-seal system, Steel pipe sleeves with sleeve-seal system.

1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs-on-Grade:

a. Piping Smaller Than NPS 6 (DN 150): Cast-iron pipe sleeves with sleeve-seal system, Steel pipe sleeves with sleeve-seal system.

1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.

b. Piping NPS 6 (DN 150) and Larger: Cast-iron pipe sleeves with sleeve-seal system, Steel pipe sleeves with sleeve-seal system.

1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.

4. Concrete Slabs above Grade:

a. Piping Smaller Than NPS 6 (DN 150): Steel pipe sleeves, PVC pipe sleeves.
b. Piping NPS 6 (DN 150) and Larger: Steel pipe sleeves, PVC pipe sleeves.

5. Interior Partitions:

a. Piping Smaller Than NPS 6 (DN 150): Steel pipe sleeves, PVC pipe sleeves.
b. Piping NPS 6 (DN 150) and Larger: Galvanized-steel sheet sleeves.

END OF SECTION 210517

SECTION 210518 - ESCUTCHEONS FOR FIRE-SUPPRESSION PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Escutcheons.
2. Floor plates.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 ESCUTCHEONS

A. One-Piece, Steel Type: With polished, chrome-plated, polished brass finish and setscrew fastener.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped steel, brass with polished, chrome-plated finish and spring-clip fasteners.

C. One-Piece, Stamped-Steel Type: With polished, chrome-plated finish and spring-clip fasteners.

D. Split-Plate, Stamped-Steel Type: With polished, chrome-plated finish; concealed and exposed-rivet hinge; and spring-clip fasteners.

2.3 FLOOR PLATES

A. Split Floor Plates: Steel with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. Escutcheons for New Piping and Relocated Existing Piping:

a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern.
b. Chrome-Plated Piping: One-piece steel, cast brass or split-plate steel with polished, chrome-plated finish.
c. Insulated Piping: One-piece steel with polished, chrome-plated, polished brass finish.
d. Insulated Piping: One-piece stamped steel or split-plate, stamped steel with concealed hinge or split-plate, stamped steel with exposed-rivet hinge with polished, chrome-plated finish.
e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece steel with polished, chrome-plated, polished brass finish.
f. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece stamped steel or split-plate, stamped steel with concealed hinge or split-plate, stamped steel with exposed-rivet hinge with polished, chrome-plated finish.
g. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece steel with polished, chrome-plated, polished brass finish.
h. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece stamped steel or split-plate, stamped steel with concealed hinge or split-plate, stamped steel with exposed-rivet hinge with polished, chrome-plated finish.

2. Escutcheons for Existing Piping to Remain:

a. Chrome-Plated Piping: Split-plate, stamped steel with concealed or exposed-rivet, hinge with polished, chrome-plated finish.
b. Insulated Piping: Split-plate, stamped steel with concealed or exposed-rivet, hinge with polished, chrome-plated finish.
c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped steel with concealed or exposed-rivet, hinge with polished, chrome-plated finish.
d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish.

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. New Piping and Relocated Existing Piping: Split floor plate.
2. Existing Piping: Split floor plate.

3.2 FIELD QUALITY CONTROL

A. Using new materials, replace broken and damaged escutcheons and floor plates.

END OF SECTION 210518

SECTION 210523 - GENERAL-DUTY VALVES FOR FIRE PROTECTION PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Iron butterfly valves with indicators.
2. Check valves.
3. Iron OS&Y gate valves.
4. NRS gate valves.
5. Indicator posts.
6. Trim and drain valves.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. UL Listed: Valves shall be listed in UL's "Online Certifications Directory" under the headings listed below and shall bear UL mark:

1. Main Level: HAMV - Fire Main Equipment.

a. Level 1: HCBZ - Indicator Posts, Gate Valve.
b. Level 1: HLOT - Valves.

1) Level 3: HLUG - Ball Valves, System Control.
2) Level 3: HLXS - Butterfly Valves.
3) Level 3: HMER - Check Valves.
4) Level 3: HMRZ - Gate Valves.

2. Main Level: VDGT - Sprinkler System & Water Spray System Devices.

a. Level 1: VQGU - Valves, Trim and Drain.

B. FM Global Approved: Valves shall be listed in its "Approval Guide," under the headings listed below:

1. Automated Sprinkler Systems:

a. Indicator posts.

b. Valves.

1) Gate valves.
2) Check valves.

a) Single check valves.

3) Miscellaneous valves.

C. Source Limitations for Valves: Obtain valves for each valve type from single manufacturer.

D. ASME Compliance:

1. ASME B16.1 for flanges on iron valves.
2. ASME B1.20.1 for threads for threaded-end valves.
3. ASME B31.9 for building services piping valves.

E. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.

F. NFPA Compliance: Comply with NFPA 24 for valves.

G. Valve Pressure Ratings: Not less than the minimum pressure rating indicated or higher as required by system pressures.

H. Valve Sizes: Same as upstream piping unless otherwise indicated.

I. Valve Actuator Types:

1. Worm-gear actuator with handwheel for quarter-turn valves, except for trim and drain valves.
2. Handwheel: For other than quarter-turn trim and drain valves.
3. Handlever: For quarter-turn trim and drain valves NPS 2 (DN 50) and smaller.

2.2 IRON BUTTERFLY VALVES WITH INDICATORS

A. Description:

1. Standard: UL 1091 and FM Global standard for indicating valves, (butterfly or ball type), Class Number 112.
2. Minimum Pressure Rating: 175 psig (1200 kPa).
3. Body Material: Cast or ductile iron with nylon, EPDM, epoxy, or polyamide coating.
4. Seat Material: EPDM.
5. Stem: Stainless steel.
6. Disc: Ductile iron, nickel plated and EPDM or SBR coated.
7. Actuator: Worm gear or traveling nut.
8. Supervisory Switch: Internal or external.
9. Body Design: Lug or wafer, Grooved-end connections.

2.3 CHECK VALVES

A. Description:

1. Standard: UL 312 and FM Global standard for swing check valves, Class Number 1210.
2. Minimum Pressure Rating: 175 psig (1200 kPa).
3. Type: Single swing check.
4. Body Material: Cast iron, ductile iron, or bronze as directed.
5. Clapper: Bronze, ductile iron, or stainless steel with elastomeric seal.
6. Clapper Seat: Brass, bronze, or stainless steel as directed.
7. Hinge Shaft: Bronze or stainless steel as directed.
8. Hinge Spring: Stainless steel.
9. End Connections: Flanged, grooved, or threaded as directed.

2.4 IRON OS&Y GATE VALVES

A. Description:

1. Standard: UL 262 and FM Global standard for fire-service water control valves (OS&Y- and NRS-type gate valves).
2. Minimum Pressure Rating: 175 psig (1200 kPa).
3. Body and Bonnet Material: Cast or ductile iron as directed.
4. Wedge: Cast or ductile iron, or bronze with elastomeric coating as directed.
5. Wedge Seat: Cast or ductile iron, or bronze with elastomeric coating as directed.
6. Stem: Brass or bronze as directed.
7. Packing: Non-asbestos PTFE.
8. Supervisory Switch: External.
9. End Connections: Flanged, Grooved, Threaded.

2.5 NRS GATE VALVES

A. Description:

1. Standard: UL 262 and FM Global standard for fire-service water control valves (OS&Y- and NRS-type gate valves).
2. Minimum Pressure Rating: 175 psig (1200 kPa).
3. Body and Bonnet Material: Cast or ductile iron as directed.
4. Wedge: Cast or ductile iron with elastomeric coating as directed.
5. Wedge Seat: Cast or ductile iron, or bronze with elastomeric coating as directed.
6. Stem: Brass or bronze as directed.
7. Packing: Non-asbestos PTFE.
8. Supervisory Switch: External.
9. End Connections: Flanged, Grooved, Threaded.

2.6 INDICATOR POSTS

A. Description:

1. Standard: UL 789 and FM Global standard for indicator posts.
2. Type: Underground, Pit, Wall.
3. Base Barrel Material: Cast or ductile iron, PVC.
4. Extension Barrel: Cast or ductile iron as directed.
5. Cap: Cast or ductile iron.
6. Operation: Wrench, Handwheel.

2.7 TRIM AND DRAIN VALVES

A. Angle Valves:
   1. Description:

      a. Pressure Rating: 175 psig (1200 kPa), 250 psig (1720 kPa) or 300 psig (2070 kPa) as directed.
      b. Body Material: Brass or bronze as directed.
      c. Ends: Threaded.
      d. Stem: Bronze.
      e. Disc: Bronze.
      f. Packing: Asbestos free.
      g. Handwheel: Malleable iron, bronze, or aluminum as directed.

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS FOR VALVE INSTALLATION

A. Comply with requirements in the following Sections for specific valve installation requirements and applications:

   1. Section 211100 "Facility Fire-Suppression Water-Service Piping" for application of valves in fire-suppression water-service piping outside the building.
   2. Section 211200 "Fire-Suppression Standpipes" for application of valves in fire-suppression standpipes.
   3. Section 211313 "Wet-Pipe Sprinkler Systems" for application of valves in wet-pipe, fire-suppression sprinkler systems.
   4. Section 211316 "Dry-Pipe Sprinkler Systems" for application of valves in dry-pipe, fire-suppression sprinkler systems.
   5. Section 211339 "Foam-Water Systems" for application of valves in AFFF piping.

B. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.

C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

D. Install valves having threaded connections with unions at each piece of equipment arranged to allow easy access, service, maintenance, and equipment removal without system shutdown. Provide separate support where necessary.

E. Install valves in horizontal piping with stem at or above the pipe center.

F. Install valves in position to allow full stem movement.

G. Install valve tags. Comply with requirements in Section 210553 "Identification for Fire-Suppression Piping and Equipment" for valve tags and schedules and signs on surfaces concealing valves; and the NFPA standard applying to the piping system in which valves are installed. Install permanent identification signs indicating the portion of system controlled by each valve.

H. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire-department connections.

I. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

END OF SECTION 210523

SECTION 210529 - HANGERS AND SUPPORTS FOR FIRE SUPRESSION PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Thermal hanger-shield inserts.
4. Fastener systems.
5. Equipment supports.

B. Related Requirements:

1. Section 055000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Section 210516 "Expansion Fittings and Loops for Fire-Suppression Piping" for pipe guides and anchors.
3. Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment" Section 210548.13 "Vibration Controls for Fire-Suppression Piping and Equipment" for vibration isolation devices and seismic restraints.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations.

C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.4 QUALITY ASSURANCE

A. Structural-Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M.

B. Pipe Welding Qualifications: Qualify procedures and operators according to "2015 ASME Boiler and Pressure Vessel Code, Section IX."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design trapeze pipe hangers and equipment supports.

B. Structural Performance: Hangers and supports for fire-suppression piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

C. NFPA Compliance: Comply with NFPA 13, NFPA 13R.

D. UL Compliance: Comply with UL 203.

2.2 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: Factory-fabricated components, NFPA approved, UL listed, or FM approved for fire-suppression piping support.
2. Galvanized Metallic Coatings: Pre-galvanized or hot-dip galvanized.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel, stainless steel.

B. Copper Pipe and Tube Hangers:

1. Description: Copper-coated-steel, factory-fabricated components, NFPA approved, UL listed, or FM approved for fire-suppression piping support.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel, stainless steel.

2.3 TRAPEZE PIPE HANGERS

A. Description: MSS SP-58, Type 59, shop- or field-fabricated pipe-support assembly, made from structural-carbon-steel shapes, with NFPA-approved, UL-listed, or FM-approved carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.4 THERMAL HANGER-SHIELD INSERTS

A. Insulation-Insert Material: Water-repellent-treated, ASTM C533, Type I calcium silicate with 100-psi (688-kPa), ASTM C552, Type II cellular glass with 100-psi (688-kPa) or ASTM C591, Type VI, Grade 1 polyisocyanurate with 125-psi (862-kPa) minimum compressive strength.

B. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

C. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

D. Insert Length: Extend 2 inches (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: NFPA-approved, UL-listed, or FM-approved threaded-steel stud, for use in hardened portland cement concrete, with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Expansion Anchors: NFPA-approved, UL-listed, or FM-approved, insert-wedge-type anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
   1. Indoor Applications: Zinc-coated or Stainless steel.
   2. Outdoor Applications: Stainless steel.

2.6 EQUIPMENT SUPPORTS

A. Description: NFPA-approved, UL-listed, or FM-approved, welded, shop- or field-fabricated equipment support, made from structural-carbon-steel shapes.

2.7 MATERIALS

A. Aluminum: ASTM B221 (ASTM B221M).

B. Carbon Steel: ASTM A1011/A1011M.

C. Structural Steel: ASTM A36/A36M, carbon-steel plates, shapes, and bars; black and galvanized.

D. Stainless Steel: ASTM A240/A240M.

E. Grout: ASTM C1107/C1107M, factory-mixed and -packaged, dry, hydraulic-cement, non-shrink and nonmetallic grout, suitable for interior and exterior applications.

   1. Properties: Non-staining, noncorrosive, and nongaseous.
   2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation, for penetrations through fire-rated walls, ceilings, and assemblies.

B. Strength of Support Assemblies: Where not indicated, select sizes of components, so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).

3.2 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with installation requirements of approvals and listings. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size, or install intermediate supports for smaller-diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A36/A36M carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Thermal Hanger-Shield Installation: Install in pipe hanger or shield for insulated piping.

D. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick in concrete, after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual. Install in accordance with approvals and listings.
2. Install mechanical-expansion anchors in concrete, after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions. Install in accordance with approvals and listings.

E. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

F. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

G. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

H. Install lateral bracing with pipe hangers and supports to prevent swaying.

I. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 (DN 65) and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

J. Load Distribution: Install hangers and supports, so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

K. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

L. Insulated Piping:

1. Attach clamps and spacers to piping.

    a. Piping Operating Above Ambient Air Temperature: Clamp may project through insulation.
    b. Piping Operating Below Ambient Air Temperature: Use thermal hanger-shield insert with clamp sized to match OD of insert.
    c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39 protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

    a. Option: Thermal hanger-shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40 protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

    a. Option: Thermal hanger-shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:

    a. NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
    b. NPS 4 (DN 100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
    c. NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.
    d. NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.
    e. NPS 16 to NPS 24 (DN 400 to DN 600): 24 inches (610 mm) long and 0.105 inch (2.67 mm) thick.

5. Pipes NPS 8 (DN 200) and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal Hanger Shields: Install with insulation of same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment, and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work.

3.5 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches (40 mm).

3.6 PAINTING

A. Touchup: Clean field welds and abraded, shop-painted areas. Paint exposed areas immediately after erecting hangers and supports. Use same materials as those used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils (0.05 mm).

B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded, shop-painted areas on miscellaneous metal are specified in Section 099113 "Exterior Painting", Section 099123 "Interior Painting" or Section 099600 "High-Performance Coatings" as directed.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas, and apply galvanizing-repair paint to comply with ASTM A780/A780M.

3.7 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with NFPA requirements for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finishes.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports and metal trapeze pipe hangers and attachments for general service applications.

F. Use stainless-steel, pipe hangers and stainless-steel or corrosion-resistant attachments for hostile environment applications.

G. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.

H. Use thermal hanger-shield inserts for insulated piping and tubing.

I. Horizontal-Piping Hangers and Supports: Comply with NFPA requirements. Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
2. Steel Pipe Clamps (MSS Type 4): For suspension of NPS 1/2 to NPS 24 (DN 15 to DN 600) if little or no insulation is required.
3. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
4. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of non-insulated, stationary pipes NPS 3/8 to NPS 8 (DN 10 to DN 200).
5. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of non-insulated, stationary pipes NPS 3/8 to NPS 3 (DN 10 to DN 80).
6. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
7. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
8. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
9. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 (DN 65 to DN 900) if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.

J. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24 (DN 24 to DN 600).

2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 (DN 20 to DN 600) if longer ends are required for riser clamps.

K. Hanger-Rod Attachments: Comply with NFPA requirements.

L. Building Attachments: Comply with NFPA requirements. Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable-Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. C-Clamps (MSS Type 23): For structural shapes.
3. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.

M. Saddles and Shields: Comply with NFPA requirements. Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal Hanger-Shield Inserts: For supporting insulated pipe.

N. Comply with NFPA requirements for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

O. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION 210529

SECTION 210533 - HEAT TRACING FOR FIRE-SUPPRESSION PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes heat tracing for fire-suppression piping with the following electric heating cables:

1. Plastic insulated, series resistance.
2. Self-regulating, parallel resistance.

B. Related Requirements:

1. Section 220533 "Heat Tracing for Plumbing Piping."
2. Section 230533 "Heat Tracing for HVAC Piping."

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For electric heating cable.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace electric heating cable that fails in materials or workmanship within specified warranty period.

1. Warranty Period: As directed Three or Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PLASTIC-INSULATED, SERIES-RESISTANCE HEATING CABLES

A. Comply with IEEE 515.1.

B. Heating Element: Single- or dual-stranded resistor wire. Terminate with waterproof, factory-assembled non-heating leads with connectors at both ends.

C. Electrical Insulating Jacket: Minimum 4.0-mil (0.10-mm) Kapton with silicone, Tefzel, or polyolefin as directed.

D. Cable Cover: Aluminum braid and silicone or Hylar outer jacket or TPR overjacket as directed.

E. Maximum Operating Temperature (Power On): 150 deg F (65 deg C).

F. Maximum Exposure Temperature (Power Off): 185 deg F (85 deg C).

G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70 and NFPA 13, by a qualified testing agency, and marked for intended location and application.

H. Capacities and Characteristics:

1. Maximum Heat Output: 6 W/ft. (19.7 W/m), 7.5 W/ft. (24.6 W/m).
2. Piping Diameter: NPS (DN).
3. Number of Parallel Cables: As directed.
4. Spiral Wrap Pitch: As directed
5. Electrical Characteristics for Single-Circuit Connection:

    a. Volts: 120, 208, 240, 277, 480.
    b. Phase: As directed.
    c. Hertz: As directed.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed.
    f. Maximum Overcurrent Protection: As directed

2.2 SELF-REGULATING, PARALLEL-RESISTANCE HEATING CABLES

A. Comply with IEEE 515.1.

B. Heating Element: Pair of parallel No. 16, No. 18 AWG, tinned, nickel-coated, stranded copper bus wires embedded in crosslinked conductive polymer core, which varies heat output in response to temperature along its length. Terminate with waterproof, factory-assembled, non-heating leads with connectors at one end, and seal the opposite end watertight. Cable shall be capable of crossing over itself once without overheating.

C. Electrical Insulating Jacket: Flame-retardant polyolefin.

D. Cable Cover: Tinned-copper, Stainless-steel braid and polyolefin outer jacket with ultraviolet inhibitor.

E. Maximum Operating Temperature (Power On): 150 deg F (65 deg C).

F. Maximum Exposure Temperature (Power Off): 185 deg F (85 deg C).

G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

H. Capacities and Characteristics:

1. Maximum Heat Output: 3 W/ft. (9.8 W/m), 5 W/ft. (16.4 W/m), 8 W/ft. (26 W/m), 10 W/ft. (32.8 W/m), 12 W/ft. (39.4 W/m).
2. Piping Diameter: NPS (DN).
3. Number of Parallel Cables: As directed.
4. Spiral Wrap Pitch: As directed
5. Electrical Characteristics for Single-Circuit Connection:

a. Volts: 120, 208, 240, 277, 480.
b. Phase: As directed.
c. Hertz: As directed.
d. Full-Load Amperes: As directed.
e. Minimum Circuit Ampacity: As directed.
f. Maximum Overcurrent Protection: As directed.

2.3 CONTROLS

A. Remote bulb unit with adjustable temperature range from 30 to 50 deg F (minus 1 to plus 10 deg C).

B. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected cable.

C. Remote bulb on capillary, resistance temperature device, or thermistor for directly sensing pipe-wall temperature.

D. Corrosion-resistant, waterproof control enclosure.

2.4 ACCESSORIES

A. Cable Installation Accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer or as recommended in writing by manufacturer.

B. Warning Tape: Continuously printed "Electrical Tracing"; vinyl, at least 3 mils (0.08 mm) thick, and with pressure-sensitive, permanent, waterproof, self-adhesive back.

1. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches (150 mm): 3/4-inch (19 mm) minimum.
2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches (150 mm) or Larger: 1-1/2 inches (38 mm) minimum.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install electric heating cable where indicated and according to NFPA 70 and NFPA 13.

B. Install electric heating cables after piping has been tested and before insulation is installed.

C. Install electric heating cables according to IEEE 515.1.

D. Install insulation over piping with electric cables according to Section 210700 "Fire-Suppression Systems Insulation."

E. Install warning tape on piping insulation where piping is equipped with electric heating cables.

F. Set field-adjustable switches and circuit-breaker trip ranges.

G. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

H. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

I. Connect heat-tracing controls to fire-alarm system according to NFPA 13. Comply with requirements in Section 284621.11 "Addressable Fire-Alarm Systems" or Section 284621.13 "Conventional Fire-Alarm Systems" as directed.

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform tests after cable installation but before application of coverings such as insulation, wall or ceiling construction, or concrete.
2. Test cables for electrical continuity and insulation integrity before energizing.
3. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.

B. Repeat tests for continuity, insulation resistance, and input power after applying thermal insulation on pipe-mounted cables.

C. Cables will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

E. Remove and replace damaged heat-tracing cables.

END OF SECTION 210533

SECTION 210548 - VIBRATION AND SEISMIC CONTROLS FOR FIRE-SUPPRESSION PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Restraint channel bracings.
5. Seismic-restraint accessories.
6. Mechanical anchor bolts.

1.2 DEFINITIONS

A. IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

C. OSHPD: Office of Statewide Health Planning & Development.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Delegated-Design Submittal: For each vibration isolation and seismic-restraint device.

1. Include design calculations and details for selecting vibration isolators and seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For professional engineer.

B. Welding certificates.

1.5 QUALITY ASSURANCE

A. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

B. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are unavailable, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:

1. Site Class as Defined in the IBC: A, B, C, D, E, F.
2. Assigned Seismic Use Group or Building Category as Defined in the IBC: I, II, III.

    a. Component Importance Factor: 1.0, 1.5.
    b. Component Response Modification Factor: 1.5, 2.5, 3.5, 5.0.
    c. Component Amplification Factor: 1.0, 2.5.

3. Design Spectral Response Acceleration at Short Periods (0.2 Second):
4. Design Spectral Response Acceleration at 1.0-Second Period:

2.2 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:
1. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
2. Size: Factory or field cut to match requirements of supported equipment.
3. Pad Material: Oil and water resistant with elastomeric properties.
4. Surface Pattern: Smooth, Ribbed, Waffle pattern.
5. Infused nonwoven cotton or synthetic fibers.
6. Load-bearing metal plates adhered to pads.

2.3 ELASTOMERIC ISOLATION MOUNTS

A. Double-Deflection, Elastomeric Isolation Mounts:

1. As directed.
2. Mounting Plates:

    a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.

b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.

3. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material as directed.

2.4 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts:
1. Description: All-directional isolator with seismic restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.

a. Housing: Cast-ductile iron or welded steel.
b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.5 RESTRAINT CHANNEL BRACINGS

A. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.6 SEISMIC-RESTRAINT ACCESSORIES

A. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections, reinforcing steel angle clamped to hanger rod.

B. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings and matched to type and size of anchor bolts and studs.

C. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings and matched to type and size of attachment devices used.

D. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

E. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488.

PART 3 - EXECUTION

3.1 VIBRATION CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.

B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

C. Equipment Restraints:

1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
2. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES, OSHPD, an agency acceptable to authorities having jurisdiction that provides required submittals for component.

D. Piping Restraints:

1. Comply with requirements in MSS SP-127.
2. Space lateral supports a maximum of 40 feet (12 m) o.c., and longitudinal supports a maximum of 80 feet (24 m) o.c.
3. Brace a change of direction longer than 12 feet (3.7 m).

E. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES, OSHPD, an agency acceptable to authorities having jurisdiction that provides required submittals for component.

F. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

G. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

H. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

I. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.

3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.2 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 211200 "Fire-Suppression Standpipes," Section 211313 "Wet-Pipe Sprinkler Systems," and Section 211316 "Dry-Pipe Sprinkler Systems" for piping flexible connections as directed.

END OF SECTION 210548

SECTION 210548.13 - VIBRATION CONTROLS FOR FIRE-SUPPRESSION PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Delegated-Design Submittal: For each vibration isolation device.

1. Include design calculations for selecting vibration isolators and for designing vibration isolation bases.

PART 2 - PRODUCTS

2.1 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:
1. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
2. Size: Factory or field cut to match requirements of supported equipment.
3. Pad Material: Oil and water resistant with elastomeric properties.
4. Surface Pattern: Smooth, Ribbed, Waffle pattern.
5. Infused nonwoven cotton or synthetic fibers.
6. Load-bearing metal plates adhered to pads.

2.2 ELASTOMERIC ISOLATION MOUNTS

A. Double-Deflection, Elastomeric Isolation Mounts:
1. Mounting Plates:

a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded, with threaded studs or bolts.
b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.

2. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.3 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts:
1. Description: All-directional isolator with restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.

a. Housing: Cast-ductile iron or welded steel.
b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

PART 3 - EXECUTION

3.1 VIBRATION CONTROL DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.

B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

END OF SECTION 210548.13

SECTION 210553 - IDENTIFICATION FOR FIRE-SUPPRESSION PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Equipment-Label Schedule: Include a listing of all equipment to be labeled and the proposed content for each label.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Material and Thickness: As directed Brass, 0.032 inch (0.8 mm), stainless steel, 0.025 inch (0.64 mm), aluminum, 0.032 inch (0.8 mm) or anodized aluminum, 0.032 inch (0.8 mm) thick, with predrilled holes for attachment hardware.
2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
3. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
4. Fasteners: Stainless-steel rivets or self-tapping screws as directed.
5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch (1.6 mm) or 1/8 inch (3.2 mm) thick as directed, with predrilled holes for attachment hardware.
2. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).
3. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).

4. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
5. Fasteners: Stainless-steel rivets or self-tapping screws.
6. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

D. Equipment-Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch (A4) bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch (1.6 mm) or 1/8 inch (3.2 mm) thick as directed, with predrilled holes for attachment hardware.

B. Letter Color: Black, Blue, Red, White or Yellow as directed.

C. Background Color: Black, Blue, Red, White or Yellow as directed.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).

F. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service and showing flow direction.

B. Pretensioned Pipe Labels: Pre-coiled, semirigid plastic formed to partially cover or cover full circumference of pipe as directed and to attach to pipe without fasteners or adhesive.

C. Self-adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

D. Pipe-Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping-system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: At least 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm) and proportionately larger lettering for greater viewing distances.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of incompatible primers, paints, and encapsulants, as well as dirt, oil, grease, release agents, and other substances that could impair bond of identification devices.

3.2 LABEL INSTALLATION REQUIREMENTS

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be installed.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install or permanently fasten labels on each major item of mechanical equipment.

D. Locate equipment labels where accessible and visible.

E. Piping: Painting of piping is specified in Section 099123 "Interior Painting" or Section 099600 "High-Performance Coatings" as directed.

F. Pipe-Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection excluding short takeoffs. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit a view of concealed piping.
5. Near major equipment items and other points of origination and termination.

6. Spaced at maximum intervals of 50 feet (15 m) along each run. Reduce intervals to 25 feet (7.6 m) in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

END OF SECTION 210553

SECTION 210700 - FIRE-SUPPRESSION SYSTEMS INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Insulating indoor engine coolant piping for remote radiator of engine-driven fire pump.
2. Insulating indoor engine exhaust piping and silencer.
3. Insulating indoor and outdoor equipment.
4. Insulating outdoor piping.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail attachment and covering of heat tracing inside insulation.
3. Detail insulation application at pipe expansion joints for each type of insulation.
4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
5. Detail removable insulation at piping specialties and equipment connections.
6. Detail application of field-applied jackets.
7. Detail application at linkages of control devices.
8. Detail field application for fire-suppression water storage tanks.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Products shall not contain asbestos, lead, mercury, or mercury compounds.

B. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C871.

C. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

D. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

E. Calcium Silicate:
1. Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C533, Type I.
2. Prefabricated Fitting Covers: Comply with ASTM C450 and ASTM C585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.

F. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
1. Block Insulation: ASTM C552, Type I.
2. Special-Shaped Insulation: ASTM C552, Type III.
3. Board Insulation: ASTM C552, Type IV.
4. Preformed Pipe Insulation without Jacket: Comply with ASTM C552, Type II, Class 1.
5. Preformed Pipe Insulation with Factory-Applied ASJ, ASJ-SSL: Comply with ASTM C552, Type II, Class 2.
6. Factory fabricate shapes according to ASTM C450 and ASTM C585.

G. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534, Type I for tubular materials and Type II for sheet materials.

H. Mineral-Fiber, Preformed Pipe Insulation:
1. Type I, 850 Deg F (454 Deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C547, Type I, Grade A, without factory-applied jacket, with factory-applied ASJ, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
2. Type II, 1200 Deg F (649 Deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C547, Type II, Grade A, without factory-applied jacket, with factory-applied ASJ, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.2 INSULATING CEMENTS

A. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C449.

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F (10 to 427 deg C).

C. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F (minus 73 to plus 93 deg C).

D. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.

E. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

2.4 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.
   1. Water-Vapor Permeance: ASTM E96/E96M, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.
   2. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
   3. Solids Content: ASTM D1644, 58 percent by volume and 70 percent by weight.
   4. Color: White.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.
   1. Water-Vapor Permeance: ASTM F1249, 1.8 perms (1.2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
   2. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
   3. Solids Content: 60 percent by volume and 66 percent by weight.
   4. Color: White.

2.5 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.
   1. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over equipment and pipe insulation.
   2. Service Temperature Range: 0 to plus 180 deg F (Minus 18 to plus 82 deg C).
   3. Color: White.

2.6 SEALANTS

A. Joint Sealants for Cellular-Glass Products:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Permanently flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C).
   4. Color: White or gray as directed.

B. FSK and Metal Jacket Flashing Sealants:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Fire- and water-resistant, flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
   4. Color: Aluminum.

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Fire- and water-resistant, flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
   4. Color: White.

2.7 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

   1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
   2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
   3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.

2.8 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm), in a Leno weave.

2.9 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and pre-sized a minimum of 8 oz./sq. yd. (271 g/sq. m).

2.10 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C921, Type I unless otherwise indicated.

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
   1. Adhesive: As recommended by jacket material manufacturer.
   2. Color: White, Color-code jackets based on system. Color as selected by Architect.
   3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
      a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
   4. Factory-fabricated tank heads and tank side panels.

C. Aluminum Jacket: Comply with ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.
   1. Sheet and roll stock ready for shop or field sizing, Factory cut and rolled to size].
   2. Finish and thickness are indicated in field-applied jacket schedules.
   3. Moisture Barrier for Indoor Applications: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper, 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper, 2.5-mil- (0.063-mm-) thick polysurlyn.
   4. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper, 2.5-mil- (0.063-mm-) thick polysurlyn.
   5. Factory-Fabricated Fitting Covers:
      a. Same material, finish, and thickness as jacket.
      b. Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
      c. Tee covers.
      d. Flange and union covers.
      e. End caps.
      f. Beveled collars.
      g. Valve covers.
      h. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.11 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
   1. Width: 3 inches (75 mm).
   2. Thickness: 11.5 mils (0.29 mm).
   3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
   4. Elongation: 2 percent.
   5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
   6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.
   1. Width: 3 inches (75 mm).
   2. Thickness: 6.5 mils (0.16 mm).
   3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.

4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
1. Width: 2 inches (50 mm).
2. Thickness: 6 mils (0.15 mm).
3. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
4. Elongation: 500 percent.
5. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. Width: 2 inches (50 mm).
2. Thickness: 3.7 mils (0.093 mm).
3. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
4. Elongation: 5 percent.
5. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.

2.12 SECUREMENTS

A. Aluminum Bands: ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm), 3/4 inch (19 mm) wide with wing seal or closed seal.

B. Insulation Pins and Hangers:

1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
   a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030-inch (0.76 mm) thick by 2 inches (50 mm) square.
   b. Spindle: Copper- or zinc-coated, low carbon steel, Aluminum, Stainless steel, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
   c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

2. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
   a. Baseplate: Galvanized carbon-steel sheet, 0.030-inch (0.76 mm) thick by 2 inches (50 mm) square.
   b. Spindle: Copper- or zinc-coated, low-carbon steel, Aluminum, Stainless steel, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
   c. Adhesive-backed base with a peel-off protective cover.

3. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick, galvanized-steel, aluminum, stainless-steel, sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
   a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.

D. Wire: 0.080-inch (2.0-mm) nickel-copper alloy, 0.062-inch (1.6-mm) soft-annealed, stainless steel, 0.062-inch (1.6-mm) soft-annealed, galvanized steel.

2.13 CORNER ANGLES

A. PVC Corner Angles: 30 mils (0.8 mm) thick, minimum 1 by 1 inch (25 by 25 mm), PVC according to ASTM D1784, Class 16354-C. White or color-coded to match adjacent surface.

B. Aluminum Corner Angles: 0.040 inch (1.0 mm) thick, minimum 1 by 1 inch (25 by 25 mm), aluminum according to ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14.

PART 3 - EXECUTION

3.1 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment and piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment and pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches (50 mm) or 4 inches (100 mm) o.c. as directed.

    a. For below-ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.3 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Below-Grade Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches (50 mm).
4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.4 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and

unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.

9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches (50 mm) over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.5 CALCIUM SILICATE INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure single-layer insulation with stainless-steel bands at 12-inch (300-mm) intervals and tighten bands without deforming insulation materials.
2. Install two-layer insulation with joints tightly butted and staggered at least 3 inches (75 mm). Secure inner layer with wire spaced at 12-inch (300-mm) intervals. Secure outer layer with stainless-steel bands at 12-inch (300-mm) intervals.
3. Apply a skim coat of mineral-fiber, hydraulic-setting cement to insulation surface. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1 inch (25 mm). Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth, uniform finish.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.

2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.
4. Finish flange insulation same as pipe insulation.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation sections of insulation are not available, install mitered sections of calcium silicate insulation. Secure insulation materials with wire or bands.
3. Finish fittings insulation same as pipe insulation.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install mitered segments of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
2. Install insulation to flanges as specified for flange insulation application.
3. Finish valve and specialty insulation same as pipe insulation.

3.6 CELLULAR-GLASS INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and applicable insulation joint sealant.
3. For insulation with factory-applied jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches (150 mm) o.c.
4. For insulation with factory-applied jackets on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.7 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.8 MINERAL-FIBER, PREFORMED PIPE INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and applicable insulation joint sealant.
3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches (150 mm) o.c.
4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.9 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch (50-mm) overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch- (1.6-mm-) thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.

2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

D. Where metal jackets are indicated, install with 2-inch (50-mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches (300 mm) o.c. and at end joints.

3.10 FINISHES

A. Equipment and Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

1. Flat Acrylic Finish: Two, finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

3.11 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one, location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.
2. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of

inspection shall be limited to three, locations of straight pipe, three, locations of threaded fittings, three, locations of welded fittings, two, locations of threaded strainers, two, locations of welded strainers, three, locations of threaded valves, and three, locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.12 EQUIPMENT INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

B. Insulate indoor and outdoor equipment that is not factory insulated.

C. Fire-suppression water storage tank insulation shall be one of the following:

1. Cellular Glass: 2 inches (50 mm) thick.
2. Flexible Elastomeric: 1 inch (25 mm) thick.

3.13 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Indoor fire-suppression piping.
2. Underground piping.

3.14 INDOOR PIPING INSULATION SCHEDULE

A. Indoor Engine Coolant Piping for Remote Radiator of Engine-Driven Fire Pump: Mineral-fiber, preformed pipe, Type I or II, 2 inches (50 mm) thick.

B. Indoor Engine Exhaust Piping and Silencer, All Pipe Sizes: Calcium silicate, 4 inches (100 mm) thick.

3.15 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Fire-Suppression Water Piping:

1. All Pipe Sizes: Insulation shall be one of the following:

a. Cellular Glass: 2 inches (50 mm) thick.
b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.

B. Outdoor Engine Coolant Piping for Remote Radiator of Engine-Driven Fire Pump:

1. All Pipe Sizes: Insulation shall be one of the following:

a. Calcium Silicate: 2 inches (50 mm) thick.
b. Cellular Glass: 2 inches (50 mm) thick.
c. Mineral-Fiber, Preformed Pipe, Type I or II: 2 inches (50 mm) thick.

C. Outdoor Engine Exhaust Piping and Silencer, All Pipe Sizes: Calcium silicate, 4 inches (100 mm) thick.

D. Outdoor Fire-Suppression Piping Filled with Water: Insulation shall be one of the following:

1. Cellular Glass: 2 inches (50 mm) thick.
2. Flexible Elastomeric: 2 inches (50 mm) thick.
3. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.

3.16 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:

1. None.
2. Aluminum, Smooth, Corrugated, Stucco Embossed: 0.016 inch (0.41 mm), 0.020 inch (0.51 mm), 0.024 inch (0.61 mm), 0.032 inch (0.81 mm), 0.040 inch (1.0 mm) thick.

D. Piping, Exposed:

1. None.
2. PVC, PVC, Color-Coded by System: 20 mils (0.5 mm), 30 mils (0.8 mm) thick.
3. Aluminum, Smooth, Corrugated, Stucco Embossed: 0.016 inch (0.41 mm), 0.020 inch (0.51 mm), 0.024 inch (0.61 mm), 0.032 inch (0.81 mm), 0.040 inch (1.0 mm) thick.

3.17 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Equipment, Concealed:

1. None.
2. PVC, PVC, Color-Coded by System: 20 mils (0.5 mm), 30 mils (0.8 mm) thick.

3. Aluminum, Smooth, Corrugated, Stucco Embossed: 0.016 inch (0.41 mm), 0.020 inch (0.51 mm), 0.024 inch (0.61 mm), 0.032 inch (0.81 mm), 0.040 inch (1.0 mm) thick.

D. Equipment, Exposed, up to 48 Inches (1200 mm) in Diameter or with Flat Surfaces up to 72 Inches (1800 mm):

1. Painted, Aluminum, Smooth, Corrugated, Stucco Embossed, with Z-Shaped Locking Seam: 0.016 inch (0.41 mm), 0.020 inch (0.51 mm), 0.024 inch (0.61 mm), 0.032 inch (0.81 mm) thick.

E. Equipment, Exposed, Larger Than 48 Inches (1200 mm) in Diameter or with Flat Surfaces Larger Than 72 Inches (1800 mm):

1. Painted, Aluminum, Smooth, Stucco Embossed with 1-1/4-Inch- (32-mm-) Deep Corrugations, 2-1/2-Inch- (65-mm-) Deep Corrugations, 4-by-1-Inch (100-by-25-mm) Box Ribs: 0.032 inch (0.81 mm), 0.040 inch (1.0 mm) thick.

F. Outdoor Exposed Piping:

1. PVC: 20 mils (0.5 mm), 30 mils (0.8 mm), 40 mils (1.0 mm) thick.
2. Painted Aluminum, Smooth, Corrugated, Stucco Embossed, with Z-Shaped Locking Seam: 0.016 inch (0.41 mm), 0.020 inch (0.51 mm), 0.024 inch (0.61 mm), 0.032 inch (0.81 mm) thick.

END OF SECTION 210700

SECTION 210800 - COMMISSIONING OF FIRE SUPPRESSION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes Cx process requirements for the following fire-suppression systems, assemblies, and equipment:

1. Water-based fire-suppression systems.
2. Fire-extinguishing systems.
3. Fire pumps.
4. Fire-suppression water storage.

B. Related Requirements:

1. Section 019113 "General Commissioning Requirements" for general Cx process requirements and CxA responsibilities.
2. For construction checklists, comply with requirements in various Division 21 Sections specifying fire-suppression systems, system components, equipment, and products.

1.2 DEFINITIONS

A. Cx: Commissioning, as defined in Section 019113 "General Commissioning Requirements."

B. CxA: Commissioning Authority, as defined in Section 019113 "General Commissioning Requirements."

C. "Systems," "Assemblies," "Subsystems," "Equipment," and "Components": Where these terms are used together or separately, they shall mean "as-built" systems, assemblies, subsystems, equipment, and components.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 CONSTRUCTION CHECKLIST REVIEW

A. Review and provide written comments on draft construction checklists. CxA will create required draft construction checklists and provide them to Contractor.

B. Return draft construction checklist review comments within 10 days of receipt.

C. When review comments have been resolved, the CxA will provide final construction checklists, marked "Approved for Use, (date)."

D. Use only construction checklists, marked "Approved for Use, (date)."

3.2 Cx TESTING PREPARATION

A. Certify that fire-suppression systems, subsystems, and equipment have been installed, calibrated, and started and that they are operating according to the Contract Documents and approved submittals.

B. Certify that fire-suppression systems instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents and approved submittals, and that pretest set points have been recorded.

C. Set systems, subsystems, and equipment into operating mode to be tested according to approved test procedures (for example, normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

3.3 Cx TEST CONDITIONS

A. Perform tests using design conditions, whenever possible.

1. Simulated conditions may, with approval of Architect, be imposed using an artificial load when it is impractical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by CxA and document simulated conditions and methods of simulation. After tests, return configurations and settings to normal operating conditions.
2. Cx test procedures may direct that set points be altered when simulating conditions is impractical.
3. Cx test procedures may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are impractical.

B. If tests cannot be completed because of a deficiency outside the scope of the fire-suppression system, document the deficiency and report it to Architect. After deficiencies are resolved, reschedule tests.

C. If seasonal testing is specified, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.4 Cx TESTS COMMON TO FIRE-SUPPRESSION SYSTEMS

A. Measure capacities and effectiveness of systems, assemblies, subsystems, equipment, and components, including operational and control functions, to verify compliance with acceptance criteria.

B. Test systems, assemblies, subsystems, equipment, and components operating modes, interlocks, control responses, responses to abnormal or emergency conditions, and response according to acceptance criteria.

C. Coordinate schedule with, and perform Cx activities at the direction of, CxA.

D. Comply with construction checklist requirements, including material verification, installation checks, startup, and performance tests requirements specified in Division 21 Sections specifying fire-suppression systems and equipment.

E. Provide technicians, instrumentation, tools, and equipment to perform and document the following:

1. Construction checklist verification tests.
2. Construction checklist verification test demonstrations.
3. Cx tests.
4. Cx test demonstrations.

F. Vibration Isolation in Fire-Suppression Systems:

1. Prerequisites: Acceptance of results of construction checklists for vibration and seismic control devices specified in Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment." Section 210548.13 "Vibration Controls for Fire-Suppression Piping and Equipment."
2. Components to Be Tested:

    a. Vibration isolation and seismic control devices in water-based fire-suppression systems.
    b. Structural systems.

3. Test Purpose: Evaluate effectiveness of vibration isolation and seismic control devices.
4. Test Conditions: Measure vibration of the facility structure at three locations designated by Owner's witness while the isolated equipment operates.
5. Test Conditions: Measure vibration of the facility structure at three locations designated by Owner's witness at the following operating conditions:

    a. Maximum speed.
    b. Minimum speed.
    c. Critical speed.

6. Acceptance Criteria: Structure-borne vibration not to exceed specified performance.

G. Supervision of Fire-Protection Valves in Water-Based Fire-Suppression Systems:

1. Prerequisites: Acceptance of results of construction checklists for valves specified in the Sections listed below:

    a. Section 210523 "General-Duty Valves for Water-Based Fire Protection Piping."
    b. Section 211100 "Facility Fire-Suppression Water-Service Piping."
    c. Section 211200 "Fire-Suppression Standpipes."
    d. Section 211313 "Wet-Pipe Sprinkler Systems."
    e. Section 211316 "Dry-Pipe Sprinkler Systems."
    f. Section 284621.11 "Addressable Fire-Alarm Systems."
    g. Section 284621.13 "Conventional Fire-Alarm Systems."

2. Equipment and Systems to Be Tested:

a. Supervised valves in water-based fire-suppression systems.
b. Division 28 fire-detection and -alarm systems.

3. Test Purpose: Verify generation of supervisory alarm at the fire-alarm control panel in response to activation of valve supervision device or tamper switch.
4. Test Conditions:

a. Fire-alarm system operating in normal, automatic mode.
b. Activate valve supervision devices and tamper switches, one at a time.

5. Acceptance Criteria: Activation of valve supervision device or tamper switch generates supervisory alarm at fire-alarm control panel.

H. Heat Tracing in Water-Based Fire-Suppression Systems:

1. Prerequisites: Acceptance of results of construction checklists for heat tracing specified in water-based fire-suppression systems. Comply with requirements in Section 210533 "Heat Tracing for Fire-Suppression Piping."
2. Equipment and Systems to Be Tested:

a. Self-regulating, parallel-resistance heating cables.
b. Heater trace circuit controller.
c. Interface with fire-alarm control panel.

3. Test Purpose:

a. Evaluate response to ambient temperature below freeze-protection set point.
b. Evaluate heating cable fault alarm.

4. Test Conditions:

a. Subject temperature sensor to temperature approximately 3 deg F (2 deg C) above freeze-protection set point (initial set point 41 deg F (5 deg C). Monitor sensed temperature with a calibration-grade thermometer. Gradually change set point or sensed temperature until freeze-protection circuit is energized.
b. Subject temperature sensor to temperature approximately 3 deg F (2 deg C) below freeze-protection set point, initial set point 41 deg F (5 deg C). Monitor sensed temperature with a calibration-grade thermometer. Gradually change set point or sensed temperature until freeze-protection circuit is de-energized.
c. Simulate an electrical fault on the heating cable.

5. Acceptance Criteria:

a. Freeze-protection circuit is energized at set-point temperature minus 2 deg F (1 deg C).
b. Freeze-protection circuit is de-energized at set-point temperature plus 2 deg F (1 deg C).
c. Heater trace circuit controller initiates an alarm of cable fault. Alarm is correctly reported at the fire-alarm control panel.

3.5 Cx TESTS FOR DRY-PIPE SPRINKLER PIPING, FITTINGS, SPRINKLERS, AND SPECIALTIES.

A. Air Compressor Run Time:

1. Prerequisites: Acceptance of results of construction checklists specified in Section 211316 "Dry-Piping Sprinkler Systems."
2. Systems and Equipment to Be Tested:

    a. Air compressors in fire-suppression systems.
    b. Associated compressed air piping, valves, and appurtenances.
    c. Associated air pressure controllers.

3. Test Purpose: Evaluate air compressor run time and number of compressor starts.
4. Test Conditions:

    a. Keep compressed air and associated sprinkler piping openings closed during test.
    b. For systems with multiple compressors, lock out compressor motors on all but one compressor. Repeat test for each compressor in turn.
    c. Record number of air compressor motor starts during a 14-day period.
    d. Record air compressor motor run time during the same 14-day period.

5. Acceptance Criteria:

    a. Number of compressor motor starts during test period shall not exceed 20.
    b. Compressor motor run time during test period shall not exceed 60 minutes.

3.6 Cx TESTS FOR CLEAN-AGENT FIRE-EXTINGUISHING SYSTEMS:

A. Carbon-Dioxide Concentration in Carbon-Dioxide Fire-Extinguishing System:

1. Prerequisites:

    a. Acceptance of results of construction checklists specified in Section 212113.13 "High-Pressure, Carbon-Dioxide Fire-Extinguishing Systems."
    b. Acceptance of results of construction checklists specified in Section 212113.16 "Low-Pressure, Carbon-Dioxide Fire-Extinguishing Systems."
    c. Acceptance of construction checklists specified in Division 23 for systems and equipment serving the protected space.
    d. Partitions, ceilings, doors, and other openings complete in the vicinity of the protected space.

2. Systems and Equipment to Be Tested:

    a. High-pressure, carbon-dioxide fire-extinguishing systems.
    b. Low-pressure, carbon-dioxide fire-extinguishing systems.
    c. Protected space enclosure.
    d. HVAC system protected space isolation equipment.

3. Test Purpose: Evaluate initial and final carbon-dioxide concentration in the protected space following carbon-dioxide release.
4. Test Conditions:

    a. HVAC systems operating in normal, occupied, automatic control.
    b. Fire-detection and -alarm systems operating in normal, occupied, automatic control.
    c. Carbon-dioxide fire-extinguishing system charged and operating in normal, occupied, automatic control.
    d. Protected space air temperature is 70 deg F (21 deg C).
    e. Create a fire-alarm event in the carbon-dioxide protected space, resulting in discharge of carbon-dioxide fire-extinguishing system.
    f. Measure and record carbon-dioxide concentration at four locations selected by the CxA when the carbon dioxide is completely dispersed and at the end of holding time.

5. Acceptance Criteria: Carbon-dioxide concentration is no less than 34 percent concentration by volume at 70 deg F (21 deg C).

B. Clean-Agent Concentration in Clean-Agent Fire-Extinguishing System:

1. Prerequisites:

    a. Acceptance of results of construction checklists for Section 212200 "Clean-Agent Fire-Extinguishing Systems."
    b. Acceptance of construction checklists specified in Division 23 for systems and equipment serving the protected space.
    c. Partitions, ceilings, doors, and other openings complete in the vicinity of the protected space.

2. Systems and Equipment to Be Tested:

    a. Clean-agent fire-extinguishing systems.
    b. HVAC system protected space isolation equipment.
    c. Protected space enclosure.

3. Test Purpose: Evaluate initial and final clean-agent concentration in the protected space following carbon-dioxide release.
4. Test Conditions:

    a. HVAC systems operating in normal, occupied, automatic control.
    b. Fire-detection and -alarm systems operating in normal, occupied, automatic control.
    c. Clean-agent fire-extinguishing system charged and operating in normal, occupied, automatic control.
    d. Protected space air temperature is 70 deg F (21 deg C).
    e. Create a fire-alarm event in the clean-agent protected space, resulting in discharge of clean-agent fire-extinguishing system.
    f. Measure and record clean-agent concentration at four locations selected by the CxA when the clean agent is completely dispersed and at the end of holding time.

5. Acceptance Criteria: Clean-agent concentration is no less than 34 percent concentration by volume at 70 deg F (21 deg C).

END OF SECTION 210800

SECTION 211100 - FACILITY FIRE-SUPPRESSION WATER-SERVICE PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes fire-suppression water-service piping and related components outside the building and service entrance piping through floor into the building and service entrance piping through wall into the building and the following:

1. Pipes, fittings, and specialties.
2. Fire-suppression specialty valves.
3. Concrete vaults.
4. Protective enclosures.
5. Alarm devices.

B. Utility-furnished products include water meters that are furnished to the site, ready for installation.

C. Related Requirements:

1. Section 211116 "Facility Fire Hydrants" for AWWA and UL-listed, dry- and wet-barrel fire hydrants.
2. Section 211119 "Fire-Department Connections" for exposed-, flush-, and yard-type, fire-department connections.
3. Section 211200 "Fire-Suppression Standpipes" for fire-suppression standpipes inside the building.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Detail precast concrete vault assemblies and indicate dimensions, method of field assembly, and components.
2. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: For piping and specialties including relation to other services in same area, drawn to scale. Show piping and specialty sizes and valves, meter and specialty locations, and elevations.

B. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Comply with requirements of utility company supplying the water. Include tapping of water mains and backflow prevention.
2. Comply with standards of authorities having jurisdiction for fire-suppression water-service piping, including materials, hose threads, installation, and testing.

B. Piping materials shall bear label, stamp, or other markings of specified testing agency.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Comply with FM Global's "Approval Guide" or UL's "Fire Protection Equipment Directory" for fire-service-main products.

E. NFPA Compliance: Comply with NFPA 24 for materials, installations, tests, flushing, and valve and hydrant supervision for fire-suppression water-service piping.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Soft Copper Tube: ASTM B88, Type K (ASTM B88M, Type A) and ASTM B88, Type L (ASTM B88M, Type B), water tube, annealed temper.

B. Hard Copper Tube: ASTM B88, Type K (ASTM B88M, Type A) and ASTM B88, Type L (ASTM B88M, Type B), water tube, drawn temper.

C. Copper, Solder-Joint Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint pressure type. Furnish only wrought-copper fittings if indicated.

D. Copper, Pressure-Seal Fittings:
1. Standard: UL 213.
2. NPS 2 (DN 50) and Smaller: Wrought-copper fitting with EPDM O-ring seal in each end.
3. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Bronze fitting with stainless-steel grip ring and EPDM O-ring seal in each end.

E. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end. Furnish Class 300 flanges if required to match piping.

F. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

2.2 DUCTILE-IRON PIPE AND FITTINGS

A. Grooved-Joint, Ductile-Iron Pipe: AWWA C151, with cut, rounded-grooved ends.

B. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end.

C. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell and plain spigot end.

D. Grooved-End, Ductile-Iron Pipe Appurtenances:
   1. Grooved-End, Ductile-Iron Fittings: ASTM A47/A47M, malleable-iron castings or ASTM A536, ductile-iron castings with dimensions matching pipe.
   2. Grooved-End, Ductile-Iron-Piping Couplings: AWWA C606, for ductile-iron-pipe dimensions. Include ferrous housing sections, gasket suitable for water, and bolts and nuts.

E. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.

   1. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

F. Push-on-Joint, Ductile-Iron Fittings: AWWA C153, ductile-iron compact pattern.

   1. Gaskets: AWWA C111, rubber.

G. Flanges: ASME B16.1, Class 125, cast iron.

2.3 PE PIPE AND FITTINGS

A. PE, Fire-Service Pipe: FM Global approved, with minimum thickness equivalent to Class 150 and Class 200.

B. Molded PE Fittings: FM Global approved; PE butt-fusion type, made to match PE pipe dimensions and class.

2.4 PVC PIPE AND FITTINGS

A. PVC Pipe: AWWA C900 or UL 1285, Class 150 and Class 200, with bell end with gasket, and with spigot end.

B. PVC Fittings: AWWA C900 or UL 1285, Class 150 and Class 200, with bell-and-spigot or double-bell ends. Include elastomeric gasket in each bell.

2.5 SPECIAL PIPE FITTINGS

A. Ductile-Iron Flexible Expansion Joints:
   1. Description: Compound, ductile-iron fitting with combination of flanged and mechanical-joint ends complying with AWWA C110 or AWWA C153. Include two gasketed ball-

joint sections and one or more gasketed sleeve sections. Assemble components for offset and expansion indicated. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.

2. Pressure Rating: 250 psig (1725 kPa) minimum.

B. Ductile-Iron Deflection Fittings:

1. Description: Compound, ductile-iron coupling fitting with sleeve and one or two flexing sections for up to 15-degree deflection, gaskets, and restrained-joint ends complying with AWWA C110 or AWWA C153. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.
2. Pressure Rating: 250 psig (1725 kPa) minimum.

2.6 JOINING MATERIALS

A. Gaskets for Ferrous Piping and Copper-Alloy Tubing: ASME B16.21, asbestos free.

B. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series.

2.7 PIPING SPECIALTIES

A. Transition Fittings: Manufactured fitting or coupling same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

B. Tubular-Sleeve Pipe Couplings:

1. Description: Metal, bolted, sleeve-type, reducing or transition coupling, with center sleeve, gaskets, end rings, and bolt fasteners, and with ends of same sizes as piping to be joined.
2. Standard: AWWA C219.
3. Center-Sleeve Material: Manufacturer's standard, Carbon steel, Stainless steel, Ductile iron, Malleable iron.
4. Gasket Material: Natural or synthetic rubber.
5. Pressure Rating: 150 psig (1035 kPa), 200 psig (1380 kPa) minimum.
6. Metal Component Finish: Corrosion-resistant coating or material.

2.8 CORPORATION VALVES

A. Corporation Valves: Comply with AWWA C800. Include saddle and valve compatible with tapping machine and manifold.

1. Service Saddle: Copper alloy with seal and AWWA C800, threaded outlet for corporation valve.
2. Corporation Valve: Bronze body and ground-key plug, with AWWA C800, threaded inlet and outlet matching service piping material.
3. Manifold: Copper fitting with two to four inlets as required, with ends matching corporation valves and outlet matching service piping material.

B. Meter Valves: Comply with AWWA C800 for high-pressure, service-line valves. Include angle- or straight-through-pattern bronze body, ground-key plug or ball, and wide tee head, with inlet and outlet matching service piping material.

2.9 CURB VALVES

A. Curb Valves: Comply with AWWA C800 for high-pressure, service-line valves. Valve has bronze body, ground-key plug or ball, wide tee head, and inlet and outlet matching service piping material.

B. Service Boxes for Curb Valves: Similar to AWWA M44 requirements for cast-iron valve boxes. Include cast-iron telescoping top section of length required for depth of burial of valve, plug with lettering "WATER," and bottom section with base that fits over curb valve and with a barrel approximately 3 inches (75 mm) in diameter.

1. Shutoff Rods: Steel; with tee-handle with one pointed end, stem of length to operate deepest buried valve, and slotted end matching curb valve.

C. Meter Valves: Comply with AWWA C800 for high-pressure, service-line valves. Include angle- or straight-through-pattern bronze body, ground-key plug or ball, and wide tee head, with inlet and outlet matching service piping material.

2.10 DETECTOR CHECK VALVES

A. Description: Galvanized cast-iron body, bolted cover with air-bleed device for access to internal parts, and flanged ends. Include one-piece bronze disc with bronze bushings, pivot, and replaceable seat. Include threaded bypass taps in inlet and outlet for bypass meter connection. Set valve to allow minimal water flow through bypass meter when major water flow is required.

B. Standards: UL 312 and FM Global's "Approval Guide."

C. Pressure Rating: 175 psig (1200 kPa).

D. Water Meter: AWWA C700, disc type, at least one-fourth size of detector check valve. Include meter, bypass piping, gate valves, check valve, and connections to detector check valve.

2.11 WATER METERS

A. Water meters are furnished by utility company.

B. Displacement-Type Water Meters:

1. Description: With bronze main case.
2. Standard: AWWA C700.
3. Registration: Flow in gallons (liters), cubic feet (cubic meters).

C. Turbine-Type Water Meters:

1. Standard: AWWA C701.

2. Registration: Flow in gallons (liters), cubic feet (cubic meters).

D. Compound-Type Water Meters:

1. Standard: AWWA C702.
2. Registration: Flow in gallons (liters), cubic feet (cubic meters).

E. Remote Registration System:

1. Description: Utility company's standard; direct-reading type. Include meter modified with signal-transmitting assembly, low-voltage connecting wiring, and remote register assembly.
2. Standard: AWWA C706.
3. Registration: Flow in gallons (liters), cubic feet (cubic meters).

F. Remote Registration System:

1. Description: Utility company's standard; encoder type. Include meter modified with signal-transmitting assembly, low-voltage connecting wiring, and remote register assembly.
2. Standard: AWWA C707.
3. Registration: Flow in gallons (liters), cubic feet (cubic meters).
4. Data-Acquisition Units: Comply with utility company's requirements for type and quantity.
5. Visible Display Units: Comply with utility company's requirements for type and quantity.

2.12 PRESSURE-REDUCING VALVES

A. Water Regulators:
1. Standard: ASSE 1003.
2. Pressure Rating: Initial pressure of 150 psig (1035 kPa).
3. Size: NPS (DN).
4. Design Flow Rate: As directed.
5. Design Inlet Pressure: As directed.
6. Design Outlet Pressure Setting: psig (kPa).
7. Body Material: Bronze with chrome-plated finish for NPS 2 (DN 50) and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and NPS 3 (DN 65 and DN 80).
8. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 and NPS 3 (DN 65 and DN 80).

B. Water Control Valves:
1. Description: Pilot-operation, diaphragm-type, single-seated main water control valve with AWWA C550 or FDA-approved, interior epoxy coating. Include small pilot control valve, restrictor device, specialty fittings, and sensor piping.
2. Pressure Rating: Initial pressure of 150 psig (1035 kPa) minimum.
3. Main Valve Body: Cast or ductile iron with AWWA C550 or FDA-approved, interior epoxy coating; or stainless-steel body.

a. Size: NPS (DN).

b. Pattern: Angle, Globe-valve design.
c. Trim: Stainless steel.

4. Design Flow Rate: gpm (L/s).
5. Design Inlet Pressure: psig (kPa).
6. Design Outlet Pressure Setting: psig (kPa).
7. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 (DN 65) and larger.

2.13 BACKFLOW PREVENTERS

A. Double-Check, Backflow-Prevention Assemblies:
1. Standard: ASSE 1015 or AWWA C510.
2. Operation: Continuous-pressure applications unless otherwise indicated.
3. Pressure Loss: 5 psig (35 kPa) maximum, through middle one-third of flow range.
4. Size: NPS (DN).
5. Design Flow Rate: gpm (L/s).
6. Selected Unit Flow Range Limits: gpm (L/s).
7. Pressure Loss at Design Flow Rate: psig (kPa) for NPS 2 (DN 50) and smaller; psig (kPa) for NPS 2-1/2 (DN 65) and larger.
8. Body Material: Bronze for NPS 2 (DN 50) and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved, steel with interior lining complying with AWWA C550 or that is FDA approved, stainless steel for NPS 2-1/2 (DN 65) and larger.
9. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 (DN 65) and larger.
10. Configuration: Designed for horizontal, straight through flow.
11. Accessories: Ball valves with threaded ends on inlet and outlet of NPS 2 (DN 50) and smaller; OS&Y gate valves with flanged ends on inlet and outlet of NPS 2-1/2 (DN 65) and larger.

B. Double-Check, Detector-Assembly Backflow Preventers:
1. Standards: ASSE 1048 and UL's "Fire Protection Equipment Directory" listing or FM Global's "Approval Guide."
2. Operation: Continuous-pressure applications.
3. Pressure Loss: 5 psig (35 kPa) maximum, through middle one-third of flow range.
4. Size: NPS (DN).
5. Design Flow Rate: gpm (L/s).
6. Selected Unit Flow Range Limits: gpm (L/s).
7. Pressure Loss at Design Flow Rate: psig (kPa).
8. Body Material: Cast iron with interior lining complying with AWWA C550 or that is FDA approved, Steel with interior lining complying with AWWA C550 or that is FDA approved, Stainless steel.
9. End Connections: Flanged.
10. Configuration: Designed for horizontal, straight through vertical inlet, horizontal center section, and vertical outlet vertical flow.
11. Accessories:

a. Valves: UL 262 and FM Global's "Approval Guide" listing; OS&Y gate type with flanged ends on inlet and outlet.

b. Bypass: With displacement-type water meter, shutoff valves, and reduced-pressure backflow preventer.

C. Backflow Preventer Test Kits:
1. Description: Factory calibrated, with gages, fittings, hoses, and carrying case with test-procedure instructions.

2.14 WATER METER BOXES

A. Description: Cast-iron body and cover for disc-type water meter, with lettering "WATER METER" on cover; and with slotted, open-bottom base section of length to fit over service piping.

1. Option: Base section may be cast-iron, PVC, clay, or other pipe.

B. Description: Cast-iron body and double cover for disc-type water meter, with lettering "WATER METER" on top cover; and with separate inner cover; air space between covers; and slotted, open-bottom base section of length to fit over service piping.

C. Description: Polymer-concrete body and cover for disc-type water meter, with lettering "WATER" on cover; and with slotted, open-bottom base section of length to fit over service piping. Include vertical and lateral design loadings of 15,000 lb minimum over 10 by 10 inches (6 800 kg minimum over 254 by 254 mm) square.

2.15 CONCRETE VAULTS

A. Description: Precast, reinforced-concrete vault, designed for A-16 load designation according to ASTM C857, and made according to ASTM C858.

B. Ladder: ASTM A36/A36M, steel ladder; or PE-encased steel steps.

C. Manhole: ASTM A48/A48M, Class No. 35A minimum tensile strength, gray-iron traffic frame and cover.

1. Dimension: 24-inch (610-mm) minimum diameter unless otherwise indicated.

D. Manhole: ASTM A536, Grade 60-40-18, ductile-iron traffic frame and cover.

1. Dimension: 24-inch (610-mm) minimum diameter unless otherwise indicated.

E. Drain: ASME A112.6.3, cast-iron floor drain with outlet of size indicated. Include body anchor flange, light-duty cast-iron grate, bottom outlet, and integral or field-installed bronze ball or clapper-type backwater valve.

2.16 ALARM DEVICES

A. General: UL 753 and FM Global's "Approval Guide" listing, of types and sizes to mate and match piping and equipment.

B. Water-Flow Indicators: Vane-type water-flow detector, rated for 250-psig (1725-kPa) working pressure; designed for horizontal or vertical installation; with two single-pole, double-throw circuit switches to provide isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal when cover is removed.

C. Supervisory Switches: Single pole, double throw; designed to signal valve in other than fully open position.

D. Pressure Switches: Single pole, double throw; designed to signal increase in pressure.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Comply with excavating, trenching, and backfilling requirements in Section 312000 "Earth Moving."

3.2 PIPING INSTALLATION

A. Water-Main Connection: Arrange with water utility company for tap of size and in location indicated in water main.

B. Water-Main Connection: Tap water main according to requirements of water utility company and of size and in location indicated.

C. Make connections larger than NPS 2 (DN 50) with tapping machine according to the following:

1. Install tapping sleeve and tapping valve according to MSS SP-60.
2. Install tapping sleeve on pipe to be tapped. Position flanged outlet for gate valve.
3. Use tapping machine compatible with valve and tapping sleeve; cut hole in main. Remove tapping machine and connect water-service piping.
4. Install gate valve onto tapping sleeve. Comply with MSS SP-60. Install valve with stem pointing up and with valve box.

D. Make connections NPS 2 (DN 50) and smaller with drilling machine according to the following:

1. Install service-saddle assemblies and corporation valves in size, quantity, and arrangement required by utility company's standards.
2. Install service-saddle assemblies on water-service pipe to be tapped. Position outlets for corporation valves.
3. Use drilling machine compatible with service-saddle assemblies and corporation valves. Drill hole in main. Remove drilling machine and connect water-service piping.
4. Install corporation valves into service-saddle assemblies.
5. Install manifold for multiple taps in water main.
6. Install curb valve in water-service piping with head pointing up and with service box.

E. Comply with NFPA 24 for fire-service-main piping materials and installation.

F. Install copper tube and fittings according to CDA's "Copper Tube Handbook."

G. Install ductile-iron, water-service piping according to AWWA C600 and AWWA M41.

1. Install encasement for piping according to ASTM A674 or AWWA C105.

H. Install PE pipe according to ASTM D2774 and ASTM F645.

I. Install PVC, AWWA pipe according to ASTM F645 and AWWA M23.

J. Bury piping with depth of cover over top at least 30 inches (750 mm), with top at least 12 inches (300 mm) below level of maximum frost penetration, and according to the following:

1. Under Driveways: With at least 36 inches (910 mm) of cover over top.
2. Under Railroad Tracks: With at least 48 inches (1220 mm) of cover over top.
3. In Loose Gravelly Soil and Rock: With at least 12 inches (300 mm) of additional cover.

K. Install piping by tunneling or jacking, or combination of both, under streets and other obstructions that cannot be disturbed.

L. Extend fire-suppression water-service piping and connect to water-supply source and building fire-suppression water-service piping systems at locations and pipe sizes indicated.

1. Terminate fire-suppression water-service piping within the building at the floor slab, wall, until building-water-piping systems are installed. Terminate piping with caps, plugs, or flanges as required for piping material. Make connections to building's fire-suppression water-service piping systems when those systems are installed.

M. Install underground piping with restrained joints at horizontal and vertical changes in direction. Use restrained-joint piping, thrust blocks, anchors, tie-rods and clamps, and other supports.

N. Comply with requirements in Section 211200 "Fire-Suppression Standpipes," Section 211313 "Wet-Pipe Sprinkler Systems," and Section 211316 "Dry-Pipe Sprinkler Systems" for fire-suppression-water piping inside the building.

O. Comply with requirements in Section 221116 "Domestic Water Piping" for potable-water piping inside the building.

P. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."

Q. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."

3.3 JOINT CONSTRUCTION

A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure rating same as or higher than systems pressure rating for aboveground applications unless otherwise indicated.

B. Install unions adjacent to each valve in tubing NPS 2 (DN 50) and smaller.

C. Install flanges, flange adaptors, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 (DN 65) and larger end connections.

D. Ream ends of tubes and remove burrs.

E. Remove scale, slag, dirt, and debris from outside and inside of pipes, tubes, and fittings before assembly.

F. Copper-Tubing, Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter.

G. Copper-Tubing, Pressure-Sealed Joints: Use proprietary crimping tool and procedure recommended by copper, pressure-seal-fitting manufacturer.

H. Ductile-Iron Piping, Gasketed Joints for Fire-Service-Main Piping: UL 194.

I. Ductile-Iron Piping, Grooved Joints: Cut-groove pipe. Assemble joints with grooved-end, ductile-iron-piping couplings, gaskets, lubricant, and bolts.

J. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with bolts according to ASME B31.9.

K. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D2657.

L. PVC Piping Gasketed Joints: Use joining materials according to AWWA C900. Construct joints with elastomeric seals and lubricant according to ASTM D2774 or ASTM D3139.

M. Dissimilar Materials Piping Joints: Use adapters compatible with both piping materials, with OD, and with system working pressure.

N. Do not use flanges or unions for underground piping.

3.4 ANCHORAGE INSTALLATION

A. Anchorage, General: Install water-distribution piping with restrained joints. Anchorages and restrained-joint types that may be used include the following:

1. Concrete thrust blocks.
2. Locking mechanical joints.
3. Set-screw mechanical retainer glands.
4. Bolted flanged joints.
5. Heat-fused joints.
6. Pipe clamps and tie rods.

B. Install anchorages for tees, plugs and caps, bends, crosses, valves, and hydrant branches in fire-suppression water-service piping according to NFPA 24 and the following:

1. Gasketed-Joint, Ductile-Iron, Water-Service Piping: According to AWWA C600.

2. Gasketed-Joint, PVC Water-Service Piping: According to AWWA M23.

C. Apply full coat of asphalt or other acceptable corrosion-resistant material to surfaces of installed ferrous anchorage devices.

3.5 VALVE INSTALLATION

A. AWWA Gate Valves: Comply with AWWA C600 and AWWA M44. Install each underground valve with stem pointing up and with valve box.

B. AWWA Valves Other Than Gate Valves: Comply with AWWA C600 and AWWA M44.

C. UL-Listed or FM Global-Approved Gate Valves: Comply with NFPA 24. Install each underground valve and valves in vaults with stem pointing up and with vertical cast-iron indicator post.

D. UL-Listed or FM Global-Approved Valves Other Than Gate Valves: Comply with NFPA 24.

E. MSS Valves: Install as component of connected piping system.

F. Corporation Valves and Curb Valves: Install each underground curb valve with head pointed up and with service box.

G. Pressure-Reducing Valves: Install in vault or aboveground between shutoff valves. Install full-size valved bypass.

H. Support valves and piping, not direct buried, on concrete piers. Comply with requirements for concrete piers in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.

3.6 DETECTOR CHECK VALVE INSTALLATION

A. Install in vault or aboveground.

B. Install for proper direction of flow. Install bypass with water meter, gate valves on each side of meter, and check valve downstream from meter.

C. Support detector check valves and piping on concrete piers. Comply with requirements for concrete piers in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.

3.7 WATER METER INSTALLATION

A. Install water meters, piping, and specialties according to utility company's written instructions.

B. Water Meters: Install displacement, turbine-type water meters NPS 2 (DN 50) and smaller in meter boxes with shutoff valves on water meter inlets. Include valves on water meter outlets and include valved bypass around meters unless prohibited by authorities having jurisdiction.

C. Water Meters: Install compound, turbine-type water meters NPS 3 (DN 80) and larger in meter vaults. Include shutoff valves on water meter inlets and outlets and include valved bypass around meters. Support meters, valves, and piping on brick or concrete piers.

D. Support water meters and piping NPS 3 (DN 80) and larger on concrete piers. Comply with requirements for concrete piers in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.

3.8 ROUGHING-IN FOR WATER METERS

A. Rough-in piping and specialties for water meter installation according to utility company's written instructions.

3.9 BACKFLOW PREVENTER INSTALLATION

A. Install backflow preventers of type, size, and capacity indicated. Include valves and test cocks. Install according to requirements of plumbing and health department and authorities having jurisdiction.

B. Do not install backflow preventers that have relief drain in vault or in other spaces subject to flooding.

C. Do not install bypass piping around backflow preventers.

D. Support NPS 2-1/2 (DN 65) and larger backflow preventers and piping on concrete piers. Comply with requirements for concrete piers in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.

3.10 WATER METER BOX INSTALLATION

A. Install water meter boxes in paved areas flush with surface.

B. Install water meter boxes in grass or earth areas with top 2 inches (50 mm) above surface.

3.11 CONCRETE VAULT INSTALLATION

A. Install precast concrete vaults according to ASTM C891.

3.12 FIRE-DEPARTMENT CONNECTION INSTALLATION

A. Install ball drip valves at each check valve for fire-department connection to mains.

B. Install protective pipe bollards on two sides of, on three sides of each freestanding fire-department connection. Pipe bollards are specified in Section 055000 "Metal Fabrications."

3.13 ALARM DEVICE INSTALLATION

A. General: Comply with NFPA 24 for devices and methods of valve supervision. Underground valves with valve box do not require supervision.

B. Supervisory Switches: Supervise valves in open position.

1. Valves: Grind away portion of exposed valve stem. Bolt switch, with plunger in stem depression, to OS&Y gate-valve yoke.
2. Indicator Posts: Drill and thread hole in upper-barrel section at target plate. Install switch, with toggle against target plate, on barrel of indicator post.

C. Locking and Sealing: Secure unsupervised valves as follows:

1. Valves: Install chain and padlock on open OS&Y gate valve.
2. Post Indicators: Install padlock on wrench on indicator post.

D. Pressure Switches: Drill and thread hole in exposed barrel of fire hydrant. Install switch.

E. Water-Flow Indicators: Install in water-service piping in vault. Select indicator with saddle and vane matching pipe size. Drill hole in pipe, insert vane, and bolt saddle to pipe.

F. Connect alarm devices to building's fire-alarm system. Wiring and fire-alarm devices are specified in Section 284621.13 "Conventional Fire-Alarm Systems." Section 284621.13 "Conventional Fire-Alarm Systems."

3.14 CONNECTIONS

A. Connect fire-suppression water-service piping to utility water main, existing water main to piping system. Use tapping sleeve and tapping valve, service clamp and corporation valve.

B. Connect fire-suppression water-service piping to interior fire-suppression piping.

C. Connect waste piping from concrete vault drains to sanitary sewerage system. Comply with requirements in Section 221313 "Facility Sanitary Sewers" for connection to sanitary sewer, storm-drainage system. Comply with requirements in Section 334100 "Storm Utility Drainage Piping" for connection to storm sewer.

3.15 FIELD QUALITY CONTROL

A. Use test procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described below.

B. Piping Tests: Conduct piping tests before joints are covered and after concrete thrust blocks have hardened sufficiently. Fill pipeline 24 hours before testing and apply test pressure to stabilize system. Use only potable water.

C. Hydrostatic Tests: Test at not less than one-and-one-half times the working pressure for two hours.

1. Increase pressure in 50-psig (350-kPa) increments and inspect each joint between increments. Hold at test pressure for one hour; decrease to zero psig (zero kPa). Slowly increase again to test pressure and hold for one more hour. Maximum allowable leakage is 2 quarts (1.89 L) per hour per 100 joints. Remake leaking joints with new materials and repeat test until leakage is within allowed limits.

D. Prepare test and inspection reports.

3.16 IDENTIFICATION

A. Install continuous underground detectable warning tape during backfilling of trench for underground fire-suppression water-service piping. Locate below finished grade, directly over piping. Underground warning tapes are specified in Section 312000 "Earth Moving."

B. Permanently attach equipment nameplate or marker indicating plastic fire-suppression water-service piping or fire-suppression water-service piping with electrically insulated fittings, on main electrical meter panel. Comply with requirements for identifying devices in Section 220553 "Identification for Plumbing Piping and Equipment."

3.17 PIPING SCHEDULE

A. Underground fire-suppression water-service piping NPS 2 (DN 50) and smaller, pipe size range shall be one of the following:

1. NPS 2 (DN 50) PE, Class 150, Class 200, fire-service pipe; molded PE fittings; and heat-fusion joints.

B. Underground fire-suppression water-service piping NPS 3 (DN 80) shall be one of the following:

1. Grooved-end, ductile-iron pipe; grooved-end, ductile-iron pipe appurtenances; and grooved joints.
2. Mechanical-joint, ductile-iron pipe; mechanical-joint, ductile- or gray-iron, standard-pattern or ductile-iron, compact-pattern fittings; glands, gaskets, and bolts; and gasketed joints.
3. Push-on-joint, ductile-iron pipe; push-on-joint, ductile-iron compact-pattern fittings; and gasketed joints.
4. PE, Class 150, Class 200, fire-service pipe; molded PE fittings; and heat-fusion joints.

C. Underground fire-suppression water-service piping NPS 4 (DN 100) shall be one of the following:

1. Grooved-end, ductile-iron pipe; grooved-end, ductile-iron pipe appurtenances; and grooved joints.
2. Mechanical-joint, ductile-iron pipe; mechanical-joint, ductile- or gray-iron, standard-pattern or ductile-iron, compact-pattern fittings; glands, gaskets, and bolts; and gasketed joints.
3. Push-on-joint, ductile-iron pipe; push-on-joint, ductile-iron compact-pattern fittings; and gasketed joints.

4. PE, Class 150, Class 200, fire-service pipe; molded PE fittings; and heat-fusion joints.
5. PVC, Class 150, Class 200 pipe listed for fire-protection service; PVC fittings of same class as pipe; and gasketed joints.

D. Underground fire-suppression water-service piping NPS 6 to NPS 12 (DN 150 to DN 300), pipe size range shall be one of the following:

1. Grooved-end, ductile-iron pipe; grooved-end, ductile-iron pipe appurtenances; and grooved joints.
2. Mechanical-joint, ductile-iron pipe; mechanical-joint, ductile- or gray-iron, standard-pattern or ductile-iron, compact-pattern fittings; glands, gaskets, and bolts; and gasketed joints.
3. Push-on-joint, ductile-iron pipe; push-on-joint, ductile-iron compact-pattern fittings; and gasketed joints.
4. PE, Class 150, Class 200, fire-service pipe; molded PE fittings; and heat-fusion joints.
5. PVC, Class 150, Class 200 pipe listed for fire-protection service; PVC fittings of same class as pipe; and gasketed joints.

E. Aboveground and vault fire-suppression water-service piping NPS 2 (DN 50) and smaller, shall be hard copper tube, ASTM B88, Type K (ASTM B88M, Type A), ASTM B88, Type L (ASTM B88M, Type B); wrought- or cast-copper-alloy, solder-joint fittings; and brazed, copper, pressure-seal fittings; and pressure-sealed joints.

F. Aboveground and vault, fire-suppression water-service piping NPS 3 and NPS 4 (DN 80 and DN 100) shall be one of the following:

1. Grooved-end, ductile-iron pipe; grooved-end, ductile-iron pipe appurtenances; and grooved joints.

G. Aboveground and vault fire-suppression water-service piping NPS 5 to NPS 12 (DN 125 to DN 300) shall be grooved-end, ductile-iron pipe; grooved-end, ductile-iron pipe appurtenances; and grooved joints.

H. Underslab fire-suppression water-service piping NPS 2 (DN 50) and smaller, shall be soft copper tube, ASTM B88, Type K (ASTM B88M, Type A), ASTM B88, Type L (ASTM B88M, Type B); wrought-copper, solder-joint fittings; and brazed, copper, pressure-seal fittings; and pressure-sealed joints.

I. Underslab fire-suppression water-service piping NPS 3 and NPS 4 (DN 80 and DN 100) shall be one of the following:

1. Grooved-end, ductile-iron pipe; grooved-end, ductile-iron pipe appurtenances; and grooved joints.
2. Mechanical-joint, ductile-iron pipe; mechanical-joint, ductile- or gray-iron, standard-pattern or ductile-iron, compact-pattern fittings; glands, gaskets, and bolts; and restrained, gasketed joints.
3. Push-on-joint, ductile-iron pipe; push-on-joint, ductile-iron compact-pattern fittings; and restrained, gasketed joints.

J. Underslab fire-suppression water-service piping NPS 6 to NPS 12 (DN 150 to DN 300) shall be one of the following:

1. Grooved-end, ductile-iron pipe; grooved-end, ductile-iron pipe appurtenances; and grooved joints.
2. Mechanical-joint, ductile-iron pipe; mechanical-joint, ductile- or gray-iron, standard-pattern or ductile-iron, compact-pattern fittings; glands, gaskets, and bolts; and restrained, gasketed joints.
3. Push-on-joint, ductile-iron pipe; push-on-joint, ductile-iron compact-pattern fittings; and restrained, gasketed joints.

3.18 VALVE SCHEDULE

A. Underground fire-suppression water-service shutoff valves NPS 2 (DN 50) and smaller shall be corporation valves or curb valves with ends compatible with piping.

B. Meter box fire-suppression water-service shutoff valves NPS 2 (DN 50) and smaller shall be meter valves.

C. Vault fire-suppression water-service shutoff valves NPS 2 (DN 50) and smaller shall be Class 125, MSS, bronze, non-rising stem or UL-listed or FM Global-approved, OS&Y, bronze, gate valves.

D. Underground fire-suppression water-service shutoff valves NPS 3 (DN 80) and larger shall be one of the following:

1. 200-psig (1380-kPa), AWWA, iron, non-rising-stem, metal, resilient-seated gate valves.
2. 250-psig (1725-kPa), AWWA, iron, non-rising-stem, resilient-seated gate valves.
3. 175-psig (1200-kPa), 250-psig (1725-kPa), UL-listed or FM Global-approved, iron, non-rising-stem gate valves.

E. Indicator-post underground fire-suppression water-service valves NPS 3 (DN 80) and larger shall be 175-psig (1200-kPa), 250-psig (1725-kPa), UL-listed or FM Global-approved, iron, non-rising-stem gate valves with indicator-post flange.

F. Standard-pressure, aboveground and vault fire-suppression water-service shutoff valves NPS 3 (DN 80) and larger shall be one of the following:

1. 200-psig (1380-kPa), AWWA, iron, OS&Y, metal, resilient-seated gate valves.
2. 250-psig (1725-kPa), AWWA, iron, OS&Y, resilient-seated gate valves.
3. 175-psig (1200-kPa), 250-psig (1725-kPa), UL-listed or FM Global-approved, iron, OS&Y gate valves.
4. AWWA or UL-listed or FM Global-approved butterfly valves.

G. Fire-suppression water-service check valves NPS 3 (DN 80) and larger shall be one of the following:

1. AWWA or UL-listed or FM Global-approved check valves.
2. UL-listed or FM Global-approved detector check valves.

END OF SECTION 211100

SECTION 211116 - FACILITY FIRE HYDRANTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Dry-barrel fire hydrants.
2. Wet-barrel fire hydrants.

B. Related Requirements:

1. Section 211100 "Facility Fire-Suppression Water-Service Piping" for piping and specialties for facility fire-suppression water-service piping outside the building and for service entrance piping into the building at the floor slab or wall.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 CLOSEOUT SUBMITTALS

A. Maintenance Data: For fire hydrants to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 DRY-BARREL FIRE HYDRANTS

A. Description: Freestanding, with one NPS 4-1/2 (DN 115) and two NPS 2-1/2 (DN 65) outlets; and with 5-1/4-inch (133-mm) main valve, drain valve, and NPS 6 (DN 150) mechanical-joint inlet. Hydrant shall have cast-iron body and compression-type valve that opens against pressure and closes with pressure.

B. Standards: UL 246 and FM Global's "Approval Guide."

C. Design: Base valve.

D. Pressure Rating: As directed 150 psig (1035 kPa) minimum, 175 psig (1200 kPa) minimum, 200 psig (1380 kPa) minimum or 250 psig (1725 kPa).

E. Outlet Threads: NFPA 1963, with external hose thread used by local fire department. Include cast-iron caps with steel chains.

F. Operating and Cap Nuts: Pentagon, 1-1/2 inches (38 mm) point to flat.

G. Direction of Opening: Hydrant valve opens by turning operating nut to left or counterclockwise.

H. Exterior Finish: Red alkyd-gloss enamel paint unless otherwise indicated.

2.2 WET-BARREL FIRE HYDRANTS

A. Description: Freestanding, with one NPS 4-1/2 (DN 115) and two NPS 2-1/2 (DN 65) outlets; and with NPS 6 (DN 150) threaded or flanged inlet, and base section with NPS 6 (DN 150) mechanical-joint inlet.

B. Standards: UL 246 and FM Global's "Approval Guide."

C. Design: Wet barrel.

D. Pressure Rating: As directed 150 psig (1035 kPa) minimum, 175 psig (1200 kPa) minimum or 200 psig (1380 kPa).

E. Outlet Threads: NFPA 1963, with external hose thread used by local fire department. Include cast-iron caps with steel chains.

F. Operating and Cap Nuts: Pentagon, 1-1/2 inches (38 mm) point to flat.

G. Direction of Opening: Hydrant valves open by turning operating nut to left or counterclockwise.

H. Exterior Finish: Red alkyd-gloss enamel paint unless otherwise indicated.

PART 3 - EXECUTION

3.1 FIRE HYDRANT INSTALLATION

A. General: Install each fire hydrant with separate gate valve in supply pipe, anchor with restrained joints or thrust blocks, and support in upright position.

B. Wet-Barrel Fire Hydrants: Install with valve below the frost line. Provide for drainage.

C. Comply with NFPA 24.

END OF SECTION 211116

SECTION 211119 – FIRE DEPARTMENT CONNECTIONS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Exposed-type fire-department connections.
2. Flush-type fire-department connections.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles and finishes for each fire-department connection.

PART 2 - PRODUCTS

2.1 EXPOSED-TYPE FIRE-DEPARTMENT CONNECTION

A. Standard: UL 405.

B. Type: Exposed, projecting, for wall mounting.

C. Pressure Rating: 175 psig (1200 kPa) minimum.

D. Body Material: Corrosion-resistant metal.

E. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.

F. Caps: Brass, lugged type, with gasket and chain.

G. Escutcheon Plate: Round, brass, wall type.

H. Outlet: Back, with pipe threads.

I. Number of Inlets: As directed Two or Three.

J. Escutcheon Plate Marking: As directed Similar to "AUTO SPKR & STANDPIPE or STANDPIPE."

K. Finish: As directed Polished chrome plated, Rough brass or bronze or Rough chrome plated.

L. Outlet Size: As directed NPS 4 (DN 100), NPS 5 (DN 125) or NPS 6 (DN 150).

2.2 FLUSH-TYPE FIRE-DEPARTMENT CONNECTION

A. Standard: UL 405.

B. Type: Flush, for wall mounting.

C. Pressure Rating: 175 psig (1200 kPa) minimum.

D. Body Material: Corrosion-resistant metal.

E. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.

F. Caps: Brass, lugged type, with gasket and chain.

G. Escutcheon Plate: Rectangular, brass, wall type.

H. Outlet: With pipe threads.

I. Body Style: As directed Horizontal, Square or Vertical.

J. Number of Inlets: As directed Two, Three, Four or Six.

K. Outlet Location: As directed Back, Bottom, Left side, Right side or Top.

L. Escutcheon Plate Marking: As directed Similar to "AUTO SPKR & STANDPIPE or STANDPIPE."

M. Finish: As directed Polished chrome plated, Rough brass or bronze or Rough chrome plated.

N. Outlet Size: As directed NPS 4 (DN 100), NPS 5 (DN 125), NPS 6 (DN 150) or NPS 8 (DN 200).

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install wall-type fire-department connections.

B. Install automatic (ball-drip) drain valve at each check valve for fire-department connection.

END OF SECTION 211119

SECTION 211200 - FIRE-SUPPRESSION STANDPIPES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipes, fittings, and specialties.
2. Fire-protection specialty valves.
3. Hose connections.
4. Alarm devices.
5. Pressure gages.

B. Related Requirements:

1. Section 210523 "General-Duty Valves for Water-Based Fire-Suppression Piping."
2. Section 211119 "Fire-Department Connections" for exposed wall-mounted and yard fire hydrants.
3. Section 211213 "Fire-Suppression Hoses and Nozzles" for rack-type hose stations, reel-type hose stations, and monitors.
4. Section 211313 "Wet-Pipe Sprinkler Systems" for wet-pipe sprinkler piping.
5. Section 211316 "Dry-Pipe Sprinkler Systems" for dry-pipe sprinkler piping.
6. Section 284621.11 "Addressable Fire-Alarm Systems" or Section 284621.13 "Conventional Fire-Alarm Systems" for connections to alarm devices as directed.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For fire-suppression standpipes.

1. Include plans, elevations, sections, and attachment details.

C. Delegated-Design Submittal: For standpipe systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer and professional engineer.

B. Approved Standpipe Drawings: Working plans, prepared according to NFPA 14, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.

C. Fire-hydrant flow test report.

D. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 14. Include "Contractor's Material and Test Certificate for Aboveground Piping" and "Contractor's Material and Test Certificate for Underground Piping."

E. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installer's responsibilities include designing, fabricating, and installing fire-suppression standpipes and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.

a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.

B. NFPA Standards: Fire-suppression standpipe equipment, specialties, accessories, installation, and testing shall comply with NFPA 14.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTIONS

A. Automatic Wet-Type, Class II Standpipe System: Includes NPS 1-1/2 (DN 40) hose stations. Has open water-supply valve with pressure maintained and is capable of supplying water demand.

2.2 PERFORMANCE REQUIREMENTS

A. Standard-Pressure, Fire-Suppression Standpipe System Component: Listed for 175-psig (1200-kPa) minimum working pressure.

B. Delegated Design: Design fire-suppression standpipes, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

C. Fire-suppression standpipe design shall be approved by authorities having jurisdiction.

1. Minimum residual pressure at each hose-connection outlet is as follows:

a. NPS 1-1/2 (DN 40) Hose Connections: 65 psig (450 kPa).

b. NPS 2-1/2 (DN 65) Hose Connections: 100 psig (690 kPa).

D. Seismic Performance: Fire-suppression standpipes shall withstand the effects of earthquake motions determined according to NFPA 13 and ASCE/SEI 7.

2.3 BLACK STEEL PIPE AND ASSOCIATED FITTINGS

A. Schedule 40: ASTM A53/A53M, Type E, Grade B; with factory- or field-formed ends to accommodate joining method.

B. Schedule 40: ASTM A135/A135M, Grade A; with factory- or field-formed ends to accommodate joining method.

C. Schedule 40: ASTM A795/A795M, Type E, Grade A; with factory- or field-formed ends to accommodate joining method.

D. Schedule 30: ASTM A53/A53M, Type E, Grade B; with factory- or field-formed ends to accommodate joining method.

E. Schedule 30: ASTM A135/A135M, Grade A; with factory- or field-formed ends to accommodate joining method.

F. Schedule 30: ASTM A795/A795M, Type E, Grade A; with factory- or field-formed ends to accommodate joining method.

G. Thinwall: ASTM A53/A53M, Type E; with wall thickness less than Schedule 30 and equal to or greater than Schedule 10; and with factory- or field-formed ends to accommodate joining method.

H. Thinwall: ASTM A135/A135M, Grade A; with wall thickness less than Schedule 30 and equal to or greater than Schedule 10; and with factory- or field-formed ends to accommodate joining method.

I. Thinwall: ASTM A795/A795M, Type E, Grade A; with wall thickness less than Schedule 30 and equal to or greater than Schedule 10; and with factory- or field-formed ends to accommodate joining method.

J. Uncoated, Steel Couplings: ASTM A865/A865M, threaded.

K. Uncoated, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.

L. Malleable- or Ductile-Iron Unions: UL 860.

M. Cast-Iron Flanges: ASME B16.1, Class 125.

N. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.

O. Steel Welding Fittings: ASTM A234/A234M and ASME B16.9.

P. Grooved-Joint, Steel-Pipe Appurtenances:

1. Pressure Rating: As directed 175 psig (1200 kPa), 250 psig (1725 kPa) or 300 psig (2070 kPa) minimum.
2. Galvanized and Uncoated, Grooved-End Fittings for Steel Piping: ASTM A47/A47M, malleable-iron casting or ASTM A536, ductile-iron casting; with dimensions matching steel pipe.
3. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213, rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

2.4 GALVANIZED-STEEL PIPE AND ASSOCIATED FITTINGS

A. Schedule 40: ASTM A53/A53M, Type E, Grade B; with factory- or field-formed ends to accommodate joining method.

B. Schedule 40: ASTM A135/A135M, Grade A; with factory- or field-formed ends to accommodate joining method.

C. Schedule 40: ASTM A795/A795M, Type E, Grade A; with factory- or field-formed ends to accommodate joining method.

D. Galvanized-Steel Pipe Nipples: ASTM A733, made of ASTM A53/A53M or ASTM A106/A106M, Standard Weight, seamless steel pipe with threaded ends.

E. Galvanized, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.

F. Malleable-Iron Unions:

1. ASME B16.39, Class 150.
2. Hexagonal-stock body.
3. Ball-and-socket, metal-to-metal, bronze seating surface.
4. Threaded ends.

G. Flanges: ASME B16.1, Class 125, cast iron.

H. Appurtenances for Grooved-End, Galvanized-Steel Pipe:
1. Fittings for Grooved-End, Galvanized-Steel Pipe: Galvanized, ASTM A47/A47M, malleable-iron casting; ASTM A106/A106M, steel pipe; or ASTM A536, ductile-iron casting; with dimensions matching steel pipe.
2. Fittings for Grooved-End, Galvanized-Steel Pipe:

    a. AWWA C606 for steel-pipe dimensions.
    b. Ferrous housing sections.
    c. EPDM-rubber gaskets suitable for hot and cold water.
    d. Bolts and nuts.
    e. Minimum Pressure Rating:

        1) NPS 8 (DN 200) and Smaller: 600 psig (4137 kPa).
        2) NPS 10 and NPS 12 (DN 250 to DN 300): 400 psig (2758 kPa).
        3) NPS 14 to NPS 24 (DN 350 to DN 600): 250 psig (1725 kPa).

2.5 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick or ASME B16.21, nonmetallic and asbestos free.

1. Class 125, Cast-Iron Flanges and Class 150, Bronze Flat-Face Flanges: Full-face gaskets.
2. Class 250, Cast-Iron Flanges and Class 300, Steel Raised-Face Flanges: Ring-type gaskets.

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

C. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.6 SPECIALTY VALVES

A. General Requirements:

1. Standard: UL's "Fire Protection Equipment Directory" listing or FM Global's "Approval Guide."
2. Pressure Rating: 175 psig (1200 kPa) minimum.
3. Body Material: Cast or ductile iron.
4. Size: Same as connected piping.
5. End Connections: Flanged or grooved.

B. Alarm Valves:
1. Standard: UL 193.
2. Design: For horizontal or vertical installation.
3. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages, retarding chamber, and fill-line attachment with strainer.
4. Drip Cup Assembly: Pipe drain without valves and separate from main drain piping.
5. Drip Cup Assembly: Pipe drain with check valve to main drain piping.

C. Pressure-Reducing Valves:
1. UL 668 hose valve, with integral UL 1468 reducing device.
2. Pressure Rating: 300 psig (2070 kPa) minimum.
3. Material: Brass or bronze.
4. Inlet: Female pipe threads.
5. Outlet: Threaded with or without adapter having male hose threads.
6. Pattern: Angle or gate.
7. Finish: As directed Polished chrome-plated, Rough brass or bronze or Rough chrome-plated.

D. Automatic (Ball Drip) Drain Valves:
1. Standard: UL 1726.
2. Pressure Rating: 175 psig (1200 kPa) minimum.
3. Type: Automatic draining, ball check.
4. Size: NPS 3/4 (DN 20).
5. End Connections: Threaded.

2.7 HOSE CONNECTIONS

A. Nonadjustable-Valve Hose Connections:
   1. Standard: UL 668 hose valve for connecting fire hose.
   2. Pressure Rating: 300 psig (2070 kPa) minimum.
   3. Material: Brass or bronze.
   4. Size: NPS 1-1/2 (DN 40), as indicated.
   5. Inlet: Female pipe threads.
   6. Outlet: Male hose threads with lugged cap, gasket, and chain. Include hose valve threads according to NFPA 1963 and matching local fire-department threads.
   7. Pattern: Angle or gate.
   8. Finish: As directed Polished chrome-plated, Rough brass or bronze or Rough chrome-plated.

2.8 ALARM DEVICES

A. Alarm-device types shall match piping and equipment connections.

B. Water-Motor-Operated Alarm:
   1. Standard: UL 753.
   2. Type: Mechanically operated, with pelton wheel.
   3. Alarm Gong: Cast aluminum with red-enamel factory finish.
   4. Size: 10-inch (250-mm) diameter.
   5. Components: Shaft length, bearings, and sleeve to suit wall construction.
   6. Inlet: NPS 3/4 (DN 20).
   7. Outlet: NPS 1 (DN 25) drain connection.

C. Electrically Operated Alarm Bell:
   1. Standard: UL 464.
   2. Type: Vibrating, metal alarm bell.
   3. Size: As directed 6-inch (150-mm) minimum, 8-inch (200-mm) minimum or 10-inch (250-mm) diameter.
   4. Finish: Red-enamel factory finish, suitable for outdoor use.

D. Water-Flow Indicators:
   1. Standard: UL 346.
   2. Water-Flow Detector: Electrically supervised.
   3. Components: Two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.
   4. Type: Paddle operated.
   5. Pressure Rating: 250 psig (1725 kPa).
   6. Design Installation: Horizontal or vertical.

E. Pressure Switches:
   1. Standard: UL 346.
   2. Type: Electrically supervised water-flow switch with retard feature.
   3. Components: Single-pole, double-throw switch with normally closed contacts.
   4. Design Operation: Rising pressure signals water flow.

F. Valve Supervisory Switches:
   1. Standard: UL 346.
   2. Type: Electrically supervised.
   3. Components: Single-pole, double-throw switch with normally closed contacts.
   4. Design: Signals that controlled valve is in other than fully open position.

G. Indicator-Post Supervisory Switches:
   1. Standard: UL 346.
   2. Type: Electrically supervised.
   3. Components: Single-pole, double-throw switch with normally closed contacts.
   4. Design: Signals that controlled indicator-post valve is in other than fully open position.

2.9 PRESSURE GAGES

A. Standard: UL 393.

B. Dial Size: 3-1/2- to 4-1/2-inch (90- to 115-mm) diameter.

C. Pressure Gage Range: As directed Zero to 250 psig (Zero to 1725 kPa) minimum or Zero to 300 psig (Zero to 2070 kPa).

D. Water System Piping Gage: Include "WATER" or "AIR/WATER" label on dial face.

E. Air System Piping Gage: Include retard feature and "AIR" or "AIR/WATER" label on dial face.

PART 3 - EXECUTION

3.1 PREPARATION

A. Perform fire-hydrant flow test according to NFPA 14 and NFPA 291. Use results for system design calculations required in "Quality Assurance" Article.

B. Report test results promptly and in writing.

3.2 SERVICE-ENTRANCE PIPING

A. Connect fire-suppression standpipe piping to water-service piping at service entrance into building. Comply with requirements for exterior piping in Section 211100 "Facility Fire-Suppression Water-Service Piping."

B. Install shutoff valve, backflow preventer, pressure gage, drain, and other accessories at connection to fire-suppression water-service piping. Comply with requirements for backflow preventers in Section 211100 "Facility Fire-Suppression Water-Service Piping."

C. Install shutoff valve, check valve, pressure gage, and drain at connection to water service.

3.3 WATER-SUPPLY CONNECTIONS

A. Connect fire-suppression standpipe piping to building's interior water-distribution piping. Comply with requirements for interior piping in Section 221116 "Domestic Water Piping."

B. Install shutoff valve, backflow preventer, pressure gage, drain, and other accessories at connection to water-distribution piping. Comply with requirements for backflow preventers in Section 221119 "Domestic Water Piping Specialties."

C. Install shutoff valve, check valve, pressure gage, and drain at connection to water supply.

3.4 PIPING INSTALLATION

A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.

1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.

B. Piping Standard: Comply with requirements in NFPA 14 for installation of fire-suppression standpipe piping.

C. Install seismic restraints on piping. Comply with requirements in NFPA 13 for seismic-restraint device materials and installation.

D. Install listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

E. Install drain valves on standpipes. Extend drain piping to outside of building.

F. Install automatic (ball drip) drain valves to drain piping between fire-department connections and check valves. Drain to floor drain or outside building.

G. Install alarm devices in piping systems.

H. Install hangers and supports for standpipe system piping according to NFPA 14. Comply with requirements in NFPA 13 for hanger materials.

I. Install pressure gages on riser or feed main and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 (DN 8) and with soft-metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal and install where they are not subject to freezing.

J. Fill standpipe system piping with water.

K. Install electric heating cables and pipe insulation on wet-type fire-suppression standpipe piping in areas subject to freezing. Comply with requirements for heating cables in Section 210533 "Heat Tracing for Fire-Suppression Piping" and for piping insulation in Section 210700 "Fire-Suppression Systems Insulation."

L. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."

M. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."

N. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 210518 "Escutcheons for Fire-Suppression Piping."

3.5 JOINT CONSTRUCTION

A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.

B. Install unions adjacent to each valve in pipes NPS 2 (DN 50) and smaller.

C. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 (DN 65) and larger end connections.

D. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

E. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

F. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.

G. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

H. Steel-Piping, Cut-Grooved Joints: Cut square-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe joints.

I. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.

J. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to "Quality Assurance" Article.

1. Shop weld pipe joints where welded piping is indicated. Do not use welded joints for galvanized-steel pipe.

3.6 VALVE AND SPECIALTIES INSTALLATION

A. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 14 and authorities having jurisdiction.

B. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.

C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

D. Specialty Valves:

1. General Requirements: Install in vertical position for proper direction of flow, in main supply to system.
2. Alarm Valves: Install bypass check valve and retarding chamber drain-line connection.

3.7 HOSE-CONNECTION INSTALLATION

A. Install hose connections adjacent to standpipes.

B. Install freestanding hose connections for access and minimum passage restriction.

C. Install NPS 1-1/2 (DN 40) hose-connection valves with flow-restricting device.

D. Install wall-mounted-type hose connections in cabinets. Include pipe escutcheons, with finish matching valves, inside cabinet where water-supply piping penetrates cabinet. Install valves at angle required for connection of fire hose. Comply with requirements for cabinets in Section 104413 "Fire Protection Cabinets."

3.8 HOSE-STATION INSTALLATION

A. Install freestanding hose stations for access and minimum passage restriction.

B. Install NPS 1-1/2 (DN 40) hose-station valves with flow-restricting device unless otherwise indicated.

C. Install freestanding hose stations with support or bracket attached to standpipe.

D. Install wall-mounted, rack hose stations in cabinets. Include pipe escutcheons, with finish matching valves, inside cabinet where water-supply piping penetrates cabinet. Install valves at angle required for connection of fire hose. Comply with requirements for cabinets in Section 104413 "Fire Protection Cabinets."

E. Install hose-reel hose stations on wall with bracket.

3.9 FIRE-DEPARTMENT CONNECTION INSTALLATION

A. Install wall-type fire-department connections.

B. Install yard-type fire-department connections in concrete slab support. Comply with requirements for concrete in Section 033000 "Cast-in-Place Concrete."

1. As directed Install two or three protective pipe bollards around or on sides of each fire-department connection. Comply with requirements for bollards in Section 055000 "Metal Fabrications."

C. Install automatic (ball drip) drain valve at each check valve for fire-department connection.

3.10 IDENTIFICATION

A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 14.

B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.11 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Flush, test, and inspect standpipe systems according to NFPA 14, "System Acceptance" Chapter.
4. Energize circuits to electrical equipment and devices.
5. Start and run air compressors.
6. Coordinate with fire-alarm tests. Operate as required.
7. Coordinate with fire-pump tests. Operate as required.
8. Verify that equipment hose threads are same as local fire-department equipment.

C. Fire-suppression standpipe system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.12 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain specialty valves.

3.13 PIPING SCHEDULE

A. Piping between Fire-Department Connections and Check Valves: Galvanized, Schedule 40, steel pipe with threaded ends; cast-iron threaded fittings; and threaded or grooved ends; grooved-end fittings; grooved-end-pipe couplings; and grooved joints as directed.

B. Wet-type fire-suppression standpipe piping, NPS 4 (DN 100) and smaller, shall be one of the following:

1. Schedule 40 or Schedule 30, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
2. Schedule 40 or Schedule 30, black-steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
3. Schedule 40 or Schedule 30, black-steel pipe with plain ends; steel welding fittings; and welded joints.
4. Thinwall black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
5. Thinwall black-steel pipe with plain ends; welding fittings; and welded joints.

C. Standard-pressure, wet-type fire-suppression standpipe piping, NPS 5 to NPS 8 (DN 125 to DN 200), shall be one of the following:

1. As directed Schedule 40, Schedule 30 or thinwall, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
2. Schedule 40 or Schedule 30, black-steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
3. Schedule 40 or Schedule 30, black-steel pipe with plain ends; steel welding fittings; and welded joints.
4. Thinwall black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
5. Thinwall black-steel pipe with plain ends; welding fittings; and welded joints.

D. Standard-pressure, wet-type fire-suppression standpipe piping, NPS 10 and NPS 12 (DN 250 and DN 300), shall be one of the following:

1. Schedule 40 or Schedule 30, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
2. Schedule 40 or Schedule 30, black-steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
3. Schedule 40 or Schedule 30, black-steel pipe with plain ends; steel welding fittings; and welded joints.
4. Thinwall black-steel pipe with plain ends; welding fittings; and welded joints.

END OF SECTION 211200

SECTION 211213 - FIRE-SUPPRESSION HOSES AND NOZZLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. NPS 1-1/2 (DN 40) rack-type hose stations.
2. NPS 1-1/2 (DN 40) reel-type hose stations.

B. Related Requirements:

1. Section 104413 "Fire Protection Cabinets" for hose cabinets.
2. Section 211200 "Fire-Suppression Standpipes" for fire hose valves.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting and attachment details.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 NPS 1-1/2 (DN 40) RACK-TYPE HOSE STATIONS

A. Hose Rack:

1. Standard: UL 47.
2. Material: As directed Brass or bronze with polished chrome-plated or Steel with red-enamel finish.
3. Type: Hose-rack assembly. Include hose valve, hose rack, water-retention device, hose pins, and hose.
4. Operation: Semiautomatic.
5. Sized to hold fire hose.

B. Hose Valve:

1. Standard: UL 668, NPS 1-1/2 (DN 40), for connecting fire hose.

2. Type: As directed Adjustable or Nonadjustable.
3. Pressure-Control Device: As directed, Not required, Pressure reducing, Pressure reducing or pressure restricting or Pressure restricting.
4. Design Outlet Pressure Setting: Not applicable.
5. Hose Valve and Trim Finish: As directed Polished chrome-plated, Rough brass or bronze or Rough chrome-plated.
6. Pressure Rating: 300 psig (2070 kPa) minimum.
7. Pattern: Angle.
8. Material: Brass or bronze.
9. Pressure-Control Device: UL 1468 integral or for field installation if indicated.
10. Size: NPS 1-1/2 (DN 40).
11. Inlet: Female pipe threads.
12. Outlet: Male hose threads according to NFPA 1963 and matching local fire-department threads.

C. Hose:

1. Standards: NFPA 1961 and UL 219 lined fire hose with swivel inlet, coupling, gaskets, and nozzle.
2. Size: NPS 1-1/2 (DN 40).
3. Length: As directed ,50 feet (15 m), 75 feet (23 m) or 100 feet (30 m).
4. Jacket: As directed, Combination of natural and synthetic threads, Natural thread or Synthetic thread.
5. Lining: As directed, Rubber, plastic, or combination of rubber and plastic compounds, Combination of rubber and plastic compounds, Rubber compound or Plastic compound.
6. Cover: Rubber, plastic, or combination of rubber and plastic compounds.
7. Nozzle: UL 401.

    a. Material: As directed, Brass, Polished brass, Rough chrome-plated brass, Polished chrome-plated brass or Polycarbonate plastic.
    b. Type: As directed, Plain, for nonadjustable water stream, Spray, adjustable from shutoff to fog spray or straight stream or Spray, adjustable from shutoff to full fog; for use on electrical fires.

2.2 NPS 1-1/2 (DN 40) REEL-TYPE HOSE STATIONS

A. Hose Reel:

1. Standard: UL 47.
2. Hose Reel and Bracket Material: Steel.
3. Type: Hose-reel assembly. Include hose valve, wall bracket, hose reel, water-retention device, hose pins, and hose.
4. Operation: Semiautomatic.
5. Sized to hold fire hose.
6. Finish: Red enamel.

B. Hose Valve:

1. Standard: UL 668, NPS 1-1/2 (DN 40), for connecting fire hose.
2. Type: As directed, Adjustable or Nonadjustable.

3. Pressure-Control Device: As directed, Not required, Pressure reducing, Pressure reducing or pressure restricting or Pressure restricting.
4. Design Outlet Pressure Setting: Not applicable.
5. Hose Valve and Trim Finish: As directed, Polished chrome-plated, Rough brass or bronze or Rough chrome-plated.
6. Pressure Rating: 300 psig (2070 kPa) minimum.
7. Pattern: Angle.
8. Material: Brass or bronze.
9. Pressure-Control Device: UL 1468, integral or for field installation if indicated.
10. Size: NPS 1-1/2 (DN 40).
11. Inlet: Female pipe threads.
12. Outlet: Male hose threads according to NFPA 1963 and matching local fire-department threads.

C. Hose:

1. Standards: NFPA 1961 and UL 219 lined fire hose with swivel inlet, coupling, gaskets, and nozzle.
2. Size: NPS 1-1/2 (DN 40).
3. Length: As directed, 50 feet (15 m), 75 feet (23 m) or 100 feet (30 m).
4. Jacket: As directed, Combination of natural and synthetic threads, Natural thread or Synthetic thread.
5. Lining: As directed, Rubber, plastic, or combination of rubber and plastic compounds, Combination of rubber and plastic compounds, Rubber compound or Plastic compound.
6. Cover: Rubber, plastic, or combination of rubber and plastic compounds.
7. Nozzle: UL 401.

a. Material: As directed, Brass, Polished brass, Rough chrome-plated brass, Polished chrome-plated brass or Polycarbonate plastic.
b. Type: Spray, adjustable from shutoff to fog spray or straight stream or full fog; for use on electrical fires as directed.

PART 3 - EXECUTION

3.1 HOSE-STATION INSTALLATION

A. Install freestanding hose stations for access and minimum passage restriction.

B. Install NPS 1-1/2 (DN 40) hose-station valves with flow-restricting device unless otherwise indicated.

C. Install freestanding hose stations with support or bracket attached to standpipe.

D. Install wall-mounted, rack hose stations in cabinets. Include pipe escutcheons, with finish matching valves, inside cabinet where water-supply piping penetrates cabinet. Install valves at angle required for connection of fire hose. Comply with requirements for cabinets in Section 104413 "Fire Protection Cabinets."

E. Install hose-reel hose stations on wall with bracket.

END OF SECTION 211213

SECTION 211313 - WET-PIPE SPRINKLER SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipes, fittings, and specialties.
2. Cover system for sprinkler piping.
3. Specialty valves.
4. Sprinklers.
5. Manual control stations.
6. Pressure gages.

B. Related Requirements:

1. Section 211119 "Fire Department Connections" for exposed-, flush-, and yard-type fire department connections.
2. Section 230523 "General-Duty Valves for Water-Based Fire-Suppression Piping" for ball, butterfly, check, gate, post-indicator, and trim and drain valves.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

C. Shop Drawings: For wet-pipe sprinkler systems.

1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power, signal, and control wiring.

D. Delegated-Design Submittal: For wet-pipe sprinkler systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Sprinkler systems, drawn to scale, on which items of other systems and equipment are shown and coordinated with each other, using input from installers of the items involved.

B. Qualification Data: For qualified Installer and professional engineer.

C. Design Data:

1. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.

D. Field Test Reports: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping."

E. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installer's responsibilities include designing, fabricating, and installing sprinkler systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.

a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Sprinkler system equipment, specialties, accessories, installation, and testing shall comply with the following:

1. NFPA 13.
2. NFPA 13R.

B. Standard-Pressure Piping System Component: Listed for 175-psig (1200-kPa) minimum working pressure.

C. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design wet-pipe sprinkler systems.

1. Available fire-hydrant flow test records indicate the following conditions:

a. Date: As directed.
b. Time: As directed a.m. or p.m.
c. Performed by: As directed.
d. Location of Residual Fire Hydrant R: As directed.
e. Location of Flow Fire Hydrant F: As directed.

f. Static Pressure at Residual Fire Hydrant R: As directed.
g. Measured Flow at Flow Fire Hydrant F: As directed.
h. Residual Pressure at Residual Fire Hydrant R: As directed.

2. Sprinkler system design shall be approved by authorities having jurisdiction.

a. Margin of Safety for Available Water Flow and Pressure: As directed 10 or 20 percent, including losses through water-service piping, valves, and backflow preventers.
b. Sprinkler Occupancy Hazard Classifications:

1) Automobile Parking Areas: Ordinary Hazard, Group 1.
2) Building Service Areas: Ordinary Hazard, Group 1.
3) Churches: Light Hazard.
4) Electrical Equipment Rooms: Ordinary Hazard, Group 1.
5) Dry Cleaners: Ordinary Hazard, Group 2.
6) General Storage Areas: Ordinary Hazard, Group 1.
7) Laundries: Ordinary Hazard, Group 1.
8) Libraries except Stack Areas: Light Hazard.
9) Library Stack Areas: Ordinary Hazard, Group 2.
10) Machine Shops: Ordinary Hazard, Group 2.
11) Mechanical Equipment Rooms: Ordinary Hazard, Group 1.
12) Office and Public Areas: Light Hazard.
13) Plastics Processing Areas: Extra Hazard, Group 2.
14) Printing Plants: Extra Hazard, Group 1.
15) Repair Garages: Ordinary Hazard, Group 2.
16) Residential Living Areas: Light Hazard.
17) Restaurant Service Areas: Ordinary Hazard, Group 1.
18) Solvent Cleaning Areas: Extra Hazard, Group 2.
19) Upholstering Plants: Extra Hazard, Group 1
20) .

3. Minimum Density for Automatic-Sprinkler Piping Design:

a. Residential (Dwelling) Occupancy: 0.05 gpm over 400-sq. ft. (2.04 mm/min. over 37.2-sq. m) area.
b. Light-Hazard Occupancy: 0.10 gpm over 1500-sq. ft. (4.1 mm/min. over 139-sq. m) area.
c. Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm over 1500-sq. ft. (6.1 mm/min. over 139-sq. m) area.
d. Ordinary-Hazard, Group 2 Occupancy: 0.20 gpm over 1500-sq. ft. (8.1 mm/min. over 139-sq. m) area.

4. Maximum Protection Area per Sprinkler: According to UL listing.
5. Maximum Protection Area per Sprinkler:

a. Residential Areas: 400 sq. ft. (37 sq. m).
b. Office Spaces: As directed,120 sq. ft. (11.1 sq. m) or 225 sq. ft. (20.9 sq. m).
c. Storage Areas: 130 sq. ft. (12.1 sq. m).
d. Mechanical Equipment Rooms: 130 sq. ft. (12.1 sq. m).
e. Electrical Equipment Rooms: 130 sq. ft. (12.1 sq. m).

f. Other Areas: According to NFPA 13 recommendations unless otherwise indicated.

D. Seismic Performance: Sprinkler piping shall withstand the effects of earthquake motions determined according to NFPA 13 and ASCE/SEI 7.

2.2 STEEL PIPE AND FITTINGS

A. Standard-Weight, Galvanized- and Black-Steel Pipe: ASTM A53/A53M, Type E or Grade B as directed. Pipe ends may be factory or field formed to match joining method.

B. Schedule 30, Galvanized- and Black-Steel Pipe: ASTM A135/A135M; ASTM A795/A795M, Type E; or ASME B36.10M wrought steel, with wall thickness not less than Schedule 30 and not more than Schedule 40. Pipe ends may be factory or field formed to match joining method.

C. Thinwall Galvanized- and Black-Steel Pipe: ASTM A135/A135M or ASTM A795/A795M, threadable, with wall thickness less than Schedule 30 and equal to or greater than Schedule 10. Pipe ends may be factory or field formed to match joining method.

D. Schedule 10, Black-Steel Pipe: ASTM A135/A135M or ASTM A795/A795M, Schedule 10 in NPS 5 (DN 125) and smaller; and NFPA 13-specified wall thickness in NPS 6 to NPS 10 (DN 150 to DN 250), plain end.

E. Nonstandard OD, Thinwall Black-Steel Pipe: ASTM A135/A135M or ASTM A795/A795M thinwall with plain ends and wall thickness less than Schedule 10.

F. Hybrid Black-Steel Pipe: ASTM A135/A135M or ASTM A795/A795M lightwall, with wall thickness less than Schedule 10 and greater than Schedule 5.

G. Schedule 5 Steel Pipe: ASTM A135/A135M or ASTM A795/A795M lightwall with plain ends.

H. Galvanized- and Black-Steel Pipe Nipples: ASTM A733, made of ASTM A53/A53M, standard-weight, seamless steel pipe with threaded ends.

I. Galvanized- and Uncoated-Steel Couplings: ASTM A865/A865M, threaded.

J. Galvanized and Uncoated, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.

K. Malleable- or Ductile-Iron Unions: UL 860.

L. Cast-Iron Flanges: ASME 16.1, Class 125.

M. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.

1. Pipe-Flange Gasket Materials: As directed AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick, ASME B16.21, nonmetallic and asbestos free or EPDM rubber gasket.

a. Class 125 and Class 250, Cast-Iron, Flat-Face Flanges: Full-face gaskets.
b. Class 150 and Class 300, Ductile-Iron or -Steel, Raised-Face Flanges: Ring-type gaskets.

N. Grooved-Joint, Steel-Pipe Appurtenances:
   1. Pressure Rating: As directed 175-psig (1200-kPa), 250-psig (1725-kPa) or 300-psig (2070-kPa) minimum.
   2. As directed Galvanized, Painted or Uncoated Grooved-End Fittings for Steel Piping: ASTM A47/A47M, malleable-iron casting or ASTM A536, ductile-iron casting, with dimensions matching steel pipe.
   3. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213 rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

O. Steel Pressure-Seal Fittings: UL 213, FM Global-approved, 175-psig (1200-kPa) pressure rating with steel housing, rubber O-rings, and pipe stop; for use with fitting manufacturers' pressure-seal tools.

2.3 CPVC PIPE AND FITTINGS

A. CPVC Pipe: ASTM F442/F442M and UL 1821, SDR 13.5, for 175-psig (1200-kPa) rated pressure at 150 deg F (62 deg C), with plain ends. Include "LISTED" and "CPVC SPRINKLER PIPE" markings.

B. CPVC Fittings: UL listed or FM Global approved, for 175-psig (1200-kPa) rated pressure at 150 deg F (62 deg C), socket type. Include "LISTED" and "CPVC SPRINKLER FITTING" markings.

   1. NPS 3/4 to NPS 1-1/2 (DN 20 to DN 40): ASTM F438 and UL 1821, Schedule 40, socket type.
   2. NPS 2 to NPS 3 (DN 50 to DN 80): ASTM F439 and UL 1821, Schedule 80, socket type.
   3. CPVC-to-Metal Transition Fittings: CPVC, one piece, with dimensions equivalent to pipe; one end with threaded brass insert, and one socket end.
   4. CPVC-to-Metal Transition Unions: CPVC, with dimensions equivalent to pipe; one end with threaded brass insert, and one socket end.
   5. Flanges: CPVC, one or two pieces.

C. Solvent Cements for Joining CPVC Piping and Tubing: ASTM F493 solvent cement recommended by pipe and fitting manufacturer and made for joining CPVC sprinkler pipe and fittings. Include cleaner or primer recommended by pipe and fitting manufacturer.

D. Plastic Pipe-Flange Gasket and Bolts and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

2.4 COVER SYSTEM FOR SPRINKLER PIPING

A. Description: System of support brackets and covers made to protect sprinkler piping.

B. Brackets: Glass-reinforced nylon.

C. Covers: Extruded-PVC sections of length, shape, and size required for size and routing of CPVC piping.

2.5 SPECIALTY VALVES

A. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."

B. Specialty Valves Pressure Rating: 175-psig (1200-kPa) minimum.

C. Body Material: Cast or ductile iron.

D. Size: Same as connected piping.

E. End Connections: Flanged or grooved.

F. Alarm Valves:
1. Standard: UL 193.
2. Design: For horizontal or vertical installation.
3. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages, retarding chamber, and fill-line attachment with strainer.
4. Drip Cup Assembly: Pipe drain without valves and separate from main drain piping.
5. Drip Cup Assembly: Pipe drain with check valve to main drain piping.

G. Automatic (Ball Drip) Drain Valves:
1. Standard: UL 1726.
2. Pressure Rating: 175-psig (1200-kPa) minimum.
3. Type: Automatic draining, ball check.
4. Size: NPS 3/4 (DN 20).
5. End Connections: Threaded.

2.6 SPRINKLER PIPING SPECIALTIES

A. Branch Outlet Fittings:
1. Standard: UL 213.
2. Pressure Rating: As directed, 175-psig (1200-kPa) minimum or 300 psig (2070 kPa).
3. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
4. Type: Mechanical-tee and -cross fittings.
5. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
6. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
7. Branch Outlets: Grooved, plain-end pipe, or threaded.

B. Flow Detection and Test Assemblies:
1. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
2. Pressure Rating: As directed, 175-psig (1200-kPa) minimum or 300 psig (2070 kPa).
3. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
4. Size: Same as connected piping.
5. Inlet and Outlet: Threaded or grooved.

C. Branch Line Testers:
1. Standard: UL 199.

2. Pressure Rating: 175 psig (1200 kPa).
3. Body Material: Brass.
4. Size: Same as connected piping.
5. Inlet: Threaded.
6. Drain Outlet: Threaded and capped.
7. Branch Outlet: Threaded, for sprinkler.

D. Sprinkler Inspector's Test Fittings:
1. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
2. Pressure Rating: As directed, 175-psig (1200-kPa) minimum or 300 psig (2070 kPa).
3. Body Material: Cast- or ductile-iron housing with sight glass.
4. Size: Same as connected piping.
5. Inlet and Outlet: Threaded.

E. Adjustable Drop Nipples:
1. Standard: UL 1474.
2. Pressure Rating: As directed ,250-psig (1725-kPa) minimum or 300 psig (2070 kPa).
3. Body Material: Steel pipe with EPDM-rubber O-ring seals.
4. Size: Same as connected piping.
5. Length: Adjustable.
6. Inlet and Outlet: Threaded.

F. Flexible Sprinkler Hose Fittings:
1. Standard: UL 1474.
2. Type: Flexible hose for connection to sprinkler, and with bracket for connection to ceiling grid.
3. Pressure Rating: As directed, 175-psig (1200-kPa) minimum or 300 psig (2070 kPa).
4. Size: Same as connected piping, for sprinkler.

2.7 SPRINKLERS

A. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."

B. Pressure Rating for Residential Sprinklers: 175-psig (1200-kPa) maximum.

C. Pressure Rating for Automatic Sprinklers: 175-psig (1200-kPa) minimum.

D. Automatic Sprinklers with Heat-Responsive Element:

1. Early-Suppression, Fast-Response Applications: UL 1767.
2. Nonresidential Applications: UL 199.
3. Residential Applications: UL 1626.
4. Characteristics: Nominal 1/2-inch (12.7-mm) orifice with Discharge Coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.

E. Sprinkler Finishes: As directed, Chrome plated, bronze and painted.

F. Special Coatings: As directed, Wax, lead and corrosion-resistant paint.

G. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.

1. Ceiling Mounting: As directed, Chrome-plated steel, one piece, flat, Chrome-plated steel, two piece, with 1-inch (25-mm) vertical adjustment or Plastic, white finish, one piece, flat.
2. Sidewall Mounting: Chrome-plated steel or Plastic, white finish, one piece, flat.

H. Sprinkler Guards:
1. Standard: UL 199.
2. Type: Wire cage with fastening device for attaching to sprinkler.

2.8 MANUAL CONTROL STATIONS

A. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide" for hydraulic operation, with union, NPS 1/2 (DN 15) pipe nipple, and bronze ball valve.

B. Include metal enclosure labeled "MANUAL CONTROL STATION," with operating instructions and cover held closed by breakable strut to prevent accidental opening.

2.9 PRESSURE GAGES

A. Standard: UL 393.

B. Dial Size: 3-1/2- to 4-1/2-inch (90- to 115-mm) diameter.

C. Pressure Gage Range: As directed 0- to 250-psig (0- to 1725-kPa) minimum or 0 to 300 psig (0 to 2070 kPa).

D. Label: Include "WATER" label on dial face.

PART 3 - EXECUTION

3.1 SERVICE-ENTRANCE PIPING

A. Connect sprinkler piping to water-service piping for service entrance to building. Comply with requirements for exterior piping in Section 211100 "Facility Fire-Suppression Water-Service Piping" for exterior piping.

B. Install shutoff valve, backflow preventer, pressure gage, drain, and other accessories indicated at connection to water-service piping. Comply with requirements for backflow preventers in Section 211100 "Facility Fire-Suppression Water-Service Piping."

C. Install shutoff valve, check valve, pressure gage, and drain at connection to water service.

3.2 WATER-SUPPLY CONNECTIONS

A. Connect sprinkler piping to building's interior water-distribution piping. Comply with requirements for interior piping in Section 221116 "Domestic Water Piping."

B. Install shutoff valve, backflow preventer, pressure gage, drain, and other accessories indicated at connection to water-distribution piping. Comply with requirements for backflow preventers in Section 221119 "Domestic Water Piping Specialties."

C. Install shutoff valve, check valve, pressure gage, and drain at connection to water supply.

3.3 PIPING INSTALLATION

A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated on approved working plans.

1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.
2. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.

B. Piping Standard: Comply with NFPA 13 requirements for installation of sprinkler piping.

C. Install seismic restraints on piping. Comply with NFPA 13 requirements for seismic-restraint device materials and installation.

D. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

E. Install unions adjacent to each valve in pipes NPS 2 (DN 50) and smaller.

F. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 (DN 65) and larger end connections.

G. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, and sized and located according to NFPA 13.

H. Install sprinkler piping with drains for complete system drainage.

I. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.

J. Install automatic (ball drip) drain valve at each check valve for fire-department connection, to drain piping between fire-department connection and check valve. Install drain piping to and spill over floor drain or to outside building.

K. Install alarm devices in piping systems.

L. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements for hanger materials in NFPA 13. In seismic-rated areas, refer to Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."

M. Install pressure gages on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 (DN 8) and with soft-metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal and install where they are not subject to freezing.

N. Pressurize and check pre-action sprinkler system piping and air-pressure maintenance devices or air compressors as directed.

O. Fill sprinkler system piping with water.

P. Install electric heating cables and pipe insulation on sprinkler piping in areas subject to freezing. Comply with requirements for heating cables in Section 210533 "Heat Tracing for Fire-Suppression Piping" and for piping insulation in Section 210700 "Fire-Suppression Systems Insulation."

Q. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."

R. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."

S. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 210518 "Escutcheons for Fire-Suppression Piping."

3.4 JOINT CONSTRUCTION

A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.

B. Install unions adjacent to each valve in pipes NPS 2 (DN 50) and smaller.

C. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 (DN 65) and larger end connections.

D. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

E. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

F. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.

G. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

H. Twist-Locked Joints: Insert plain end of steel pipe into plain-end-pipe fitting. Rotate retainer lugs one-quarter turn or tighten retainer pin.

I. Steel-Piping, Pressure-Sealed Joints: Join lightwall steel pipe and steel pressure-seal fittings with tools recommended by fitting manufacturer.

J. Steel-Piping, Cut-Grooved Joints: Cut square-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe joints.

K. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.

L. Steel-Piping, Pressure-Sealed Joints: Join Schedule 5 steel pipe and steel pressure-seal fittings with tools recommended by fitting manufacturer.

M. Extruded-Tee Connections: Form tee in copper tube according to ASTM F2014. Use tool designed for copper tube; drill pilot hole, form collar for outlet, dimple tube to form seating stop, and braze branch tube into collar.

N. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

O. Plastic-Piping, Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements. Apply primer.
2. CPVC Piping: Join according to ASTM D2846/D2846M Appendix.

3.5 INSTALLATION OF COVER SYSTEM FOR SPRINKLER PIPING

A. Install cover system, brackets, and cover components for sprinkler piping according to manufacturer's "Installation Manual" and NFPA 13 or NFPA 13R for supports.

3.6 VALVE AND SPECIALTIES INSTALLATION

A. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 13 and authorities having jurisdiction.

B. Install listed fire-protection shutoff valves supervised open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.

C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

D. Specialty Valves:

1. Install valves in vertical position for proper direction of flow, in main supply to system.
2. Install alarm valves with bypass check valve and retarding chamber drain-line connection.
3. Install deluge valves in vertical position, in proper direction of flow, and in main supply to deluge system. Install trim sets for drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.

3.7 SPRINKLER INSTALLATION

A. Install sprinklers in suspended ceilings in center of narrow dimension of acoustical ceiling panels.

B. Install dry-type sprinklers with water supply from heated space. Do not install pendent or sidewall, wet-type sprinklers in areas subject to freezing.

C. Install sprinklers into flexible, sprinkler hose fittings, and install hose into bracket on ceiling grid.

3.8 IDENTIFICATION

A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13.

B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.9 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
4. Energize circuits to electrical equipment and devices.
5. Coordinate with fire-alarm tests. Operate as required.
6. Coordinate with fire-pump tests. Operate as required.

7. Verify that equipment hose threads are same as local fire department equipment.

B. Sprinkler piping system will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.10 CLEANING

A. Clean dirt and debris from sprinklers.

B. Only sprinklers with their original factory finish are acceptable. Remove and replace any sprinklers that are painted or have any other finish than their original factory finish.

3.11 PIPING SCHEDULE

A. Piping between Fire Department Connections and Check Valves: Galvanized, standard-weight steel pipe with threaded ends, cast-iron threaded fittings, and threaded, grooved ends, grooved-end fittings, grooved-end-pipe couplings, and grooved joints as directed.

B. Sprinkler specialty fittings may be used, downstream of control valves, instead of specified fittings.

C. As directed CPVC pipe, Schedule 40 or Schedule 80 CPVC fittings, and solvent-cemented joints may be used for light-hazard and residential occupancies.

D. Standard-pressure, wet-pipe sprinkler system, NPS 2 (DN 50) and smaller, shall be one of the following:

1. Standard-weight or Schedule 30, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
   Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
2. Standard-weight or Schedule 30, black-steel pipe with plain ends; uncoated, plain-end-pipe fittings; and twist-locked joints.
3. Standard-weight or Schedule 30, galvanized-steel pipe with plain ends; galvanized, plain-end-pipe fittings; and twist-locked joints.
4. Standard-weight or Schedule 30, black-steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
5. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
6. As directed Thinwall, Schedule 10, nonstandard OD, thinwall or hybrid black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
7. As directed Thinwall, Schedule 10 or hybrid black-steel pipe with plain ends; uncoated, plain-end-pipe fittings; and twist-locked joints.
8. Schedule 5 steel pipe; steel pressure-seal fittings; and pressure-sealed joints.

E. Standard-pressure, wet-pipe sprinkler system, NPS 2-1/2 to NPS 4 (DN 65 to DN 100), shall be one of the following:

1. Standard-weight or Schedule 30, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
2. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
3. Standard-weight or Schedule 30, black-steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
4. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
5. Thinwall, Schedule 10, nonstandard OD, thinwall or hybrid black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

F. Standard-pressure, wet-pipe sprinkler system, NPS 5 (DN 125) and larger, shall be one of the following:

1. Standard-weight or Schedule 30, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
2. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
3. Standard-weight or Schedule 30, black-steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
4. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
5. As directed Thinwall, Schedule 10 or hybrid black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

3.12 SPRINKLER SCHEDULE

A. Use sprinkler types in subparagraphs below for the following applications:

1. Rooms without Ceilings: Upright sprinklers.
2. Rooms with Suspended Ceilings: As directed Pendent sprinklers, Recessed sprinklers, Flush sprinklers, Concealed sprinklers or Pendent, recessed, flush, and concealed sprinklers as indicated.
3. Wall Mounting: Sidewall sprinklers.
4. Spaces Subject to Freezing: As directed Upright sprinklers, Pendent, dry sprinklers, Sidewall, dry sprinklers or Upright, pendent, dry sprinklers; and sidewall, dry sprinklers as indicated.
5. Special Applications: As directed Extended-coverage, flow-control, and quick-response sprinklers where indicated, Attic sprinklers, Combustible concealed space sprinklers or Institutional space sprinklers.

B. Provide sprinkler types in subparagraphs below with finishes indicated.

1. Concealed Sprinklers: Rough brass, with factory-painted white cover plate.
2. Flush Sprinklers: Bright chrome, with painted white escutcheon.
3. Recessed Sprinklers: Bright chrome, with bright chrome escutcheon.
4. Residential Sprinklers: Dull chrome.
5. As directed Upright, Pendent and Sidewall Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.

END OF SECTION 211313

SECTION 211316 - DRY-PIPE SPRINKLER SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipes, fittings, and specialties.
2. Specialty valves.
3. Sprinkler specialty pipe fittings.
4. Sprinklers.
5. Alarm devices.
6. Manual control stations.
7. Pressure gages.

B. Related Requirements:

1. Section 211119 "Fire Department Connections" for exposed-, flush-, and yard-type fire department connections.
2. Section 230523 "General-Duty Valves for Water-Based Fire-Suppression Piping" for ball, butterfly, check, gate, post-indicator, and trim and drain valves.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For dry-pipe sprinkler systems.

1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal: For dry-pipe sprinkler systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Sprinkler systems, drawn to scale, on which items of other systems and equipment are shown and coordinated with each other, using input from installers of the items involved.

B. Design Data:

1. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.

C. Field Test Reports: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping."

D. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installer's responsibilities include designing, fabricating, and installing sprinkler systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.

a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTIONS

A. Dry-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing compressed air. Opening of sprinklers releases compressed air and permits water pressure to open dry-pipe valve. Water then flows into piping and discharges from opened sprinklers.

2.2 PERFORMANCE REQUIREMENTS

A. Sprinkler system equipment, specialties, accessories, installation, and testing shall comply with the following:

1. NFPA 13.
2. NFPA 13R.

B. Standard-Pressure Piping System Component: Listed for 175-psig (1200-kPa) minimum working pressure.

C. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design dry-pipe sprinkler systems.

1. Available fire-hydrant flow test records indicate the following conditions:

a. Date: As directed.
b. Time: a.m. or p.m. as directed.

c. Performed by: As directed.
d. Location of Residual Fire Hydrant R: As directed.
e. Location of Flow Fire Hydrant F: As directed.
f. Static Pressure at Residual Fire Hydrant R: As directed.
g. Measured Flow at Flow Fire Hydrant F: As directed.
h. Residual Pressure at Residual Fire Hydrant R: As directed.

D. Sprinkler system design shall be approved by authorities having jurisdiction.

1. Margin of Safety for Available Water Flow and Pressure: As directed 10 or 20 percent, including losses through water-service piping, valves, and backflow preventers.
2. Sprinkler Occupancy Hazard Classifications:

a. Automobile Parking Areas: Ordinary Hazard, Group 1.
b. Building Service Areas: Ordinary Hazard, Group 1.
c. Churches: Light Hazard.
d. Electrical Equipment Rooms: Ordinary Hazard, Group 1.
e. Dry Cleaners: Ordinary Hazard, Group 2.
f. General Storage Areas: Ordinary Hazard, Group 1.
g. Laundries: Ordinary Hazard, Group 1.
h. Libraries except Stack Areas: Light Hazard.
i. Library Stack Areas: Ordinary Hazard, Group 2.
j. Machine Shops: Ordinary Hazard, Group 2.
k. Mechanical Equipment Rooms: Ordinary Hazard, Group 1.
l. Office and Public Areas: Light Hazard.
m. Plastics Processing Areas: Extra Hazard, Group 2.
n. Printing Plants: Extra Hazard, Group 1.
o. Repair Garages: Ordinary Hazard, Group 2.
p. Restaurant Service Areas: Ordinary Hazard, Group 1.
q. Solvent Cleaning Areas: Extra Hazard, Group 2.
r. Upholstering Plants: Extra Hazard, Group 1.

3. Minimum Density for Automatic-Sprinkler Piping Design:

a. Light-Hazard Occupancy: 0.10 gpm over 1500-sq. ft. (4.1 mm/min. over 139-sq. m) area.
b. Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm over 1500-sq. ft. (6.1 mm/min. over 139-sq. m) area.
c. Ordinary-Hazard, Group 2 Occupancy: 0.20 gpm over 1500-sq. ft. (8.1 mm/min. over 139-sq. m) area.

4. Maximum Protection Area per Sprinkler: According to UL listing.
5. Maximum Protection Area per Sprinkler:

a. Office Spaces: As directed 120 sq. ft. (11.1 sq. m) or 225 sq. ft. (20.9 sq. m).
b. Storage Areas: 130 sq. ft. (12.1 sq. m).
c. Mechanical Equipment Rooms: 130 sq. ft. (12.1 sq. m).
d. Electrical Equipment Rooms: 130 sq. ft. (12.1 sq. m).
e. Other Areas: According to NFPA 13 recommendations unless otherwise indicated.

6. Total Combined Hose-Stream Demand Requirement: According to NFPA 13 unless otherwise indicated:

   a. Light-Hazard Occupancies: 100 gpm (6.3 L/s) for 30 minutes.
   b. Ordinary-Hazard Occupancies: 250 gpm (15.75 L/s) for 60 to 90 minutes.

E. Seismic Performance: Sprinkler piping shall withstand the effects of earthquake motions determined according to NFPA 13 and ASCE/SEI 7.

2.3 STEEL PIPE AND FITTINGS

A. Standard-Weight, Galvanized-Steel Pipe: As directed, ASTM A53/A53M, Type E or Grade B. Pipe ends may be factory or field formed to match joining method.

B. Schedule 30, Galvanized-Steel Pipe: ASTM A135/A135M; ASTM A795/A795M, Type E; or ASME B36.10M wrought steel, with wall thickness not less than Schedule 30 and not more than Schedule 40. Pipe ends may be factory or field formed to match joining method.

C. Thinwall Galvanized-Steel Pipe: ASTM A135/A135M or ASTM A795/A795M, threadable, with wall thickness less than Schedule 30 and equal to or greater than Schedule 10. Pipe ends may be factory or field formed to match joining method.

D. Galvanized-Steel Pipe Nipples: ASTM A733, made of ASTM A53/A53M, standard-weight, seamless steel pipe with threaded ends.

E. Galvanized-Steel Couplings: ASTM A865/A865M, threaded.

F. Galvanized, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.

G. Malleable- or Ductile-Iron Unions: UL 860.

H. Cast-Iron Flanges: ASME B16.1, Class 125.

I. Plain-End-Pipe Fittings: UL 213, ductile-iron body with retainer lugs that require one-quarter turn or screwed retainer pin to secure pipe in fitting.

J. Grooved-Joint, Steel-Pipe Appurtenances:
   1. Pressure Rating: As directed, 175-psig (1200-kPa), 250-psig (1725-kPa) or 300-psig (2070-kPa) minimum.
   2. Galvanized, Grooved-End Fittings for Steel Piping: ASTM A47/A47M, malleable-iron casting or ASTM A536, ductile-iron casting, with dimensions matching steel pipe.
   3. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213 rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

2.4 SPECIALTY VALVES

A. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."

B. Specialty Valves Pressure Rating: 175-psig (1200-kPa) minimum.

C. Body Material: Cast or ductile iron.

D. Size: Same as connected piping.

E. End Connections: Flanged or grooved.

F. Dry-Pipe Valves:
1. Standard: UL 260.
2. Design: Differential-pressure type.
3. Include UL 1486, quick-opening devices, trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.
4. Air-Pressure Maintenance Device:
   a. Standard: UL 260.
   b. Type: Automatic device to maintain minimum air pressure in piping.
   c. Include shutoff valves to permit servicing without shutting down sprinkler piping, bypass valve for quick filling, pressure regulator or switch to maintain pressure, strainer, pressure ratings with 14- to 60-psig (95- to 410-kPa) adjustable range, and 175-psig (1200-kPa) or 300-psig (2070-kPa) outlet pressure as directed.
5. Air Compressor:
   a. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
   b. Motor Horsepower: Fractional.
   c. Power: 120-V ac, 60 Hz, single phase.

G. Automatic (Ball Drip) Drain Valves:
1. Standard: UL 1726.
2. Pressure Rating: 175-psig (1200-kPa) minimum.
3. Type: Automatic draining, ball check.
4. Size: NPS 3/4 (DN 20).
5. End Connections: Threaded.

2.5 SPRINKLER PIPING SPECIALTIES

A. General Requirements for Dry-Pipe System Fittings: UL listed for dry-pipe service.

B. Branch Outlet Fittings:
1. Standard: UL 213.
2. Pressure Rating: As directed, 175-psig (1200-kPa) minimum or 300 psig (2070 kPa).
3. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
4. Type: Mechanical-tee and -cross fittings.
5. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
6. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
7. Branch Outlets: Grooved, plain-end pipe, or threaded.

C. Flow Detection and Test Assemblies:
1. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
2. Pressure Rating: As directed, 175-psig (1200-kPa) minimum or 300 psig (2070 kPa).

3. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
4. Size: Same as connected piping.
5. Inlet and Outlet: Threaded.

D. Branch Line Testers:
1. Standard: UL 199.
2. Pressure Rating: 175-psig (1200-kPa) minimum.
3. Body Material: Brass.
4. Size: Same as connected piping.
5. Inlet: Threaded.
6. Drain Outlet: Threaded and capped.
7. Branch Outlet: Threaded, for sprinkler.

E. Sprinkler Inspector's Test Fittings:
1. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
2. Pressure Rating: As directed, 175-psig (1200-kPa) minimum or 300 psig (2070 kPa).
3. Body Material: Cast- or ductile-iron housing with sight glass.
4. Size: Same as connected piping.
5. Inlet and Outlet: Threaded.

F. Adjustable Drop Nipples:
1. Standard: UL 1474.
2. Pressure Rating: 250-psig (1725-kPa) minimum or 300 psig (2070 kPa).
3. Body Material: Steel pipe with EPDM O-ring seals.
4. Size: Same as connected piping.
5. Length: Adjustable.
6. Inlet and Outlet: Threaded.

G. Flexible Sprinkler Hose Fittings:
1. Standard: UL 1474.
2. Type: Flexible hose for connection to sprinkler, and with bracket for connection to ceiling grid.
3. Pressure Rating: As directed, 175-psig (1200-kPa) minimum or 300 psig (2070 kPa).
4. Size: Same as connected piping, for sprinkler.

2.6 SPRINKLERS

A. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."

B. Pressure Rating for Residential Sprinklers: 175-psig (1200-kPa) maximum.

C. Pressure Rating for Automatic Sprinklers: 175-psig (1200-kPa) minimum.

D. Pressure Rating for High-Pressure Automatic Sprinklers: As directed 250-psig (1725-kPa) minimum or 300 psig (2070 kPa).

E. Automatic Sprinklers with Heat-Responsive Element:

1. Nonresidential Applications: UL 199.

2. Residential Applications: UL 1626.
3. Characteristics: Nominal 1/2-inch (12.7-mm) orifice with Discharge Coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.

F. Sprinkler Finishes: As directed, Chrome plated, bronze and painted.

G. Special Coatings: As directed, Wax, lead and corrosion-resistant paint.

H. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.

1. Ceiling Mounting: As directed, Chrome-plated steel, one piece, flat, Chrome-plated steel, two piece, with 1-inch (25-mm) vertical adjustment or Plastic, white finish, one piece, flat.
2. Sidewall Mounting: As directed, Chrome-plated steel or Plastic, white finish, one piece, flat.

I. Sprinkler Guards:
1. Standard: UL 199.
2. Type: Wire cage with fastening device for attaching to sprinkler.

2.7 MANUAL CONTROL STATIONS

A. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide" for hydraulic operation, with union, NPS 1/2 (DN 15) pipe nipple, and bronze ball valve.

B. Include metal enclosure labeled "MANUAL CONTROL STATION" with operating instructions and cover held closed by breakable strut to prevent accidental opening.

2.8 PRESSURE GAGES

A. Standard: UL 393.

B. Dial Size: 3-1/2- to 4-1/2-inch (90- to 115-mm) diameter.

C. Pressure Gage Range: As directed, 0- to 250-psig (0- to 1725-kPa) minimum or 0 to 300 psig (0 to 2070 kPa).

D. Label: Include "WATER" or "AIR/WATER" label on dial face.

E. Air System Piping Gage: Include retard feature and "AIR" or "AIR/WATER" label on dial face.

PART 3 - EXECUTION

3.1 SERVICE-ENTRANCE PIPING

A. Connect sprinkler piping to water-service piping for service entrance to building. Comply with requirements in Section 211100 "Facility Fire-Suppression Water-Service Piping" for exterior piping.

B. Install shutoff valve, backflow preventer, pressure gage, drain, and other accessories indicated at connection to water-service piping. Comply with requirements for backflow preventers in Section 211100 "Facility Fire-Suppression Water-Service Piping."

C. Install shutoff valve, check valve, pressure gage, and drain at connection to water service.

3.2 WATER-SUPPLY CONNECTIONS

A. Connect sprinkler piping to building's interior water-distribution piping. Comply with requirements for interior piping in Section 221116 "Domestic Water Piping."

B. Install shutoff valve, backflow preventer, pressure gage, drain, and other accessories indicated at connection to water-distribution piping. Comply with requirements in Section 221119 "Domestic Water Piping Specialties" for backflow preventers.

C. Install shutoff valve, check valve, pressure gage, and drain at connection to water supply.

3.3 PIPING INSTALLATION

A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated on approved working plans.

1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.
2. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.

B. Piping Standard: Comply with NFPA 13 requirements for installation of sprinkler piping.

C. Install seismic restraints on piping. Comply with NFPA 13 requirements for seismic-restraint device materials and installation.

D. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

E. Install unions adjacent to each valve in pipes NPS 2 (DN 50) and smaller.

F. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 (DN 65) and larger end connections.

G. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, and sized and located according to NFPA 13.

H. Install sprinkler piping with drains for complete system drainage.

I. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.

J. Install automatic (ball drip) drain valves to drain piping between fire department connections and check valves. Drain to floor drain or to outside building.

K. Connect compressed-air supply to dry-pipe sprinkler piping.

L. Connect air compressor to the following piping and wiring:

1. Pressure gages and controls.
2. Electrical power system.
3. Fire-alarm devices, including low-pressure alarm.

M. Install alarm devices in piping systems.

N. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements in NFPA 13. In seismic-rated areas, refer to Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."

O. Install pressure gages on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 (DN 8) and with soft-metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal and install where they are not subject to freezing.

P. Drain dry-pipe sprinkler piping.

Q. Pressurize and check dry-pipe sprinkler system piping and air-pressure maintenance devices or air compressors as directed.

R. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."

S. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."

T. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 210518 "Escutcheons for Fire-Suppression Piping."

3.4 JOINT CONSTRUCTION

A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.

B. Install unions adjacent to each valve in pipes NPS 2 (DN 50) and smaller.

C. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 (DN 65) and larger end connections.

D. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

E. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

F. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.

G. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

H. Twist-Locked Joints: Insert plain end of steel pipe into plain-end-pipe fitting. Rotate retainer lugs one-quarter turn or tighten retainer pin.

I. Steel-Piping, Cut-Grooved Joints: Cut square-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe joints.

J. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

3.5 VALVE AND SPECIALTIES INSTALLATION

A. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 13 and authorities having jurisdiction.

B. Install listed fire-protection shutoff valves supervised open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.

C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

D. Specialty Valves:

1. Install valves in vertical position for proper direction of flow, in main supply to system.
2. Install dry-pipe and deluge valves with trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.

    a. Install air compressor and compressed-air-supply piping.

b. Install air-pressure maintenance device with shutoff valves to permit servicing without shutting down sprinkler system; bypass valve for quick system filling; pressure regulator or switch to maintain system pressure; strainer; pressure ratings with 14- to 60-psig (95- to 410-kPa) adjustable range; and 175-psig (1200-kPa) maximum inlet pressure.
c. Install compressed-air-supply piping from building's compressed-air piping system.

3.6 SPRINKLER INSTALLATION

A. Install sprinklers in suspended ceilings in center of narrow dimension of acoustical ceiling panels.

B. Install sprinklers with water supply from heated space. Do not install pendant or sidewall, sprinklers in areas subject to freezing.

C. Install sprinklers into flexible, sprinkler hose fittings, and install hose into bracket on ceiling grid.

3.7 IDENTIFICATION

A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13.

B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.8 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
4. Energize circuits to electrical equipment and devices.
5. Start and run air compressors.
6. Coordinate with fire-alarm tests. Operate as required.
7. Coordinate with fire-pump tests. Operate as required.
8. Verify that equipment hose threads are same as local fire department equipment.

B. Sprinkler piping system will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.9 CLEANING

A. Clean dirt and debris from sprinklers.

B. Only sprinklers with their original factory finish are acceptable. Remove and replace any sprinklers that are painted or have any other finish than their original factory finish.

3.10 PIPING SCHEDULE

A. Piping between Fire Department Connections and Check Valves: As directed Galvanized, standard-weight steel pipe with threaded ends, cast-iron threaded fittings, and threaded or grooved ends, grooved-end fittings, grooved-end-pipe couplings, and grooved joints.

B. Sprinkler specialty fittings may be used, downstream of control valves, instead of specified fittings.

C. Standard-pressure, dry-pipe sprinkler system, NPS 2 (DN 50) and smaller, shall be one of the following:

1. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
2. Standard-weight Schedule 30 or thinwall, galvanized-steel pipe with plain ends; plain-end-pipe fittings; and twist-locked joints.
3. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

D. Standard-pressure, dry-pipe sprinkler system, NPS 2-1/2 to NPS 6 (DN 65 to DN 150), shall be one of the following:

1. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
2. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

3.11 SPRINKLER SCHEDULE

A. Use sprinkler types in subparagraphs below for the following applications:

1. Rooms without Ceilings: Upright sprinklers.
2. Rooms with Suspended Ceilings: As directed Dry pendent sprinklers, Dry recessed sprinklers, Dry flush sprinklers, Dry concealed sprinklers, Dry pendent, recessed, flush, and concealed sprinklers as indicated.
3. Wall Mounting: Dry sidewall sprinklers.
4. Spaces Subject to Freezing: As directed Upright sprinklers, Dry pendent sprinklers, Dry sidewall sprinklers or Upright, dry pendent sprinklers; and dry sidewall sprinklers as indicated.
5. Special Applications: Extended-coverage and quick-response sprinklers where indicated.

B. Provide sprinkler types in subparagraphs below with finishes indicated.

1. Concealed Sprinklers: Rough brass, with factory-painted white cover plate.
2. Flush Sprinklers: Bright chrome, with painted white escutcheon.
3. Recessed Sprinklers: Bright chrome, with bright chrome escutcheon.
4. Upright, Pendent and Sidewall Sprinklers as directed: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.

END OF SECTION 211316

SECTION 211339 - FOAM-WATER SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Concentrate piping and piping specialties.
2. Bladder tanks and proportioning devices.
3. Foam concentrate.
4. Discharge devices.
5. Monitoring and alarm devices.

1.2 SYSTEM DESCRIPTION

A. Description: As directed, Engineered, fixed, wet-pipe, dry-pipe, pre-action or deluge, automatically actuated, low-expansion, AR-AFFF fire-extinguishing system for flammable-liquid fires. System includes diaphragm proportioning tanks and devices as described in NFPA 16.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: For each hazard area, drawn to scale, and signed and sealed by a qualified professional engineer. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.
3. Design Calculations: For amount of foam concentrate required for each hazard area.
4. Plans:

a. Show the following:

1) Foam-solution proportioning tanks and devices, piping, discharge devices, monitoring and alarm devices, and accessories.
2) Method of attaching hangers to building structure.
3) Fire-alarm panel.
4) Equipment and furnishings.

b. Permit-Approved Drawings: Working plans prepared according to NFPA 16 and approved by authorities having jurisdiction. Include hydraulic calculations complying with NFPA 13.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. FM Global Compliance: Provide components that are FM Approved and that are listed in FM's "Approval Guide."

C. UL Compliance: Provide equipment listed in UL's "Fire Protection Equipment Directory."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Standard Working Pressure of Piping-System Component: Listed for at least 175 psig (1200 kPa).

B. Unless authorities having jurisdiction have stricter requirements, minimum design parameters are as follows:

1. Solution: 3 percent foam-water solution.
2. Sprinkler Spacing: Maximum of 100 sq. ft. (9.5 sq. m) per sprinkler, and maximum 12-foot (3.7-m) spacing.
3. Design Density: Minimum 0.16 gpm/sq. ft. (0.108 L/s per sq. m).
4. Foam Supply: Minimum 10-minute discharge time.
5. Water Supply: Minimum 60 minutes.
6. Remote Area: Minimum 5000-sq. ft. (476-sq. m) design area for closed-sprinkler systems. Open-sprinkler systems shall discharge over the entire system area.
7. Sprinkler Temperature Rating: Maximum 250 to 300 deg F (121 to 149 deg C) at a roof or ceiling, and 135 to 170 deg F (57 to 77 deg C) for intermediate sprinklers.

2.2 CONCENTRATE PIPING MATERIALS

A. Comply with requirements specified in Section 211313 "Wet-Pipe Sprinkler Systems" or Section 211316 "Dry-Pipe Sprinkler Systems" for pipes, fittings, joining materials, and valves.

B. Schedule 40, Black Steel Pipe: ASTM A53/A53M, Type E, Grade B or ASTM A795/A795M, Type E. Pipe ends may be factory or field formed to match joining method.

1. Gray Iron Threaded Fittings, Classes 125 and 250: ASME B16.4.
2. Gray Iron Pipe Flanges and Flanged Fittings: ASME B16.1.
3. Malleable Iron Threaded Fittings, Classes 150 and 300: ASME B16.3.

2.3 VALVES

A. General Valve Requirements:

1. UL listed or FM Approved for use in fire-protection systems.
2. Compatible with type of foam concentrate used.

2.4 SPECIALTIES

A. Specialties shall comply with NFPA 16, be compatible with the foam concentrate, and be designed to be drained and cleaned.

B. Foam-Concentrate Storage Tanks: Buna-N, bladder-type proportioning tank complying with UL 162 and ASME Boiler and Pressure Vessel Code: Section VIII; designed for use with foam-concentrate pumps and for specific type of foam concentrate used. Include bladder, internal piping, fill and drain, glass sight gage, piping, and valves. Contain concentrate in the bladder.

1. Orientation: As directed Horizontal design with saddle or Vertical design with skirt support.

C. Proportioning Controllers: Venturi type complying with UL 162 and of capacity to match design at minimum and maximum flow.

D. Concentrate Control Valves: Water-operated ball or deluge valve designed to open with flow through the proportioning controller.

E. Concentrate Strainers: Bronze body and stainless-steel mesh strainer with minimum 0.125-inch (3.2-mm) perforations to remove solids that would block system components.

F. Pressure Gages: Comply with UL 393; with 3-1/2-inch (90-mm) minimum-diameter dial, 0- to 300-psig (0- to 2070-kPa) dial range, and caption "WATER" or "CONCENTRATE" on dial face.

2.5 FOAM CONCENTRATE

A. Description: AR-AFFF liquid concentrate, complying with NFPA 11 and UL 162, for making foam-water fire-extinguishing foam solution.

2.6 DISCHARGE DEVICES

A. Discharge devices shall be UL listed or FM Approved.

B. Sprinklers: As directed Closed, Open, non-air-aspirating type; UL listed or FM Approved and listed for use with type of foam concentrate used.

C. Spray Nozzles: For foam water; include foam generator and distributing deflector to distribute foam or water.

2.7 MONITORING DEVICES

A. Valve Supervisory Switches: Single pole, double throw, with normally closed contacts complying with UL 753. Switch shall signal fire-alarm panel or releasing panel when valve is in other than fully open position.

B. Pressure Switches: Single pole, double throw, UL listed or FM Approved and complying with UL 753. Switch shall signal an alarm condition at the fire-alarm panel or releasing panel when switch is in other than fully open position.

C. Flow Switches: Single pole, double throw, UL listed or FM Approved and complying with UL 753. Switch shall signal an alarm condition at the fire-alarm panel or releasing panel when switch is in other than fully open position.

2.8 ALARM DEVICES

A. Description: UL listed or FM Approved, low voltage, and surface mounting. Alarm and monitoring devices are specified in Section 284621.11 "Addressable Fire-Alarm Systems" or Section 284621.13 "Conventional Fire-Alarm Systems."

PART 3 - EXECUTION

3.1 CONCENTRATE STORAGE TANK INSTALLATION

A. Equipment Mounting:

1. Install concentrate storage tanks on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."
3. Comply with requirements for vibration isolation devices specified in Section 210548.13 "Vibration Controls for Fire-Suppression Piping and Equipment."

B. Install concentrate storage tanks anchored to substrate according to tank manufacturer's written instructions.

C. Install tanks level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

3.2 PIPING INSTALLATION

A. Install piping and other components level and plumb.

B. Install pipe and fittings, valves, and discharge devices according to requirements listed in NFPA 16, "Installation of Foam-Water Sprinkler and Foam-Water Spray Systems."

1. Support piping using supports and methods according to NFPA 13.
2. Install monitoring and alarm devices according to NFPA 16 and NFPA 72.

C. Install flanges, flange adapters, or couplings for grooved-end piping on piping, valves, apparatus, and equipment having NPS 2-1/2 (DN 65) and larger end connections.

D. Ream ends of pipes and tubes and remove burrs.

E. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

F. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for foam concentrate. Join flanges with gasket and bolts according to ASME B31.9.

G. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

H. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.

I. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems and with foam concentrate.

3.3 CONNECTIONS

A. Comply with requirements for piping specified in Section 211313 "Wet-Pipe Sprinkler Systems" or Section 211316 "Dry-Pipe Sprinkler Systems." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Provide concentrate control and drain valves with piping to permit maintenance of the foam concentrate with continuous sprinkler-system service.

C. Install proportioning controller in fire-suppression piping to provide coverage to area indicated on Drawings.

D. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

E. Connect electrical devices to building's fire-alarm system. Comply with requirements for wiring and connections in Section 284621.11 "Addressable Fire-Alarm Systems" or Section 284621.13 "Conventional Fire-Alarm Systems."

F. Install a fire department connection on the supply side of the proportioning controller when required.

3.4 CHARGING SYSTEM

A. Fill proportioning tanks with foam concentrate after field quality-control testing is complete and satisfactory results have been achieved.

3.5 FIELD QUALITY CONTROL

A. Inspection: Engage the services of a qualified professional engineer to inspect installed fire-extinguishing systems, prepare installation report, and certify that installation complies with the Contract Documents, calculations, and requirements of authorities having jurisdiction.

B. Comply with operating instructions and procedures in NFPA 16, "Acceptance Tests" Chapter.

C. Perform tests and inspections.

D. Tests and Inspections:

1. After installing foam fire-extinguishing piping system and after electrical circuitry has been energized, test for compliance with requirements.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start systems to confirm proper unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Foam fire-extinguishing piping system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

END OF SECTION 211339

SECTION 212113.13 - HIGH-PRESSURE, CARBON-DIOXIDE FIRE-EXTINGUISHING SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Carbon dioxide.
2. Piping.
3. Flexible-hose connectors.
4. Carbon-dioxide cylinders.
5. Cylinder valves.
6. Discharge nozzles.
7. Hangers and supports.
8. Control panels.
9. Detection devices.
10. Manual stations.
11. Switches.
12. Alarm devices.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For high-pressure carbon-dioxide fire-extinguishing system signed and sealed by a qualified professional engineer.

1. Include plans, elevations, sections, and mounting or attachment details as directed.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Design Data:

1. Permit-Approved Drawings: Working plans including design calculations, prepared according to NFPA 12, that have been approved by authorities having jurisdiction.

B. Seismic Qualification Data: Certificates, for container foundations, cylinder racks, supports, hangers, braces, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For carbon-dioxide fire-extinguishing system to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Total-Flooding System Design Criteria:

1. Hazard Type: As directed Data-processing center, Manufacturing process, Power generation, Telecommunications center or Electrical equipment room.
2. Discharge carbon dioxide for 60 seconds and maintain 34 percent concentration by volume at 70 deg F (21 deg C) for 10-minute holding time in hazard areas.
3. System shall include separate zones above and below the ceiling and beneath the raised floor.
4. Operations and Controls: If smoke is detected below the raised floor, extinguishing agent shall be discharged in the underfloor zone only. If smoke is detected below the ceiling, extinguishing agent shall be discharged in zones above and below the ceiling and below the floor. If smoke is detected above the ceiling, extinguishing agent shall be discharged in the zone above the ceiling only.

B. Seismic Performance: Cylinder racks, supports, hangers, and braces shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the system will remain in place without separation of any parts when subjected to the seismic forces specified and the system will be fully operational after the seismic event."
2. Component Importance Factor is 1.5 or 1.0 as directed.

2.2 SYSTEM DESCRIPTION

A. Total-Flooding System: Pre-engineered carbon-dioxide fire-extinguishing system designed for total flooding of the hazard area including the room cavity above the ceiling, below the ceiling, and below the raised floor.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. NFPA Compliance: Fire-extinguishing system, equipment, and components shall comply with NFPA 12.

2.3 CARBON DIOXIDE

A. Vapor Phase: Equal to or more than 99.5 percent carbon dioxide.

B. Taste and Odor: None detectable.

C. Water Content: Comply with CGA G-6.2.

D. Oil Content: Equal to or less than 10 ppm by weight.

2.4 PIPING MATERIALS

A. Piping, Valves, and Discharge Nozzles: Comply with types and standards listed in NFPA 12, Section "Distribution," for charging pressure of system.

2.5 PIPES AND FITTINGS

A. Steel Pipe: ASTM A53/A53M, Grade B, Schedule 40, Type E or ASTM A106/A106M, Grade A, black finish, seamless-steel pipe.

1. Threaded Fittings:

a. Malleable-Iron Fittings: ASME B16.3, Class 300.
b. Flanges and Flanged Fittings: ASME B16.5, Class 300 unless Class 600 is indicated.

2.6 HIGH-PRESSURE FLEXIBLE-HOSE CONNECTORS

A. Description: Teflon-lined, braided hose with stainless-steel wire-braid covering.

1. Burst Pressure: 5000 psi (34 474 kPa) minimum.
2. End Connections: Threaded male couplings.

2.7 CARBON-DIOXIDE CYLINDERS

A. Operating Pressure: Between 2400 psi (16 547 kPa) and 3000 psi (20 684 kPa).

1. Pressure Relief Device: Rupture-disk type.

a. Sized and fitted according to 49 CFR 178.

B. Ambient Storage Conditions: Less than 120 deg F (49 deg C) and more than 32 deg F (0 deg C).

C. Wall Storage Racks: Fabricate racks with chain restraints for upright cylinders as indicated or provide equivalent manufactured wall racks.

D. Freestanding Storage Racks: Fabricate racks as indicated or provide equivalent manufactured storage racks.

E. Storage Cylinder Nominal Size: As directed, 50 lb (23 kg), 75 lb (34 kg) or 100 lb (45 kg).

2.8 CYLINDER VALVES

A. Bursting Pressure Rating:

1. Valves under Constant Pressure: 6000 psi (41 369 kPa).
2. Valves Not under Constant Pressure: 5000 psi (34 474 kPa).

B. Discharge Valves:

1. Actuation: As directed, Pneumatic, Electric or Manual.
2. Solenoid Actuator: As directed 12-V dc or 24-V dc.
3. Pilot Hose: As directed, Rigid or Flexible.
4. Valve Material: Brass or stainless steel.
5. Slave Valve Material: Brass.
6. Lock-Out: Key-operation selector, for prevention of discharge during maintenance.

2.9 DISCHARGE NOZZLES

A. Equipment manufacturer's standard material of working pressure, size, discharge pattern, and capacity required for application.

B. Corrosion-resistant metal.

C. Stamped with orifice size and type.

2.10 HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pre-galvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod with compatible nuts and washers.

2.11 FIRE CONTROL PANELS

A. Description: FM Approved or listed and labeled by a nationally recognized testing agency acceptable to authorities having jurisdiction, including equipment and features required for testing, supervising, and operating fire-extinguishing system.

B. Power Requirements: 120/240-V ac; with electrical contacts for connection to system components and fire-alarm system, and transformer or rectifier as needed to produce power at voltage required for accessories and alarm devices.

2.12 DETECTION DEVICES

A. General Requirements for Detection Devices:

1. Comply with NFPA 12, NFPA 72, and UL 268.
2. 24-V dc, nominal.

B. Ionization Detectors: Dual-chamber type, having sampling and referencing chambers, with smoke-sensing element.

C. Photoelectric Detectors: LED light source and silicon photodiode receiving element.

2.13 MANUAL STATIONS

A. Description: As directed Surface or Semi-recessed, FM Approved or listed and labeled by a nationally recognized testing agency acceptable to authorities having jurisdiction, with clear plastic hinged cover, 120-V ac or low voltage compatible with controls. Include contacts for connection to control panel.

B. Manual Release: "MANUAL RELEASE" caption, with red finish. Unit can manually discharge extinguishing agent with operating device that remains engaged until unlocked.

C. Abort Switch: "ABORT" caption, momentary contact, with green finish.

D. EPO Switch: "EPO" caption, with yellow finish.

2.14 SWITCHES

A. Description: FM Approved or listed and labeled by a nationally recognized testing agency acceptable to authorities having jurisdiction.

1. Control Voltage: 120-V ac compatible with controls.
2. Include contacts for connection to control panel.
3. Discharge Pressure Switches: Pneumatic operation for shutdown of equipment.
4. Power Transfer Switches: Key-operation selector for transfer of release circuit signal from main supply to reserve supply.
5. Door Closers: Magnetic retaining and release device or electrical interlock to cause the door operator to drive the door closed.

2.15 ALARM DEVICES

A. Description: FM Approved or listed and labeled by a nationally recognized testing agency acceptable to authorities having jurisdiction; low voltage and surface mounting.

B. As directed Comply with requirements in Section 284621.11 "Addressable Fire-Alarm Systems" or Section 284621.13 "Conventional Fire-Alarm Systems" for alarm and monitoring devices.

C. Bells: Minimum 6-inch (150-mm) diameter.

D. Horns: 90 to 94 dBA.

E. Strobe Lights: Translucent lens, with "FIRE" or similar caption.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with requirements in NFPA 12.

B. Install pipe and fittings, valves, and discharge nozzles according to requirements listed in NFPA 12, Section "Distribution Systems."

1. Install pressure relief devices in piping systems.
2. Install seismic restraints for carbon-dioxide cylinders and piping systems.
3. Install control panels, detection system components, alarms, and accessories, complying with requirements of NFPA 12, Section "Detection, Actuation, and Control," as required for supervised system application.

C. Install carbon-dioxide cylinders in racks anchored to substrate.

3.2 HANGERS AND SUPPORTS

A. Field fabricate hangers and supports from ASTM A36/A36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

B. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

C. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

D. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

E. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 (DN 65)

and larger, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

F. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

G. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes to facilitate draining moisture and to not exceed maximum pipe deflections allowed by ASME B31.9 for building-services piping.

H. Install carbon-steel hangers and supports for steel piping.

I. Vertical Piping: MSS Type 8 or 42, clamps.

J. Individual, Straight, Horizontal Piping Runs:

1. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel, clevis hangers.
2. Longer Than 100 Feet (30 m): MSS Type 43, adjustable, roller hangers.

K. Base of Vertical Piping: MSS Type 52, spring hangers.

L. Support horizontal piping within 12 inches (300 mm) of each fitting and coupling.

M. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.

N. Install hangers with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 3/8 to NPS 1/2 (DN 10 to DN 15): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
2. NPS 3/4 to NPS 1-1/4 (DN 20 to DN 32): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
3. NPS 1-1/2 (DN 40): 12 feet (3.7 m) with 3/8-inch (10-mm) rod.
4. NPS 2 (DN 50): 13 feet (4 m) with 3/8-inch (10-mm) rod.
5. NPS 2-1/2 (DN 65): 14 feet (4.3 m) with 1/2-inch (13-mm) rod.
6. NPS 3 (DN 80): 15 feet (4.6 m) with 1/2-inch (13-mm) rod.
7. NPS 3-1/2 (DN 90): 16 feet (4.9 m) with 1/2-inch (13-mm) rod.
8. NPS 4 (DN 100): 17 feet (5.2 m) with 5/8-inch (16-mm) rod.
9. NPS 5 (DN 125): 19 feet (5.8 m) with 5/8-inch (16-mm) rod.
10. NPS 6 (DN 150): 21 feet (6.4 m) with 3/4-inch (19-mm) rod.
11. NPS 8 (DN 200): 24 feet (7.3 m) with 3/4-inch (19-mm) rod.

O. Install seismic restraints on piping. Comply with requirements in Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."

3.3 IDENTIFICATION

A. Identify piping, extinguishing-agent containers, other equipment, and panels according to NFPA 12.

B. Install signs at entry doors for protected areas to warn occupants that they are entering a room protected by a carbon-dioxide fire-extinguishing system.

C. Install signs at entry doors to advise persons outside the room of the meaning of the horn(s), bell(s), and strobe light(s) outside the protected space.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections according to NFPA 12.

B. Carbon-dioxide fire-extinguishing system will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain carbon-dioxide fire-extinguishing system.

END OF SECTION 212113.13

SECTION 212113.16 - LOW-PRESSURE, CARBON-DIOXIDE FIRE-EXTINGUISHING SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Carbon dioxide.
2. Piping.
3. Flexible-hose connectors.
4. Insulated carbon-dioxide containers.
5. Distribution valves.
6. Discharge nozzles.
7. Hangers and supports.
8. Control panels.
9. Detection devices.
10. Manual stations.
11. Switches.
12. Alarm devices.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For low-pressure carbon-dioxide fire-extinguishing system signed and sealed by a qualified professional engineer.

1. Include plans, elevations, sections, and mounting or attachment details as directed.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Design Data:

1. Permit-Approved Drawings: Working plans including design calculations, prepared according to NFPA 12, that have been approved by authorities having jurisdiction.

B. Seismic Qualification Data: Certificates, for container foundations, container racks, supports, hangers, braces, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For carbon-dioxide fire-extinguishing system to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Total-Flooding System Design Criteria:

1. Hazards: As directed Printing presses, Transformer vaults, Rolling mills, Open pits, Dip tanks, Manufacturing process, Power generation, Telecommunications center or Electrical equipment room.
2. Discharge carbon dioxide for 60 seconds and maintain 34 percent concentration by volume at 70 deg F (21 deg C) for 10-minute holding time in hazard areas.
3. System shall include separate zones above and below the ceiling and beneath the raised floor.
4. Operations and Controls: If smoke is detected below the raised floor, extinguishing agent shall be discharged in the underfloor zone only. If smoke is detected below the ceiling, extinguishing agent shall be discharged in zones above and below the ceiling and below the floor. If smoke is detected above the ceiling, extinguishing agent shall be discharged in the zone above the ceiling only.

B. Seismic Performance: Container foundations, supports, hangers, and braces shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the system will remain in place without separation of any parts when subjected to the seismic forces specified and the system will be fully operational after the seismic event."
2. Component Importance Factor is 1.5 or 1.0 as directed.

C. Design low-pressure carbon-dioxide fire-extinguishing system and obtain approval from authorities having jurisdiction.

2.2 SYSTEM DESCRIPTION

A. Total-Flooding System: Pre-engineered carbon-dioxide fire-extinguishing system designed for total flooding of the hazard area including the room cavity above the ceiling, below the ceiling, and below the raised floor.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. NFPA Compliance: Fire-extinguishing system, equipment, and components shall comply with NFPA 12.

2.3 CARBON DIOXIDE

A. Vapor Phase: Equal to or more than 99.5 percent carbon dioxide.

B. Taste and Odor: None detectable.

C. Water Content: Comply with CGA G-6.2.

D. Oil Content: Equal to or less than 10 ppm by weight.

2.4 PIPES AND FITTINGS

A. Piping, Valves, and Discharge Nozzles: Comply with types and standards listed in NFPA 12, Section "Distribution," for charging pressure of system.

B. Steel Pipe: ASTM A53/A53M, Schedule 40, Grade B, Type E or ASTM A106/A106M, Grade A, black finish, seamless-steel pipe.

1. Threaded Fittings:

a. Malleable-Iron Fittings: ASME B16.3, Class 300.
b. Flanges and Flanged Fittings: ASME B16.5, Class 300.

2.5 LOW-PRESSURE FLEXIBLE-HOSE CONNECTORS

A. Description: Teflon-lined, braided hose with stainless-steel wire-braid covering.

1. Design Standard: ASME B31.1.
2. Internal Pressure: 450 psi (3101 kPa).
3. Burst Pressure: 1800 psi (12 411 kPa) minimum.
4. End Connections: Threaded male couplings.

2.6 INSULATED CARBON-DIOXIDE CONTAINERS

A. Containers:

1. Minimum Manufacturing Standard: ASME Boiler & Pressure Vessel Code, Section VIII, Division 1.
2. Housing: Steel or fiberglass.
3. Working Pressure: 363 psi (2503 kPa).

4. Maintenance Pressure Requirements: 300 psi (2068 kPa) and 0 deg F (minus 18 deg C) with a design pressure of 325 psi (2241 kPa).
5. Bulk System Storage Container Nominal Size: As directed 3/4 ton (680 kg), 2 tons (1814 kg) or 10 tons (9070 kg).
6. Mini-Bulk System Storage Container Nominal Size: As directed 800 lb (363 kg), 1000 lb (454 kg) or 1500 lb (680 kg).

B. Valves:

1. Manual shutoff valve.
2. Bleeder Valve: 341 psi (2352 kPa).
3. Relief Valve: 357 psi (2462 kPa).

C. Gages:

1. Liquid level.
2. Pressure.

D. High- and Low-Pressure Supervisory Alarm:

1. Maximum Pressure Set Point: 90 percent of allowable working pressure.
2. Minimum Pressure Set Point: 250 psi (1724 kPa).

E. Refrigeration System:

1. Maintenance Pressure: 300 psi (2068 kPa) at maximum expected temperature.
2. Pressure Switch:

    a. Start Pressure: 295 psi (2034 kPa).
    b. Stop Pressure: 305 psi (2103 kPa).

3. Compressor: Commercial grade.
4. Refrigeration Coil Location: Lengthwise near top.
5. Motor:

    a. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 210513 "Common Motor Requirements for Fire Suppression Equipment."
    b. Efficiency: Premium efficient.
    c. Electrical Characteristics:

        1) Horsepower: As directed 1, 1-1/2 or 3.
        2) Volts: As directed 120, 208, 230 or 460.
        3) Phase: As directed Single or Poly.
        4) Hertz: 60.
        5) Full-Load Amperes: As directed.
        6) Minimum Circuit Ampacity: As directed.
        7) Maximum Overcurrent Protection: As directed.

F. Heating System:

1. Maintenance Temperature: 32 deg F (0 deg C) at minimum expected temperature.

2.7 DISTRIBUTION VALVES

A. Selector Valve:

1. Actuation: Pneumatic, electro pneumatic, or manual.
2. Design: As directed Ball or Butterfly, with spring-return actuator.

a. Minimum Burst Pressure: 5000 psi (34 474 kPa).
b. Minimum Pressure without Permanent Distortion: 1800 psi (12 411 kPa).

B. Master Valve:

1. Actuation: Pneumatic, electro pneumatic, or manual.
2. Design: As directed Ball or butterfly, with spring-return actuator.

a. Minimum burst pressure: 5000 psi (34 474 kPa).
b. Minimum pressure without permanent distortion: 1800 psi (12 411 kPa).

2.8 DISCHARGE NOZZLES

A. Equipment manufacturer's standard material of working pressure, size, discharge pattern, and capacity required for application.

B. Corrosion-resistant metal.

C. Stamped with orifice size and type.

2.9 HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pre-galvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod with compatible nuts and washers.

2.10 FIRE CONTROL PANELS

A. Description: FM Approved or listed and labeled by a nationally recognized testing agency acceptable to authorities having jurisdiction, including equipment and features required for testing, supervising, and operating fire-extinguishing system.

B. Power Requirements: 120/240-V ac; with electrical contacts for connection to system components and fire-alarm system, and transformer or rectifier as needed to produce power at voltage required for accessories and alarm devices.

2.11 DETECTION DEVICES

A. General Requirements for Detection Devices:

1. Comply with NFPA 12, NFPA 72, and UL 268.
2. 24-V dc, nominal.

B. Ionization Detectors: Dual-chamber type, having sampling and referencing chambers, with smoke-sensing element.

C. Photoelectric Detectors: LED light source and silicon photodiode receiving element.

2.12 MANUAL STATIONS

A. Description: As directed Surface or Semi-recessed, FM Approved or listed and labeled by a nationally recognized testing agency acceptable to authorities having jurisdiction, with clear plastic hinged cover, 120-V ac or low voltage compatible with controls. Include contacts for connection to control panel.

B. Manual Release: "MANUAL RELEASE" caption, with red finish. Unit can manually discharge extinguishing agent with operating device that remains engaged until unlocked.

C. Abort Switch: "ABORT" caption, momentary contact, with green finish.

D. EPO Switch: "EPO" caption, with yellow finish.

2.13 SWITCHES

A. Description: FM Approved or listed and labeled by a nationally recognized testing agency acceptable to authorities having jurisdiction.

1. Control Voltage: 120-V ac compatible with controls.
2. Include contacts for connection to control panel.
3. Discharge Pressure Switches: Pneumatic operation for shutdown of equipment.
4. Power Transfer Switches: Key-operation selector for transfer of release circuit signal from main supply to reserve supply.
5. Door Closers: Magnetic retaining and release device or electrical interlock to cause the door operator to drive the door closed.

2.14 ALARM DEVICES

A. Description: FM Approved or listed and labeled by a nationally recognized testing agency acceptable to authorities having jurisdiction; low voltage and surface mounting.

B. As directed Comply with requirements in Section 284621.11 "Addressable Fire-Alarm Systems" or Section 284621.13 "Conventional Fire-Alarm Systems" for alarm and monitoring devices.

C. Bells: Minimum 6-inch (150-mm) diameter.

D. Horns: 90 to 94 dBA.

E. Strobe Lights: Translucent lens, with "FIRE" or similar caption.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with requirements in NFPA 12.

3.2 HANGERS AND SUPPORTS

A. Field fabricate hangers and supports from ASTM A36/A36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

B. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

C. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

D. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

E. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 (DN 65) and larger, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

F. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

G. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes to facilitate draining moisture and to not exceed maximum pipe deflections allowed by ASME B31.9 for building-services piping.

H. Install carbon-steel hangers and supports for steel piping.

I. Vertical Piping: MSS Type 8 or 42, clamps.

J. Individual, Straight, Horizontal Piping Runs:

1. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel, clevis hangers.

2. Longer Than 100 Feet (30 m): MSS Type 43, adjustable, roller hangers.

K. Base of Vertical Piping: MSS Type 52, spring hangers.

L. Support horizontal piping within 12 inches (300 mm) of each fitting and coupling.

M. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch- (10-mm-) minimum rods.

N. Maximum Span between Hangers and Piping with Threaded or Welded Joints:

1. NPS 1/4 to NPS 1/2 (DN 8 to DN 15): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
2. NPS 3/4 (DN 20): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
3. NPS 1 (DN 25): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
4. NPS 1-1/4 (DN 32): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
5. NPS 1-1/2 (DN 40): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
6. NPS 2 (DN 50): 10 feet (3 m) with 3/8-inch (10-mm) rod.
7. NPS 2-1/2 (DN 65): 11 feet (3.4 m) with 3/8-inch (10-mm) rod.
8. NPS 3 (DN 80): 12 feet (3.6 m) with 1/2-inch (13-mm) rod.
9. NPS 4 (DN 100): 14 feet (4.3 m) with 1/2-inch (13-mm) rod.

O. Maximum Span between Hangers and Piping with Mechanical Joints:

1. NPS 3/4 to NPS 2 (DN 20 to DN 50): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
2. NPS 3 to NPS 4 (DN 80 to DN 100): 10 feet (3 m) with 3/8-inch (10-mm) rod.

P. Install seismic restraints on piping. Comply with requirements in Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."

3.3 IDENTIFICATION

A. Identify piping, extinguishing-agent containers, other equipment, and panels according to NFPA 12.

B. Install signs at entry doors for protected areas to warn occupants that they are entering a room protected by a carbon-dioxide fire-extinguishing system.

C. Install signs at entry doors to advise persons outside the room of the meaning of the horn(s), bell(s), and strobe light(s) outside the protected space.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections according to NFPA 12.

B. Carbon-dioxide fire-extinguishing system will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain carbon-dioxide fire-extinguishing system.

END OF SECTION 212113.16

SECTION 212200 - CLEAN-AGENT FIRE-EXTINGUISHING SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Clean-agent systems.
2. Pipe and fittings.
3. Valves.
4. Extinguishing-agent containers.
5. Fire-extinguishing clean agent.
6. Discharge nozzles.
7. Fire control panels.
8. Detection devices.
9. Manual stations.
10. Switches.
11. Alarm devices.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Sustainable Design Submittals:

C. Shop Drawings: For clean-agent fire-extinguishing system signed and sealed by a qualified professional engineer.

1. Include plans, elevations, sections, details, and attachments to other work.
2. Include design calculations.
3. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4. Wiring Diagrams: For power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Design Data:

1. Permit Approved Drawings: Working plans, prepared according to NFPA 2001, that have been approved by authorities having jurisdiction. Include design calculations.

B. Field quality-control reports.

C. Seismic Qualification Data: Certificates, for extinguishing-agent containers and control panels from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. FM Global Compliance: Provide components that are FM Approved and that are listed in FM Global's "Approval Guide."

C. UL Compliance: Provide equipment listed in UL's "Fire Protection Equipment Directory."

PART 2 - PRODUCTS

2.1 CLEAN-AGENT SYSTEMS

A. Description: Clean-agent fire-extinguishing system shall be an engineered system for total flooding of the hazard area including the room cavity above the ceiling, below the ceiling, and below the raised floor. System includes separate zones above and below the ceiling and beneath the raised floor. If smoke is detected below the raised floor, extinguishing agent shall be discharged in the underfloor zone only. If smoke is detected below the ceiling, extinguishing agent shall be discharged in zones above and below the ceiling and below the floor. If smoke is detected above the ceiling, extinguishing agent shall be discharged in the zone above the ceiling only.

B. Delegated Design: Design clean-agent fire-extinguishing system and obtain approval from authorities having jurisdiction. Design system for Class A, B, and C fires as appropriate for areas being protected, and include safety factor. Use clean agent indicated and in concentration suitable for normally occupied areas.

C. Performance Requirements: Discharge HFC 227ea within 10 seconds and maintain 7.1 percent concentration by volume at 70 deg F (21 deg C) for 10-minute holding time in hazard areas.

1. HFC 227ea concentration in hazard areas greater than 9.0 percent immediately after discharge or less than 5.8 percent throughout holding time will not be accepted without written authorization from Owner and authorities having jurisdiction.
2. System Capabilities: Minimum 620-psig (4278-kPa) calculated working pressure and 360-psig (2484-kPa) initial charging pressure.

D. Cross-Zoned Detection: Devices located in two separate zones. Sound alarm on activating single-detection device, and discharge extinguishing agent on actuating single-detection device in other zone.

E. System Operating Sequence:

1. Actuating First Detector: Visual indication on annunciator panel. Energize audible and visual alarms (slow pulse), shut down air-conditioning and ventilating systems serving protected area, close doors in protected area, and send signal to fire-alarm system.
2. Actuating Second Detector: Visual indication on annunciator panel. Energize audible and visual alarms (fast pulse), shut down power to protected equipment, start time delay for extinguishing-agent discharge for 30 seconds, and discharge extinguishing agent. On agent discharge, release preaction valve to allow water to fill sprinkler system.
3. Extinguishing-agent discharge will operate audible alarms and strobe lights inside and outside the protected area.

F. Manual stations shall immediately discharge extinguishing agent when activated.

G. Operating abort switches will delay extinguishing-agent discharge while being activated, and switches must be reset to prevent agent discharge. Release of hand pressure on the switch will cause agent discharge if the time delay has expired.

H. EPO: Will terminate power to protected equipment immediately on actuation.

I. Low-Agent Pressure Switch: Initiate trouble alarm if sensing less than set pressure.

J. Power Transfer Switch: Transfer from normal to stand-by power source.

K. Seismic Performance: Fire-suppression piping and containers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.2 PIPE AND FITTINGS

A. See "HFC 227ea Agent Piping Applications." Article for applications of pipe, tube, fitting, and joining materials.

B. Piping, Valves, and Discharge Nozzles: Comply with types and standards listed in NFPA 2001, Section "Distribution," for charging pressure of system.

C. Steel Pipe: ASTM A53/A53M, Type S, Grade B or ASTM A106/A106M, Grade A; Schedule 40, Schedule 80, and Schedule 160, seamless steel pipe.

1. Threaded Fittings:

a. Malleable-Iron Fittings: ASME B16.3, Class 300.
b. Flanges and Flanged Fittings: ASME B16.5, Class 300 unless Class 600 is indicated.

c. Fittings Working Pressure: 620 psig (4278 kPa) minimum.
d. Flanged Joints: Class 300 minimum.

2. Forged-Steel Welding Fittings: ASME B16.11, Class 3000, socket pattern.
3. Steel, Grooved-End Fittings: FM Approved and NRTL listed, ASTM A47/A47M malleable iron or ASTM A536 ductile iron, with dimensions matching steel pipe and ends factory grooved according to AWWA C606.

D. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.

E. Flange Bolts and Nuts: ASME B18.2.1, carbon steel.

F. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

G. Steel, Keyed Couplings: UL 213, AWWA C606, approved or listed for clean-agent service, and matching steel-pipe dimensions. Include ASTM A536, ductile-iron housing, rubber gasket, and steel bolts and nuts.

2.3 VALVES

A. General Valve Requirements:

1. UL listed or FM Approved for use in fire-protection systems.
2. Compatible with type of clean agent used.

B. Container Valves: With rupture disc or solenoid and manual-release lever, capable of immediate and total agent discharge and suitable for intended flow capacity.

C. Valves in Sections of Closed Piping and Manifolds: Fabricate to prevent entrapment of liquid or install valve and separate pressure relief device.

D. Valves in Manifolds: Check valve; installed to prevent loss of extinguishing agent when container is removed from manifold.

2.4 EXTINGUISHING-AGENT CONTAINERS

A. Description: Steel tanks complying with ASME Boiler and Pressure Vessel Code: Section VIII, for unfired pressure vessels. Include minimum working-pressure rating that matches system charging pressure, valve, pressure switch, and pressure gage.

1. Finish: As directed Red or Manufacturer's standard color, enamel or epoxy paint.
2. Manifold: Fabricate with valves, pressure switches, and connections for multiple storage containers, as indicated.
3. Manifold: Fabricate with valves, pressure switches, selector switch, and connections for main- and reserve-supply banks of multiple storage containers.

4. Storage-Tank Brackets: Factory- or field-fabricated retaining brackets consisting of steel straps and channels; suitable for container support, maintenance, and tank refilling or replacement.

2.5 FIRE-EXTINGUISHING CLEAN AGENT

A. HFC 227ea Clean Agent: Heptafluoropropane.

2.6 DISCHARGE NOZZLES

A. Equipment manufacturer's standard one-piece brass or aluminum alloy of type, size, discharge pattern, and capacity required for application.

B. Material: Corrosion-resistant metal.

C. Stamped with orifice size and type.

2.7 FIRE CONTROL PANEL

A. Description: FM Approved or NRTL listed, including equipment and features required for testing, supervising, and operating fire-extinguishing system.

B. Power Requirements: 120/240-V ac; with electrical contacts for connection to system components and fire-alarm system, and transformer or rectifier as needed to produce power at voltage required for accessories and alarm devices.

C. Enclosure: NEMA ICS 6, Type 1, enameled-steel cabinet.

1. Mounting: As directed Recessed flush with surface or Surface.

D. Supervised Circuits: Separate circuits for each independent hazard area.

1. Detection circuits equal to the required number of zones, or addressable devices assigned to the required number of zones.
2. Manual pull-station circuit.
3. Alarm circuit.
4. Release circuit.
5. Abort circuit.
6. EPO circuit.

E. Control-Panel Features:

1. Electrical contacts for shutting down fans, activating dampers, and operating system electrical devices.
2. Automatic switchover to standby power at loss of primary power.
3. Storage container, low-pressure indicator.
4. Service disconnect to interrupt system operation for maintenance with visual status indication on the annunciator panel.

F. Annunciator Panel: Graphic type showing protected, hazard-area plans, as well as locations of detectors and abort, EPO, and manual stations. Include lamps to indicate device-initiating alarm, electrical contacts for connection to control panel, and stainless-steel or aluminum enclosure.

G. Standby Power: As directed Sealed lead calcium, Sealed, valve-regulated, recombinant lead acid or Vented, wet-cell pocket, plate nickel cadmium batteries with capacity to operate system for 24 hours and alarm for minimum of 15 minutes. Include automatic battery charger that has a varying charging rate between trickle and high depending on battery voltage, and that is capable of maintaining batteries fully charged. Include manual voltage control, dc voltmeter, dc ammeter, electrical contacts for connection to control panel, automatic transfer switch, and suitable enclosure.

2.8 DETECTION DEVICES

A. General Requirements for Detection Devices:

1. Comply with NFPA 2001, NFPA 72, and UL 268.
2. 24-V dc, nominal.

B. Ionization Detectors: Dual-chamber type, having sampling and referencing chambers, with smoke-sensing element.

C. Photoelectric Detectors: LED light source and silicon photodiode receiving element.

D. Signals to the Central Fire Alarm Control Panel: Any type of local system trouble is reported to the central fire alarm control panel as a composite "trouble" signal. Alarms on each system zone are individually reported to the central fire alarm control panel as separately identified zones.

2.9 MANUAL STATIONS

A. General Description: As directed Surface or Semi-recessed FM Approved or NRTL listed, with clear plastic hinged cover, 120-V ac or low voltage compatible with controls. Include contacts for connection to control panel.

B. Manual Release: "MANUAL RELEASE" caption, and red finish. Unit can manually discharge extinguishing agent with operating device that remains engaged until unlocked.

C. Abort Switch: "ABORT" caption, momentary contact, with green finish.

D. EPO Switch: "EPO" caption, with yellow finish.

2.10 SWITCHES

A. Description: FM Approved or NRTL listed, where available, 120-V ac or low voltage compatible with controls. Include contacts for connection to control panel.

1. Low-Agent Pressure Switches: Pneumatic operation.

2. Power Transfer Switches: Key-operation selector, for transfer of release circuit signal from main supply to reserve supply.
3. Door Closers: Magnetic retaining and release device or electrical interlock to cause the door operator to drive the door closed.

2.11 ALARM DEVICES

A. Description: Listed and labeled by an NRTL or FM Approved, low voltage, and surface mounting. Comply with requirements in Section 284621.11 "Addressable Fire-Alarm Systems" or Section 284621.13 "Conventional Fire-Alarm Systems" for alarm and monitoring devices.

B. Bells: Minimum 6-inch (150-mm) diameter.

C. Horns: 90 to 94 dBA.

D. Strobe Lights: Translucent lens, with "FIRE" or similar caption.

PART 3 - EXECUTION

3.1 HFC 227ea AGENT PIPING APPLICATIONS

A. Flanged pipe and fittings and flanged joints may be used to connect to specialties and accessories and where required for maintenance.

B. NPS 2 (DN 50) and Smaller: Schedule 40, steel pipe; malleable-iron threaded fittings; and threaded joints.

C. NPS 2-1/2 (DN 65) and Larger: Schedule 40, steel pipe; forged-steel welding fittings; and welded joints or steel, grooved-end fittings; steel, keyed couplings; and grooved joints as directed.

3.2 CLEAN-AGENT PIPING INSTALLATION

A. Install clean-agent extinguishing piping and other components level and plumb, according to manufacturers' written instructions.

B. Grooved Piping Joints: Groove pipe ends according to AWWA C606 dimensions. Assemble grooved-end steel pipe and steel, grooved-end fittings with steel, keyed couplings and lubricant according to manufacturer's written instructions.

C. Install extinguishing-agent containers anchored to substrate.

D. Install pipe and fittings, valves, and discharge nozzles according to requirements listed in NFPA 2001, Section "Distribution."

1. Install valves designed to prevent entrapment of liquid or install pressure relief devices in valved sections of piping systems.
2. Support piping using supports and methods according to NFPA 13.

3. Install seismic restraints for extinguishing-agent containers and piping systems.
4. Install control panels, detection system components, alarms, and accessories, complying with requirements of NFPA 2001, Section "Detection, Actuation, and Control Systems," as required for supervised system application.

E. Drawings indicate general arrangement of piping, fittings, and specialties.

F. Where installing piping adjacent to equipment, allow space for service and maintenance.

G. Connect electrical devices to control panel and to building's fire-alarm system. Electrical power, wiring, and devices are specified in Section 284621.11 "Addressable Fire-Alarm Systems" or Section 284621.13 "Conventional Fire-Alarm Systems."

H. Identify piping, extinguishing-agent containers, other equipment, and panels according to NFPA 2001.

I. Install signs at entry doors for protected areas to warn occupants that they are entering a room protected with a clean-agent fire-extinguishing system.

J. Install signs at entry doors to advise persons outside the room the meaning of the horn(s), bell(s), and strobe light(s) outside the protected space.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. After installing clean-agent extinguishing piping system and after electrical circuitry has been energized, test for compliance with requirements.
2. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Sections "Inspection and Test Procedures" and "System Function Tests." Certify compliance with test parameters.
3. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
4. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.
5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Units will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.4 SYSTEM FILLING

A. Preparation:

1. Verify that piping system installation is completed and cleaned.
2. Check for complete enclosure integrity.
3. Check operation of ventilation and exhaust systems.

B. Filling Procedures:

1. Fill extinguishing-agent containers with extinguishing agent and pressurize to indicated charging pressure.
2. Install filled extinguishing-agent containers.
3. Energize circuits.
4. Adjust operating controls.

3.5 DEMONSTRATION

A. As directed Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain clean-agent fire-extinguishing systems.

END OF SECTION 212200

SECTION 213113 - ELECTRIC-DRIVE, CENTRIFUGAL FIRE PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. End-suction fire pumps.
2. In-line fire pumps.
3. Fire-pump accessories and specialties.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For fire pumps, motor drivers, and fire-pump accessories and specialties.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For fire pumps, accessories, and components, from manufacturer.

B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. NFPA Compliance: Comply with NFPA 20.

B. Seismic Performance: Fire pumps shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5.

C. Pump Equipment, Accessory, and Specialty Pressure Rating: 175 psig (1200 kPa) minimum unless higher pressure rating is indicated.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 GENERAL REQUIREMENTS FOR CENTRIFUGAL FIRE PUMPS

A. Description: Factory-assembled and -tested fire-pump and driver unit.

B. Base: Fabricated and attached to fire-pump and driver unit, with reinforcement to resist movement of pump during seismic events when base is anchored to building substrate.

C. Finish: Red paint applied to factory-assembled and -tested unit before shipping.

2.3 END-SUCTION FIRE PUMPS

A. Pump:

1. Standard: UL 448, for end-suction pumps for fire service.
2. Casing: Radially split case, top centerline discharge, self-venting, cast iron, with ASME B16.1 pipe-flange connections.
3. Impeller: Cast bronze, statically and dynamically balanced, and keyed to shaft.
4. Wear Rings: Replaceable bronze.
5. Shaft and Sleeve: As directed shaft with bronze or stainless-steel sleeves.

    a. Shaft Bearings: Grease-lubricated, back-to-back thrust ball bearings and one radial roller bearing.
    b. Seals: Stuffing box with minimum of four rings of graphite-impregnated braided yarn and bronze packing gland.

6. Mounting: Back pullout design, allowing complete rotating assembly removal without disturbing the casing piping connections. Pump and driver shafts are horizontal, with pump and driver on same base.

B. Coupling: Flexible and capable of absorbing torsional vibration and shaft misalignment. Include metal coupling guard.

C. Driver:

1. Standard: UL 1004A.
2. Type: Electric motor; NEMA MG 1, polyphase Design B.

D. Capacities and Characteristics:

1. Rated Capacity: As directed.
2. Total Rated Head: As directed.
3. Inlet Flange: As directed Class 125 or Class 250.
4. Outlet Flange: As directed Class 125 or Class 250.
5. Suction Head Available at Pump: As directed.
6. Motor Horsepower: As directed.
7. Motor Speed: As directed.
8. Electrical Characteristics:

    a. Volts: As directed 208, 230 or 460 V.
    b. Phase: Three.
    c. Hertz: 60.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed.
    f. Maximum Overcurrent Protection: As directed.

9. Pump-Start, Pressure-Switch Setting: As directed.
10. Pump-Stop, Pressure-Switch Setting: As directed.

2.4 IN-LINE FIRE PUMPS

A. Pump:

1. Standard: UL 448, for in-line pumps for fire service.
2. Casing: Radially split case, cast iron, with ASME B16.1 pipe-flange connections.
3. Impeller: Cast bronze, statically and dynamically balanced, and keyed to shaft.
4. Wear Rings: Replaceable bronze.
5. Shaft and Sleeve: Steel shaft with bronze sleeve.

    a. Shaft Bearings: Grease-lubricated ball bearings in cast-iron housing.
    b. Seals: Stuffing box with minimum of four rings of graphite-impregnated braided yarn and bronze packing gland.

6. Mounting: Pump and driver shaft is vertical, with motor above pump and pump on base. Motor and pump rotating assembly shall be removable from top without removing the pump casing from the piping.

B. Coupling: None or rigid.

C. Driver:

1. Standard: UL 1004A.
2. Type: Electric motor; NEMA MG 1, polyphase Design B.

D. Capacities and Characteristics:

1. Rated Capacity: As directed.
2. Total Rated Head: As directed.
3. Inlet Flange: As directed Class 125 or Class 250.
4. Outlet Flange: As directed Class 125 or Class 250.

5. Suction Head Available at Pump: As directed.
6. Motor Horsepower: As directed.
7. Motor Speed: As directed.
8. Electrical Characteristics:

    a. Volts: As directed 208, 230 or 460 V.
    b. Phase: Three.
    c. Hertz: 60.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed.
    f. Maximum Overcurrent Protection: As directed.

9. Pump-Start, Pressure-Switch Setting: As directed.
10. Pump-Stop, Pressure-Switch Setting: As directed.

2.5 FIRE-PUMP ACCESSORIES AND SPECIALTIES

A. Automatic Air-Release Valves: Comply with NFPA 20 for installation in fire-pump casing.

B. Circulation Relief Valves: UL 1478, brass, spring loaded; for installation in pump discharge piping.

C. Relief Valves:
1. Description: UL 1478, bronze or cast iron, spring loaded; for installation in fire-suppression water-supply piping.

D. Inlet Fitting: Eccentric tapered reducer at pump suction inlet.

E. Outlet Fitting: Concentric tapered reducer at pump discharge outlet.

F. Discharge Cone: As directed Closed, Open or Closed or open type.

2.6 GROUT

A. Standard: ASTM C1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Non-shrink and recommended for interior and exterior applications.

C. Design Mix: 5000-psi (34-MPa), 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Fire-Pump Installation Standard: Comply with NFPA 20 for installation of fire pumps, relief valves, and related components.

B. Equipment Mounting:

1. Install fire pumps on cast-in-place concrete equipment bases. As directed Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."
3. Comply with requirements for vibration isolation devices specified in Section 210548.13 "Vibration Controls for Fire-Suppression Piping and Equipment."

C. Install fire-pump suction and discharge piping equal to or larger than sizes required by NFPA 20.

D. Support piping and pumps separately, so weight of piping does not rest on pumps.

E. Install valves that are same size as connecting piping. As directed Comply with requirements for fire-protection valves specified in Section 211200 "Fire-Suppression Standpipes" or Section 211313 "Wet-Pipe Sprinkler Systems."

F. Install pressure gages on fire-pump suction and discharge flange pressure-gage tappings. As directed Comply with requirements for pressure gages specified in Section 211200 "Fire-Suppression Standpipes" or Section 211313 "Wet-Pipe Sprinkler Systems."

G. Install piping hangers and supports, anchors, valves, gages, and equipment supports according to NFPA 20.

H. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not factory mounted. Furnish copies of manufacturers' wiring diagram submittals to electrical Installer.

I. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

3.2 ALIGNMENT

A. Align end-suction pump and driver shafts after complete unit has been leveled on concrete base, grout has set, and anchor bolts have been tightened.

B. After alignment is correct, tighten anchor bolts evenly. Fill baseplate completely with grout, with metal blocks and shims or wedges in place. Tighten anchor bolts after grout has hardened. Check alignment and make required corrections.

C. Align piping connections.

D. Align pump and driver shafts for angular and parallel alignment according to HI 1.4 and to tolerances specified by manufacturer.

3.3 CONNECTIONS

A. As directed Comply with requirements for piping and valves specified in Section 211200 "Fire-Suppression Standpipes" or Section 211313 "Wet-Pipe Sprinkler Systems." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to pumps and equipment to allow service and maintenance.

C. Connect relief-valve discharge to drainage piping or point of discharge.

D. Connect flowmeter-system meters, sensors, and valves to tubing.

E. Connect fire pumps to their controllers.

3.4 IDENTIFICATION

A. Identify system components. Comply with requirements for fire-pump marking according to NFPA 20.

3.5 FIELD QUALITY CONTROL

A. Test each fire pump with its controller as a unit. Comply with requirements for electric-motor-driver fire-pump controllers specified in Section 2623933 "Controllers for Fire-Pump Drivers."

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative.

1. After installing components, assemblies, and equipment, including controller, test for compliance with requirements.
2. Test according to NFPA 20 for acceptance and performance testing.
3. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
4. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Components, assemblies, and equipment will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

E. Furnish fire hoses in number, size, and length required to reach storm drain or other acceptable location to dispose of fire-pump test water. Hoses are for tests only and do not convey to Owner.

3.6 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

END OF SECTION 213113

SECTION 213116 - DIESEL-DRIVE, CENTRIFUGAL FIRE PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Single-stage, split-case fire pumps with diesel-engine drive.
2. Fire-pump accessories and specialties.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For each fire pump.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of fire pumps.
4. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
5. Include diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal: For fire pumps.

1. Include design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For fire pumps, accessories, and components, from manufacturer.

B. Product Certificates: For each type of fire pump.

C. Source quality-control reports.

D. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Fire pumps shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

B. Environmental Conditions:

1. Ambient Temperature: As directed 5 to 40 deg C or Minus 15 to plus 40 deg C.
2. Relative Humidity: Zero to 95 percent.
3. Altitude: Sea level to 1000 feet (300 m).

C. Pump Equipment, Accessory, and Specialty Pressure Rating: 175 psig (1200 kPa) minimum unless higher pressure rating is indicated.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 ASSEMBLY DESCRIPTION

A. Description: Factory-assembled and -tested fire-pump and driver unit.

B. Assembly Attachment to Base: Fabricate mounting base and attachment to fire-pump assembly with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC" when mounting base is anchored to building structure.

C. Finish: Red paint applied to factory-assembled and -tested unit before shipping.

D. NFPA Compliance: Comply with NFPA 20.

2.3 SINGLE-STAGE, SPLIT-CASE FIRE PUMPS

A. Pump:

1. Standard: UL 448, for split-case pumps for fire service.
2. Casing: Axially split case, cast iron with ASME B16.1 pipe-flange connections.
3. Impeller: Double suction, cast bronze, statically and dynamically balanced, and keyed to shaft.
4. Wear Rings: Replaceable bronze.
5. Shaft and Sleeve: Alloy-steel shaft with bronze sleeve.

a. Shaft Bearings: Grease-lubricated ball bearings in cast-iron housing.

b. Seals: Stuffing box with minimum of four rings of graphite-impregnated braided yarn and bronze packing gland.

6. Mounting: Pump and driver shafts are horizontal, with pump and driver on same base.

B. Coupling: Flexible and capable of absorbing torsional vibration and shaft misalignment. Include metal coupling guard.

C. Capacities and Characteristics:

1. Rated Capacity: As directed.
2. Total Rated Head: As directed.
3. Inlet Flange: As directed Class 125 or Class 250.
4. Outlet Flange: As directed Class 125 or Class 250.
5. Suction Head Available at Pump: As directed.
6. Engine Horsepower: As directed.
7. Engine Speed: As directed.
8. Fuel Tank Capacity: As directed.
9. Pump-Start, Pressure-Switch Setting: As directed.
10. Pump-Stop, Pressure-Switch Setting: As directed.
11. Rotation As directed Clockwise or Counterclockwise.

2.4 DIESEL ENGINE

A. Fuel: Fuel oil, Grade DF-2.

B. Horse Power Rating: Not less than 110 percent of maximum brake horsepower (after derating for temperature and elevation according to NFPA 20).

C. Emergency Manual Operator: Factory wired for starting and operating standby engine in case of malfunction in main controller or wiring.

D. Controls:

1. Adjustable governor.
2. Over-speed shutdown.
3. Manual reset, speed switch.
4. Instrument panel with tachometer, oil pressure gage, water temperature gage, and hour meter.

E. Fuel System:

1. Comply with NFPA 20.
2. Main Fuel Pump: Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.
3. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.
4. Flexible metallic fuel lines.
5. Inline fuel filter.
6. Oil pressure safety switch.

7. Air cleaner.
8. Engine-driven oil pump.
9. Enclosed control wiring electric starter with voltage regulator.
10. Double-Wall Storage Tank: Size indicated, but not less than required by NFPA 20; with floor legs, direct-reading level gage, and secondary containment tank having capacity at least equal to storage tank.

F. Exhaust System:

1. Piping: ASTM A53/A53M, Type E or S, Schedule 40 black steel pipe; ASME B16.9 weld-type pipe fittings; ASME B16.5 steel flanges; and ASME B16.21 nonmetallic gaskets.
2. Fabricate double-wall, ventilated thimble from steel pipe.
3. Flexible exhaust connector.
4. As directed Industrial or Residential exhaust silencer with spark arrestor.

G. Rated Engine Speed: 1800 rpm.

H. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm (11.4 m/s).

I. Engine- or Skid-Mounted Lubrication System:

1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
2. Thermostatic Control Valve: Controls flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

J. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system.

K. Cooling System:

1. Factory installed, closed loop, liquid cooled, with radiator factory mounted on fire-pump mounting frame and integral engine-driven coolant pump.
2. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
3. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
4. Expansion Tank: Constructed of welded-steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
5. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
6. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.

    a. Rating: 50-psig (345-kPa) maximum working pressure, with coolant at 180 deg F (82 deg C), and non-collapsible under vacuum.

b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

L. Muffler/Silencer: Residential type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

1. Minimum sound attenuation of 18 dB at 500 Hz.
2. Sound level measured at a distance of 10 feet (3 m) from exhaust discharge after installation is complete shall be 95 dBA or less.

M. Air-Intake Filter: Standard-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

N. Starting System: As directed 12 or 24-V dc, with negative ground.

1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in "Performance Requirements" Article.
2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
3. Cranking Cycle: 60 seconds.
4. Battery: Adequate capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least twice without recharging.
5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 10 deg C regardless of external ambient temperature within range specified in "Performance Requirements" Article. Include accessories required to support and fasten batteries in place.
7. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
8. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236 and include the following features:

a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
e. Enclosure and Mounting: NEMA 250, Type 1 wall-mounted cabinet.

2.5 FIRE-PUMP ACCESSORIES AND SPECIALTIES

A. Automatic Air-Release Valves: Comply with NFPA 20 for installation in fire-pump casing.

B. Circulation Relief Valves: UL 1478, bronze or cast iron, spring loaded; for installation in pump-discharge piping.

C. Inlet Fitting: Eccentric tapered reducer at pump suction inlet.

D. Outlet Fitting: Concentric tapered reducer at pump-discharge outlet.

E. Discharge Cone: As directed Closed, Open or Closed or open type.

F. Hose Valve Manifold Assembly:

1. Standard: Comply with requirements in NFPA 20.
2. Header Pipe: ASTM A53/A53M, Schedule 40 galvanized steel, with ends threaded according to ASME B1.20.1.
3. Header Pipe Fittings: ASME B16.4 galvanized cast-iron threaded fittings.
4. Automatic Drain Valve: Complying with UL 1726.
5. Manifold:

    a. Test Connections: Comply with UL 405, except provide outlets without clappers instead of inlets.
    b. Body: As directed Flush or Exposed-type, brass or ductile iron, with number of outlets required by NFPA 20.
    c. Escutcheon Plate: Brass or bronze; rectangular.
    d. Exposed Parts Finish: As directed Polished brass, Rough brass or Chrome-plated brass.
    e. Escutcheon Plate Marking: Equivalent to "FIRE PUMP TEST."

2.6 FUEL OIL STORAGE

A. Comply with NFPA 30.

B. Day Tank: UL 142, freestanding, factory-fabricated fuel tank assembly, with integral, float-controlled transfer pump and the following features:

1. Containment: Integral rupture basin, with a capacity of 150 percent of nominal capacity of day tank.

    a. Leak Detector: Locate in rupture basin and connect to provide audible and visual alarm in the event of day-tank leak.

2. Tank Capacity: As recommended by engine manufacturer.
3. Pump Capacity: Exceeds maximum flow of fuel drawn by engine-mounted fuel supply pump at 110 percent of rated capacity, including fuel returned from engine.
4. Low-Level Alarm Sensor: Liquid-level device operates alarm contacts at 25 percent of normal fuel level.

5. Piping Connections: Factory-installed fuel supply and return lines from tank to engine; local fuel fill, vent line, overflow line; and tank drain line with shutoff valve.

C. Base-Mounted Fuel Oil Tank: Factory installed and piped, complying with UL 142 fuel oil tank. Features include the following:

1. Tank level indicator.
2. Capacity: Fuel for eight hours' continuous operation at 100 percent rated power output.
3. Vandal-resistant fill cap.
4. Containment Provisions: Comply with requirements of authorities having jurisdiction.

2.7 GROUT

A. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Non-shrink and recommended for interior and exterior applications.

C. Design Mix: 5000-psi (34-MPa), 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.8 SOURCE QUALITY CONTROL

A. Testing: Test and inspect fire pumps according to UL 448 requirements for "Operation Test" and "Manufacturing and Production Tests."

1. Verification of Performance: Rate fire pumps according to UL 448.

B. Fire pumps will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Fire-Pump Installation Standard: Comply with NFPA 20 for installation of fire pumps, relief valves, and related components.

B. Equipment Mounting:

1. Install fire pumps on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.
2. Attach pumps to equipment base using anchor bolts.

3. Comply with requirements for vibration isolation and seismic control devices specified in Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."
4. Comply with requirements for vibration isolation devices specified in Section 210548.13 "Vibration Controls for Fire-Suppression Piping and Equipment."

C. Install fire-pump suction and discharge piping equal to or larger than sizes required by NFPA 20.

D. Support piping and pumps separately, so weight of piping does not rest on pumps.

E. Install valves that are same size as connecting piping. Comply with requirements for fire-protection valves specified in Section 211200 "Fire-Suppression Standpipes" or Section 211313 "Wet-Pipe Sprinkler Systems" as directed

F. Install pressure gages on fire-pump suction and discharge flange pressure-gage tappings. Comply with requirements for pressure gages specified in Section 211200 "Fire-Suppression Standpipes" or Section 211313 "Wet-Pipe Sprinkler Systems" as directed.

G. Install piping hangers and supports, anchors, valves, gages, and equipment supports according to NFPA 20.

H. Install fuel system according to NFPA 20.

I. Install water supply and drain piping for diesel-engine heat exchangers. Extend drain piping from heat exchangers to point of disposal.

J. Install exhaust-system piping for diesel engines. Extend to point of termination outside structure. Install pipe and fittings with welded joints; install components having flanged connections with gasketed joints.

K. Install condensate-drain piping for diesel-engine exhaust system. Extend drain piping from low points of exhaust system to condensate traps and to point of disposal.

L. Electrical Wiring: Install electrical devices furnished by equipment manufacturers that are not factory mounted. Furnish copies of manufacturers' wiring diagram submittals to electrical Installer.

M. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

N. Align split-case pump and driver shafts after complete unit has been leveled on concrete base, grout has set, and anchor bolts have been tightened.

O. After alignment is correct, tighten anchor bolts evenly. Fill baseplate completely with grout, with metal blocks and shims or wedges in place. Tighten anchor bolts after grout has hardened. Check alignment and make required corrections.

P. Align piping connections.

Q. Align pump and driver shafts for angular and parallel alignment according to HI 1.4 and to tolerances specified by manufacturer.

R. Comply with requirements for piping and valves specified in Section 211200 "Fire-Suppression Standpipes" or Section 211313 "Wet-Pipe Sprinkler Systems" as directed. Drawings indicate general arrangement of piping, fittings, and specialties.

S. Install piping adjacent to pumps and equipment to allow service and maintenance.

T. Connect relief-valve discharge to drainage piping or point of discharge.

U. Connect fire pumps to their controllers.

V. Identify system components. Comply with requirements for fire-pump marking according to NFPA 20.

3.2 FIELD QUALITY CONTROL

A. Test each fire pump with its controller as a unit. Comply with requirements for diesel-engine-driver fire-pump controllers specified in Section 262933 "Controllers for Fire-Pump Drivers."

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. After installing components, assemblies, and equipment, including controller, test for compliance with requirements.
2. Test according to NFPA 20 for acceptance and performance testing.
3. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
4. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Components, assemblies, and equipment will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

E. Furnish fire hoses in number, size, and length required to reach storm drain or other acceptable location to dispose of fire-pump test water. Hoses are for tests only and do not convey to Owner.

3.3 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.4 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain fire pumps.

END OF SECTION 213116

SECTION 213213 - ELECTRIC-DRIVE, VERTICAL-TURBINE FIRE PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes vertical-turbine fire pumps, accessories, and specialties:

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For fire pumps, motor drivers, and fire-pump accessories and specialties.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For fire pumps, accessories, and components, from manufacturer.

B. Product Certificates: For each type of fire pump, from manufacturer.

C. Source quality-control reports.

D. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. NFPA Compliance: Comply with NFPA 20.

B. Seismic Performance: Fire pumps shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5.

C. Pump Equipment, Accessory, and Specialty Pressure Rating: 175 psig (1200 kPa) minimum unless higher pressure rating is indicated.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 ASSEMBLY DESCRIPTION

A. Description: Factory-assembled and -tested fire-pump and driver unit.

B. Base: Fabricated and attached to fire-pump and driver unit, with reinforcement to resist movement of pump during seismic events when base is anchored to building substrate.

C. Finish: Red paint applied to factory-assembled and -tested unit before shipping.

2.3 VERTICAL-TURBINE FIRE PUMPS

A. Pump Head: Cast iron, for surface discharge.

1. Discharge Outlet: Flanged with flanges complying with ASME B16.1; except connections may be threaded according to ASME B1.20.1, in sizes where flanges are not available.
2. Pump Head Seal: Stuffing box and packing.
3. Base: Cast iron or steel with hole for electrical cable.

B. Pump:

1. Standard: UL 448, for vertical-turbine pumps for fire service.
2. Discharge Head: High profile, with flange above ground outlet Class 125 for cast iron, and with flange above ground outlet Class 150 for steel, with 0.5-inch (12.7-mm) NPT pressure gauge connection.
3. Stuffing Box: Cast iron with packing rings, pressure-relief connection, stainless-steel packing gland, bronze bearing, and rubber slinger.
4. Line Shaft: Stainless steel in sections 10 feet (3 m) or less, with left-hand threaded steel couplings, centering spiders, and fluted rubber bearings.
5. Line Shaft Bearings: Bronze, water lubricated.
6. Bowl Section: Multiple close-grained, flanged cast-iron bowls. Intermediate bowls have enamel-lined waterways for maximum efficiency and wear protection, and they are of identical design for interchangeability. Bowls are fitted with bronze or neoprene bearings as directed.
7. Impeller: As directed Closed type, silicon bronze or stainless steel, dynamically balanced, and securely fastened to the bowl.
8. Suction Bell: Close-grained cast-iron bowl with bronze bearing and bronze sand collar.

9. Wear Rings: Bronze located in the suction and intermediate bowls and with minimum clearance to the surface of the impeller.
10. Column Pipe: ASTM A53/A53M, Schedule 40, galvanized-steel pipe with threaded sleeve couplings or rabbet fit flange ends in sections of 10 feet (3 m) or less.
11. Suction Strainer: Cast or fabricated; bronze, stainless steel, or Monel; and sized to restrict passage of 0.5-inch (12.7-mm) diameter objects.

C. Driver:

1. Standard: UL 1004A.
2. Type: Electric motor; NEMA MG 1, polyphase Design B.
3. Mounting: On pump head above pump.

D. Capacities and Characteristics:

1. Rated Capacity: As directed.
2. Total Rated Head: As directed.
3. Inlet Column Size: As directed.
4. Pump Column Length: As directed.
5. Pump Head Outlet Flange: Class 125 or Class 250 As directed.
6. Suction Head Available at Pump: As directed.
7. Motor Horsepower: As directed.
8. Motor Speed: As directed.
9. Electrical Characteristics:

    a. Volts: 208, 230 or 460 V As directed.
    b. Phase: Three.
    c. Hertz: 60.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed.
    f. Maximum Overcurrent Protection: As directed.

10. Pump-Start, Pressure-Switch Setting: As directed.
11. Pump-Stop, Pressure-Switch Setting: As directed.

2.4 FIRE-PUMP ACCESSORIES AND SPECIALTIES

A. Automatic Air-Release Valves: Comply with NFPA 20 for installation in fire-pump discharge piping.

B. Relief Valves:
1. Description: UL 1478, bronze or cast iron, spring loaded; for installation in fire-suppression water-supply piping.

C. Outlet Fitting: Concentric tapered reducer at pump-head discharge outlet.

D. Discharge Cone: Closed, Open or Closed or open type as directed.

E. Hose Valve Manifold Assembly:

1. Standard: Comply with requirements in NFPA 20.
2. Header Pipe: ASTM A53/A53M, Schedule 40, galvanized steel, with ends threaded according to ASME B1.20.1.
3. Header Pipe Fittings: ASME B16.4, galvanized cast-iron threaded fittings.
4. Automatic Drain Valve: UL 1726.
5. Manifold:

    a. Test Connections: Comply with UL 405; however, provide outlets without clappers instead of inlets.
    b. Body: Exposed type, brass, with number of outlets required by NFPA 20.
    c. Escutcheon Plate: Brass or bronze; round.
    d. Exposed Parts Finish: Polished, Rough, brass, chrome plated as directed.
    e. Escutcheon Plate Marking: Equivalent to "FIRE PUMP TEST."

2.5 GROUT

A. Standard: ASTM C1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Non-shrink and recommended for interior and exterior applications.

C. Design Mix: 5000-psi (34-MPa), 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.6 SOURCE QUALITY CONTROL

A. Testing: Test and inspect fire pumps according to UL 448 requirements for "Operation Test" and "Manufacturing and Production Tests."

1. Verification of Performance: Rate fire pumps according to UL 448.

B. Fire pumps will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Fire-Pump Installation Standard: Comply with NFPA 20 for installation of fire pumps, relief valves, and related components.

B. Equipment Mounting:

1. Install fire pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed

2. Comply with requirements for vibration isolation and seismic control devices specified in Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."
3. Comply with requirements for vibration isolation devices specified in Section 210548.13 "Vibration Controls for Fire-Suppression Piping and Equipment."

C. Install fire-pump discharge piping equal to or larger than size required by NFPA 20.

D. Support piping and pumps separately, so weight of piping does not rest on pumps.

E. Install valves that are same size as connecting piping. Comply with requirements for fire-protection valves specified in Section 211200 "Fire-Suppression Standpipes" or Section 211313 "Wet-Pipe Sprinkler Systems" as directed

F. Install pressure gage on pump-head discharge flange pressure-gage tapping. Comply with requirements for pressure gages specified in Section 211200 "Fire-Suppression Standpipes" or Section 211313 "Wet-Pipe Sprinkler Systems" as directed.

G. Install piping hangers and supports, anchors, valves, gages, and equipment supports according to NFPA 20.

H. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not factory mounted. Furnish copies of manufacturers' wiring diagram submittals to electrical Installer.

I. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

3.2 ALIGNMENT

A. Align pump and driver shafts after complete unit has been leveled on concrete base, grout has set, and anchor bolts have been tightened.

B. After alignment is correct, tighten anchor bolts evenly. Fill baseplate completely with grout, with metal blocks and shims or wedges in place. Tighten anchor bolts after grout has hardened. Check alignment and make required corrections.

C. Align piping connection.

D. Align pump and driver shafts for angular and parallel alignment according to HI 2.4 and to tolerances specified by manufacturer.

E. Comply with requirements for piping and valves specified in Section 211200 "Fire-Suppression Standpipes" or Section 211313 "Wet-Pipe Sprinkler Systems" as directed. Drawings indicate general arrangement of piping, fittings, and specialties.

F. Install piping adjacent to pumps and equipment to allow service and maintenance.

G. Connect relief-valve discharge to drainage piping or point of discharge.

H. Connect fire pumps to their controllers.

I. Identify system components. Comply with requirements for fire-pump marking according to NFPA 20.

3.3 FIELD QUALITY CONTROL

A. Test each fire pump with its controller as a unit. Comply with requirements for electric-motor-driver fire-pump controllers specified in Section 262933 "Controllers for Fire-Pump Drivers."

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative.

1. After installing components, assemblies, and equipment including controller, test for compliance with requirements.
2. Test according to NFPA 20 for acceptance and performance testing.
3. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
4. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Components, assemblies, and equipment will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

E. Furnish fire hoses in number, size, and length required to reach storm drain or other acceptable location to dispose of fire-pump test water. Hoses are for tests only and do not convey to Owner.

3.4 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain fire pumps.

END OF SECTION 213213

SECTION 213216 - DIESEL-DRIVE, VERTICAL-TURBINE FIRE PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Vertical-turbine fire pumps with diesel-engine drives.
2. Fire-pump accessories and specialties.
3. Fuel oil storage.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For fire pumps, right-angle gear drives, engine drivers, and fire-pump accessories and specialties.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of fire pumps.
4. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
5. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For fire pumps, accessories, and components, from manufacturer.

B. Product Certificates: For each type of fire pump.

C. Source quality-control reports.

D. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Fire pumps shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

B. Environmental Conditions:

1. Ambient Temperature: 5 to 40 deg C or Minus 15 to plus 40 deg C as directed.
2. Relative Humidity: Zero to 95 percent.
3. Altitude: Sea level to 1000 feet (300 m).

2.2 ASSEMBLY DESCRIPTION

A. Description: Factory-assembled and -tested fire pump, right-angle gear drive, and driver.

B. NFPA Compliance: Comply with NFPA 20.

C. Base: Fabricated and attached to fire pump, right-angle gear drive, and driver, with reinforcement to resist movement of pump, gear drive, and driver during seismic events when base is anchored to building substrate.

D. Finish: Red paint applied to factory-assembled and -tested unit before shipping.

E. Pump Equipment, Accessory, and Specialty Pressure Rating: 175 psig (1200 kPa) minimum unless higher pressure rating is indicated.

F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 VERTICAL-TURBINE FIRE PUMPS

A. Pump Head: Cast iron, for surface discharge.

1. Discharge Outlet: With flange according to ASME B16.1, except connections may be threaded according to ASME B1.20.1, in sizes where flanges are not available.
2. Pump Head Seal: Stuffing box and packing.
3. Base: Cast iron or steel with hole for electrical cable.

B. Pump:

1. Standard: UL 448, for vertical-turbine pumps for fire service.

2. Discharge Head: High-profile cast iron or steel with flanged, aboveground, outlet Class 125 for cast iron and Class 150 for steel, with NPS 1/2 (DN 50), threaded, pressure-gage connection.
3. Stuffing Box: Cast iron with packing rings, pressure relief connection, stainless-steel packing gland, bronze bearing, and rubber slinger.
4. Line Shaft: Stainless steel in sections 10 feet (3 m) or less, with left-hand threaded-steel couplings, centering spiders, and fluted rubber bearings.
5. Line Shaft Bearings: Bronze, water lubricated.
6. Bowl Section:

    a. Multiple close-grained, flanged cast-iron bowls.
    b. Intermediate bowls with enamel-lined waterways for maximum efficiency and wear protection and of identical design for interchangeability.
    c. Bowls fitted with bronze or neoprene bearings as directed.

7. Impeller: Closed-type silicon bronze or stainless steel dynamically balanced and securely fastened to bowl as directed.
8. Suction Bell: Close-grained cast-iron bowl with bronze bearing and bronze sand collar.
9. Wear Rings: Bronze located in the suction and intermediate bowls and with minimum clearance to the impeller surface.
10. Column Pipe: ASTM A53/A53M, Schedule 40, galvanized-steel pipe with threaded sleeve couplings or rabbet fit flange ends in sections 10 feet (3 m) or less.
11. Suction Strainer: Cast or fabricated; bronze, stainless steel, or Monel; and sized to restrict passage of 1/2-inch (13-mm) spheres.

C. Right-Angle Gear Drive: FM-Approved, speed-reduction gear drive for pump speed control. Provide ratio for outlet speed of approximately 1760 rpm.

D. Engine-to-Gear Drive Shaft: FM-Approved, telescoping, steel drive shaft with universal joint and grease fitting at each end. Include metal shaft guard.

E. Capacities and Characteristics:

1. Rated Capacity: As directed.
2. Total Rated Head: As directed.
3. Inlet Column Size: As directed.
4. Pump Column Length: As directed.
5. Pump Head Outlet Flange: Class 125 or Class 250 as directed.
6. Suction Head Available at Pump: As directed.
7. Engine Horsepower: As directed.
8. Engine Speed: As directed.
9. Fuel Tank Capacity: As directed.
10. Right-Angle Gear-Drive Speed-Reduction Ratio: 1:1 or 2:1 as directed.
11. Right-Angle Gear-Drive Outlet and Pump Speed: As directed.
12. Pump-Start, Pressure-Switch Setting: As directed.
13. Pump-Stop, Pressure-Switch Setting: As directed.

2.4 DIESEL-ENGINE DRIVER

A. Fuel: Fuel oil, Grade DF-2.

B. Horse Power Rating: Not less than 110 percent of maximum brake horsepower (after derating for temperature and elevation according to NFPA 20).

C. Emergency Manual Operator: Factory wired for starting and operating standby engine in case of malfunction in main controller or wiring.

D. Controls:

1. Adjustable governor.
2. Over-speed shutdown.
3. Manual reset, speed switch.
4. Instrument panel with tachometer, oil pressure gage, water temperature gage, and hour meter.

E. Fuel System:

1. Comply with NFPA 20.
2. Main Fuel Pump: Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.
3. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.
4. Flexible metallic fuel lines.
5. Inline fuel filter.
6. Oil pressure safety switch.
7. Air cleaner.
8. Engine-driven oil pump.
9. Enclosed control wiring electric starter with voltage regulator.
10. Double-Wall Storage Tank: Size indicated, but not less than required by NFPA 20; with floor legs, direct-reading level gage, and secondary containment tank having capacity at least equal to storage tank.

F. Exhaust System:

1. Piping: ASTM A53/A53M, Type E or S, Schedule 40 black steel pipe; ASME B16.9 weld-type pipe fittings; ASME B16.5 steel flanges; and ASME B16.21 nonmetallic gaskets.
2. Fabricate double-wall, ventilated thimble from steel pipe.
3. Flexible exhaust connector.
4. As directed Industrial or Residential exhaust silencer with spark arrestor.

G. Rated Engine Speed: 1800 rpm.

H. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm (11.4 m/s).

I. Engine- or Skid-Mounted Lubrication System:

1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
2. Thermostatic Control Valve: Controls flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.

3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

J. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system.

K. Cooling System:

1. Factory-installed, closed loop, liquid cooled, with radiator factory mounted on fire-pump mounting frame and integral engine-driven coolant pump.
2. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
3. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
4. Expansion Tank: Constructed of welded-steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
5. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
6. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.

    a. Rating: 50-psig (345-kPa) maximum working pressure, with coolant at 180 deg F (82 deg C), and non-collapsible under vacuum.
    b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

L. Muffler/Silencer: Residential type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

1. Minimum sound attenuation of 18 dB at 500 Hz.
2. Sound level measured at a distance of 10 feet (3 m) from exhaust discharge after installation is complete shall be 95 dBA or less.

M. Air-Intake Filter: Standard-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

N. Starting System: As directed 12 or 24-V dc, with negative ground.

1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in "Performance Requirements" Article.
2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
3. Cranking Cycle: 60 seconds.
4. Battery: Adequate capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least twice without recharging.
5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.

6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 10 deg C regardless of external ambient temperature within range specified in "Performance Requirements" Article. Include accessories required to support and fasten batteries in place.
7. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
8. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236 and include the following features:

    a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
    b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
    c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
    d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
    e. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.5 FIRE-PUMP ACCESSORIES AND SPECIALTIES

A. Automatic Air-Release Valves: Comply with NFPA 20 for installation in fire-pump discharge piping.

B. Relief Valves: UL 1478, bronze or cast iron, spring loaded; for installation in fire-suppression water-supply piping.

C. Outlet Fitting: Concentric tapered reducer at pump-head-discharge outlet.

D. Discharge Cone: Closed, Open or Closed or open type as directed.

E. Hose Valve Manifold Assembly:

1. Standard: Comply with requirements in NFPA 20.
2. Header Pipe: ASTM A53/A53M, Schedule 40 galvanized steel, with ends threaded according to ASME B1.20.1.
3. Header Pipe Fittings: ASME B16.4 galvanized cast-iron threaded fittings.
4. Automatic Drain Valve: Complying with UL 1726.
5. Manifold:

    a. Test Connections: Comply with UL 405, except provide outlets without clappers instead of inlets.
    b. Body: As directed Flush or Exposed-type, brass or ductile iron, with number of outlets required by NFPA 20.
    c. Escutcheon Plate: Brass or bronze; rectangular.

d. Exposed Parts Finish: Polished brass, Rough brass or Chrome plated brass as directed.
e. Escutcheon Plate Marking: Equivalent to "FIRE PUMP TEST."

2.6 FUEL OIL STORAGE

A. Comply with NFPA 30.

B. Day Tank: UL 142, freestanding, factory-fabricated fuel tank assembly, with integral, float-controlled transfer pump and the following features:

1. Containment: Integral rupture basin, with a capacity of 150 percent of nominal capacity of day tank.

a. Leak Detector: Locate in rupture basin and connect to provide audible and visual alarm in the event of day-tank leak.

2. Tank Capacity: As recommended by engine manufacturer.
3. Pump Capacity: Exceeds maximum flow of fuel drawn by engine-mounted fuel supply pump at 110 percent of rated capacity, including fuel returned from engine.
4. Low-Level Alarm Sensor: Liquid-level device operates alarm contacts at 25 percent of normal fuel level.
5. Piping Connections: Factory-installed fuel supply and return lines from tank to engine; local fuel fill, vent line, overflow line; and tank drain line with shutoff valve.

C. Base-Mounted Fuel Oil Tank: Factory installed and piped, complying with UL 142 fuel oil tank. Features include the following:

1. Tank level indicator.
2. Capacity: Fuel for eight hours' continuous operation at 100 percent rated power output.
3. Vandal-resistant fill cap.
4. Containment Provisions: Comply with requirements of authorities having jurisdiction.

2.7 GROUT

A. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Non-shrink and recommended for interior and exterior applications.

C. Design Mix: 5000-psi (34-MPa), 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.8 SOURCE QUALITY CONTROL

A. Testing: Test and inspect fire pumps according to UL 448 requirements for "Operation Test" and "Manufacturing and Production Tests."

1. Verification of Performance: Rate fire pumps according to UL 448.

B. Fire pumps will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Fire-Pump Installation Standard: Comply with NFPA 20 for installation of fire pumps, relief valves, and related components.

B. Equipment Mounting:

1. Install fire pumps on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.
2. Attach pumps to equipment base using anchor bolts.
3. Comply with requirements for vibration isolation and seismic control devices specified in Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."
4. Comply with requirements for vibration isolation devices specified in Section 210548.13 "Vibration Controls for Fire-Suppression Piping and Equipment."

C. Install fire-pump discharge piping equal to or larger than size required by NFPA 20.

D. Support piping and pumps separately, so weight of piping does not rest on pumps.

E. Install valves that are same size as connecting piping. Comply with requirements for fire-protection valves specified in Section 211200 "Fire-Suppression Standpipes" or Section 211313 "Wet-Pipe Sprinkler Systems" as directed.

F. Install pressure gage on pump head discharge flange pressure-gage tapping. Comply with requirements for pressure gages specified in Section 211200 "Fire-Suppression Standpipes" or Section 211313 "Wet-Pipe Sprinkler Systems" as directed.

G. Install piping hangers and supports, anchors, valves, gages, and equipment supports according to NFPA 20.

H. Install fuel system according to NFPA 20.

I. Install water supply and drain piping for diesel-engine heat exchangers. Extend drain piping from heat exchangers to point of disposal.

J. Install exhaust-system piping for diesel engines. Extend to point of termination outside structure. Install pipe and fittings with welded joints; install components having flanged connections with gasketed joints.

K. Install condensate drain piping for diesel-engine exhaust system. Extend drain piping from low points of exhaust system to condensate traps and to point of disposal.

L. Electrical Wiring: Install electrical devices furnished by equipment manufacturers that are not factory mounted. Furnish copies of manufacturers' wiring diagram submittals to electrical Installer.

M. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

N. Align fire-pump-driver, right-angle gear-drive, and fire-pump shafts after complete unit has been leveled on concrete base, grout has set, and anchor bolts have been tightened.

O. After alignment is correct, tighten anchor bolts evenly. Fill baseplate completely with grout, with metal blocks and shims or wedges in place. Tighten anchor bolts after grout has hardened. Check alignment and make required corrections.

P. Align piping connections.

Q. Align pump and driver shafts for angular and parallel alignment according to HI 2.4 and to tolerances specified by manufacturer.

R. Comply with requirements for piping and valves specified in Section 211200 "Fire-Suppression Standpipes" or Section 211313 "Wet-Pipe Sprinkler Systems" as directed. Drawings indicate general arrangement of piping, fittings, and specialties.

S. Install piping adjacent to pumps and equipment to allow service and maintenance.

T. Connect relief-valve discharge to drainage piping or point of discharge.

U. Connect fire pumps to their controllers.

V. Identify system components. Comply with requirements for fire-pump marking according to NFPA 20.

3.2 FIELD QUALITY CONTROL

A. Test each fire pump with its right-angle gear drive and controller as a unit. Comply with requirements for electric-motor-driver fire-pump controllers specified in Section 262933 "Controllers for Fire-Pump Drivers."

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. After installing components, assemblies, and equipment, including controller, test for compliance with requirements.
2. Test according to NFPA 20 for acceptance and performance testing.
3. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

4. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Components, assemblies, and equipment will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

E. Furnish fire hoses in number, size, and length required to reach storm drain or other acceptable location to dispose of fire-pump test water. Hoses are for tests only and do not convey to Owner.

3.3 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.4 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain fire pumps, right-angle gear drives, and fire-pump controllers.

END OF SECTION 213216

SECTION 213413 - PRESSURE-MAINTENANCE PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Regenerative-turbine, pressure-maintenance pumps.
2. Vertical-turbine, pressure-maintenance pumps.

B. Related Requirements:

1. Section 262933 "Controllers for Fire-Pump Drivers" for pressure-maintenance-pump controllers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For pumps, accessories, and specialties.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 REGENERATIVE-TURBINE, PRESSURE-MAINTENANCE PUMPS

A. Description: Factory-assembled and -tested, close-coupled, single-stage, regenerative-turbine centrifugal pump as defined in HI 1.1-1.2 and HI 1.3; with pump and motor mounted horizontally.

B. Pump Construction:

1. Casing: Radially split, cast iron, with threaded inlet and outlet.
2. Impeller: Bronze, balanced, and keyed to shaft.
3. Pump Shaft: Stainless steel or steel with deflector.
4. Shaft Sleeve: Bronze.
5. Seal: Mechanical type with spring-loaded rotating head.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Motor: Single speed with permanently lubricated ball bearings. Comply with requirements in Section 210513 "Common Motor Requirements for Fire Suppression Equipment."

1. Power Cord: Factory-connected to motor for field connection to controller and at least 10 feet (3 m) long.

E. Nameplate: Permanently attached to pump and indicating capacity and characteristics.

F. Capacities and Characteristics:

1. Rated Capacity: As directed.
2. Total Dynamic Head: As directed.
3. Working Pressure: 175 psig (1200 kPa) or 300 psig (2070 kPa) As directed.
4. Inlet Size: Threaded; As directed.
5. Outlet Size: Threaded; As directed.
6. Suction Head Available at Pump: As directed.
7. Motor Horsepower: As directed.
8. Motor Speed: As directed.
9. Electrical Characteristics:

a. Volts: 120 or 240 As directed.
b. Phases: Single or Three As directed.
c. Hertz: 60.
d. Full-Load Amperes: As directed.
e. Minimum Circuit Ampacity: As directed.
f. Maximum Overcurrent Protection: As directed.

10. Pump-Start, Pressure-Switch Setting: As directed.
11. Pump-Stop, Pressure-Switch Setting: As directed.

2.2 VERTICAL-TURBINE, PRESSURE-MAINTENANCE PUMPS

A. Description: Factory-assembled and -tested, vertical, multistage, open-line-shaft turbine pump as defined in HI 2.1-2.2 and HI 2.3; with pump motor mounted above pump head.

B. Pump Construction:

1. Pump Head: Cast iron, for surface discharge, with flange except connections may be threaded in sizes in which flanges are not available.

2. Pump Head Seal: Stuffing box and stuffing.
3. Line Shaft: Stainless steel or steel, with corrosion-resistant shaft sleeves.
4. Line Shaft Bearings: Rubber sleeve, water lubricated.
5. Line Shaft: Steel.
6. Line Shaft Bearings: Corrosion resistant, oil lubricated.
7. Impeller Shaft: Monel metal or stainless steel.
8. Bowl Section: Multiple cast-iron bowls with closed-type bronze or stainless-steel impellers.
9. Column Pipe: ASTM A53/A53M, Schedule 40, galvanized-steel pipe with threaded ends and cast-iron or steel fittings, in sections 10 feet (3 m) or less, with strainer of cast or fabricated bronze or stainless steel at bottom.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Motor: Single speed with permanently lubricated ball bearings. Comply with requirements in Section 210513 "Common Motor Requirements for Fire Suppression Equipment."

1. Power Cord: Factory-connected to motor for field connection to controller and at least 10 feet (3 m) long.

E. Base: Cast iron or steel with hole for electrical cable.

F. Nameplate: Permanently attached to pump and indicating capacity and characteristics.

G. Capacities and Characteristics:

1. Rated Capacity: As directed.
2. Total Dynamic Head: As directed.
3. Working Pressure: As directed.
4. Inlet Column Size: As directed.
5. Pump Column Length: As directed.
6. Outlet Size: As directed.
7. Flange: Class 125.
8. Suction Head Available at Pump: As directed.
9. Motor Horsepower: As directed.
10. Motor Speed: As directed.
11. Electrical Characteristics:

    a. Volts: 120 or 240 As directed.
    b. Phases: Single or Three As directed.
    c. Hertz: 60.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed.
    f. Maximum Overcurrent Protection: As directed.

12. Pump-Start, Pressure-Switch Setting: As directed.
13. Pump-Stop, Pressure-Switch Setting: As directed.

2.3 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 210513 "Common Motor Requirements for Fire Suppression Equipment."

1. Motor Sizes: Minimum size as indicated; if not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

A. NFPA Standard: Comply with NFPA 20 for installation of pressure-maintenance pumps.

B. Equipment Mounting:

1. Install regenerative-turbine, pressure-maintenance pumps according to HI 1.4.
2. Install vertical-turbine, pressure-maintenance pumps according to HI 2.4.
3. Install base-mounted pumps on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.

    a. Comply with requirements for vibration isolation and seismic control devices specified in Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."
    b. Comply with requirements for vibration isolation devices specified in Section 210548.13 "Vibration Controls for Fire-Suppression Piping and Equipment."
    c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
    d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
    e. Install anchor bolts to elevations required for proper attachment to supported equipment.
    f. Attach pumps to equipment base using anchor bolts.
    g. Shim pumps as needed to make them level.

4. Install isolation valves in both inlet and outlet pipes near the pump. Comply with requirements for valves specified in Section 211313 "Wet-Pipe Sprinkler Systems."

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Pressure-maintenance pumps will be considered defective if they do not pass tests and inspections.

B. Prepare test and inspection reports.

3.3 ADJUSTING

A. Lubricate pumps as recommended by manufacturer.

B. Set field-adjustable pressure-switch ranges as indicated.

END OF SECTION 213413

SECTION 220513 - COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on alternating-current power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.2 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.
4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet (1000 m) above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Premium efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.

1. For motors with 2:1 speed ratio, consequent pole, single winding.
2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Rotor: Random-wound, squirrel cage.

F. Bearings: Re-greasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

G. Temperature Rise: Match insulation rating.

H. Insulation: Class F.

I. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.

J. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 ADDITIONAL REQUIREMENTS FOR POLYPHASE MOTORS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable-Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width-modulated inverters.
2. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
3. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

2.5 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Split phase.
3. Capacitor start, inductor run.
4. Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Pre-lubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 220513

SECTION 220516 - EXPANSION FITTINGS AND LOOPS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Rubber union connector packless expansion joints.
2. Flexible-hose packless expansion joints.
3. Externally pressurized metal-bellows packless expansion joints.
4. Alignment guides and anchors.
5. Pipe loops and swing connections.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Delegated-Design Submittal: For each anchor and alignment guide, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
3. Alignment Guide Details: Detail field assembly and attachment to building structure.
4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

1.3 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.

B. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

2.2 PACKLESS EXPANSION JOINTS

A. Rubber Union Connector Expansion Joints:
   1. Material: Twin reinforced-rubber spheres with external restraining cables.
   2. Minimum Pressure Rating: 150 psig at 170 deg F (1035 kPa at 77 deg C), unless otherwise indicated.
   3. End Connections for NPS 2 (DN 50) and Smaller: Threaded.

B. Flexible-Hose Packless Expansion Joints:
   1. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.
   2. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
   3. Expansion Joints for Copper Tubing NPS 2 (DN 50) and Smaller: Copper-alloy fittings with soldered end connections.
      a. Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F (3100 kPa at 21 deg C) and 340 psig at 450 deg F (2340 kPa at 232 deg C) ratings.
   4. Expansion Joints for Copper Tubing NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Copper-alloy fittings with threaded end connections.
      a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 psig at 70 deg F (2070 kPa at 21 deg C) and 225 psig at 450 deg F (1550 kPa at 232 deg C) ratings.
   5. Expansion Joints for Steel Piping NPS 2 (DN 50) and Smaller: Carbon-steel fittings with threaded end connections.
      a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 450 psig at 70 deg F (3100 kPa at 21 deg C) and 325 psig at 600 deg F (2250 kPa at 315 deg C) ratings.
   6. Expansion Joints for Steel Piping NPS 2-1/2 to NPS 6 (DN 65 to DN 150): Carbon-steel fittings with flanged or welded end connections as directed.
      a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 psig at 70 deg F (1380 kPa at 21 deg C) and 145 psig at 600 deg F (1000 kPa at 315 deg C) ratings.

C. Externally Pressurized Metal-Bellows Packless Expansion Joints:
   1. Minimum Pressure Rating: 150 psig (1035 kPa), unless otherwise indicated.
   2. Description:
      a. Totally enclosed, externally pressurized, multi-ply, stainless-steel bellows isolated from fluid flow by an internal pipe sleeve.
      b. Carbon-steel housing.
      c. Drain plugs and lifting lug for NPS 3 (DN 80) and larger.
      d. Bellows shall have operating clearance between the internal pipe sleeves and the external shrouds.

e. Joints shall be supplied with a built-in scale to confirm the starting position and operating movement.
f. Joint Axial Movement: 4 inches (100 mm) of compression and 0.75 inch (19 mm) of extension or as directed.

3. Permanent Locking Bolts: Set locking bolts to maintain joint lengths during installation. Temporary welding tabs that are removed after installation in lieu of locking bolts are not acceptable.
4. End Connection Configuration: Flanged; one raised, fixed and one floating flange.

2.3 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides:

1. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding slider for bolting to pipe.

B. Anchor Materials:

1. Steel Shapes and Plates: ASTM A36/A36M.
2. Bolts and Nuts: ASME B18.10 or ASTM A183, steel hex head.
3. Washers: ASTM F844, steel, plain, flat washers.
4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.

    a. Stud: Threaded, zinc-coated carbon steel.
    b. Expansion Plug: Zinc-coated steel.
    c. Washer and Nut: Zinc-coated steel.

5. Chemical Fasteners: Insert-type stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.

    a. Bonding Material: ASTM C881/C881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
    b. Stud: ASTM A307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
    c. Washer and Nut: Zinc-coated steel.

PART 3 - EXECUTION

3.1 EXPANSION JOINT INSTALLATION

A. Install expansion joints of sizes matching sizes of piping in which they are installed.

B. Install metal-bellows expansion joints according to EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."

3.2 PIPE LOOP AND SWING CONNECTION INSTALLATION

A. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.

B. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.

C. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.

D. Connect mains and branch connections to terminal units with at least four pipe fittings, including tee in main.

3.3 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.

B. Install two guides on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.

C. Attach guides to pipe, and secure guides to building structure.

D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

E. Anchor Attachments:

1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24; U bolts bolted to anchor.

F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.

1. Anchor Attachment to Steel Structural Members: Attach by welding.
2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.

G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION 220516

SECTION 220517 - SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Sleeves.
2. Sleeve-seal systems.
3. Grout.
4. Silicone sealants.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop collar.

B. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, anticorrosion coated or galvanized, with plain ends and integral welded waterstop collar.

C. Galvanized-Steel Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

D. PVC Pipe Sleeves: ASTM D1785, Schedule 40.

2.2 SLEEVE-SEAL SYSTEMS

A. Description:

1. Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
2. Designed to form a hydrostatic seal of 20 psig (137 kPa) minimum.
3. Sealing Elements: EPDM-rubber, High-temperature-silicone or Nitrile (Buna N) interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
4. Pressure Plates: Carbon steel, Composite plastic, Stainless steel or Stainless steel, Type 316 as directed.

5. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, ASTM B633, Stainless steel or Stainless steel, Type 316 as directed, of length required to secure pressure plates to sealing elements.

2.3 GROUT

A. Description: Nonshrink, for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.4 SILICONE SEALANTS

A. Silicone, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant, ASTM C920, Type S, Grade NS, Class 25, Use NT.

B. Silicone, S, P, 25, T, NT: Single-component, pourable, plus 25 percent and minus 25 percent movement capability, traffic- and nontraffic-use, neutral-curing silicone joint sealant; ASTM C920, Type S, Grade P, Class 25, Uses T and NT. Grade P Pourable (self-leveling) formulation is for opening in floors and other horizontal surfaces that are not fire rated.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch (25-mm) or as directed annular clear space between piping and concrete slabs and walls.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

1. Cut sleeves to length for mounting flush with both surfaces.

    a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level or as directed.

2. Using grout or silicone sealant as directed, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint.

E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 078413 "Penetration Firestopping."

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.

B. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.4 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls above Grade:

a. Piping Smaller Than NPS 6 (DN 150): Cast-iron pipe sleeves or Steel pipe sleeves as directed.
b. Piping NPS 6 (DN 150) and Larger: Cast-iron pipe sleeves or Steel pipe sleeves as directed.

2. Exterior Concrete Walls below Grade:

a. Piping Smaller Than NPS 6 (DN 150): Cast-iron pipe sleeves or Steel pipe sleeves as directed.

1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.

b. Piping NPS 6 (DN 150) and Larger: Cast-iron pipe sleeves or Steel pipe sleeves as directed.

1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs-on-Grade:

a. Piping Smaller Than NPS 6 (DN 150): Cast-iron pipe sleeves with sleeve-seal system or Steel pipe sleeves with sleeve-seal system as directed.

1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.

b. Piping NPS 6 (DN 150) and Larger: Cast-iron pipe sleeves with sleeve-seal system or Steel pipe sleeves with sleeve-seal system as directed.

1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.

4. Concrete Slabs above Grade:

a. Piping Smaller Than NPS 6 (DN 150): Steel pipe sleeves or PVC pipe sleeves as directed.
b. Piping NPS 6 (DN 150) and Larger: Steel pipe sleeves or PVC pipe sleeves as directed.

5. Interior Partitions:

a. Piping Smaller Than NPS 6 (DN 150): Steel pipe sleeves or PVC pipe sleeves as directed.
b. Piping NPS 6 (DN 150) and Larger: Galvanized-steel sheet sleeves.

END OF SECTION 220517

SECTION 220518 - ESCUTCHEONS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Escutcheons.
2. Floor plates.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 ESCUTCHEONS

A. One-Piece, Steel Type: As directed with polished, chrome-plated or polished brass finish and setscrew fastener.

B. One-Piece, Deep-Pattern Type: As directed Deep-drawn, box-shaped steel or brass with polished, chrome-plated finish and spring-clip fasteners.

C. One-Piece, Stamped-Steel Type: With polished, chrome-plated finish and spring-clip fasteners.

D. Split-Plate, Stamped-Steel Type: As directed with polished, chrome-plated finish; concealed and exposed-rivet hinge; and spring-clip fasteners.

2.3 FLOOR PLATES

A. Split Floor Plates: Cast brass with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of insulated piping and with OD that completely covers opening.

1. Escutcheons for New Piping and Relocated Existing Piping:

a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern.
b. Chrome-Plated Piping: As directed, One-piece steel, cast brass or split-casting brass with polished, chrome-plated finish.
c. Insulated Piping: As directed, One-piece steel with polished, chrome-plated or polished brass finish.
d. Insulated Piping: As directed, One-piece stamped steel or split-plate, stamped steel with concealed hinge or split-plate, stamped steel with exposed-rivet hinge with polished, chrome-plated finish.
e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: As directed, One-piece steel with polished, chrome-plated or polished brass finish.
f. Bare Piping at Wall and Floor Penetrations in Finished Spaces: As directed, One-piece stamped steel or split-plate, stamped steel with concealed hinge or split-plate, stamped steel with exposed-rivet hinge with polished, chrome-plated finish.
g. Bare Piping at Ceiling Penetrations in Finished Spaces: As directed, One-piece steel with polished, chrome-plated or polished brass finish.
h. Bare Piping at Ceiling Penetrations in Finished Spaces: As directed, One-piece stamped steel or split-plate, stamped steel with concealed hinge or split-plate, stamped steel with exposed-rivet hinge with polished, chrome-plated finish.

2. Escutcheons for Existing Piping to Remain:

a. Chrome-Plated Piping: Split-casting, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish.
b. Insulated Piping: Split-plate, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish
c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish.
d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish.

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. New Piping and Relocated Existing Piping: Split floor plate.
2. Existing Piping: Split floor plate.

3.2 FIELD QUALITY CONTROL

A. Using new materials, replace broken and damaged escutcheons and floor plates.

END OF SECTION 220518

SECTION 220519 - METERS AND GAGES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Bimetallic-actuated thermometers.
2. Liquid-in-glass thermometers.
3. Thermowells.
4. Dial-type pressure gages.
5. Gage attachments.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of meter and gage.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 BIMETALLIC-ACTUATED THERMOMETERS

A. Standard: ASME B40.200.

B. Case: Liquid-filled and sealed type(s); Stainless steel with 3-inch (76-mm) or 5-inch (127-mm) nominal diameter, as directed.

C. Dial: Nonreflective aluminum with permanently etched scale markings and scales in deg F (deg C) or deg F and deg C, as directed.

D. Connector Type(s): As directed Union joint, adjustable angle, rigid, back and rigid, bottom, with unified-inch screw threads.

E. Connector Size: 1/2 inch (13 mm), with ASME B1.1 screw threads.

F. Stem: 0.25 or 0.375 inch (6.4 or 9.4 mm) in diameter; stainless steel.

G. Window: Plain glass or plastic.

H. Ring: Stainless steel.

I. Element: Bimetal coil.

J. Pointer: Dark-colored metal.

K. Accuracy: As directed Plus or minus 1 or 1.5 percent of scale range.

2.2 LIQUID-IN-GLASS THERMOMETERS

A. Metal-Case, Compact-Style, Liquid-in-Glass Thermometers:
1. Standard: ASME B40.200.
2. Case: Cast aluminum; 6-inch (152-mm) nominal size.
3. Case Form: As directed, Back angle or Straight unless otherwise indicated.
4. Tube: Glass with magnifying lens and blue or red organic liquid.
5. Tube Background: As directed, Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C) or deg F and deg C.
6. Window: Glass or plastic.
7. Stem: Aluminum or brass and of length to suit installation.

    a. Design for Thermowell Installation: Bare stem.

8. Connector: 3/4 inch (19 mm), with ASME B1.1 screw threads.
9. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

B. Plastic-Case, Compact-Style, Liquid-in-Glass Thermometers:
1. Standard: ASME B40.200.
2. Case: Plastic; 6-inch (152-mm) nominal size.
3. Case Form: As directed, Back angle or Straight unless otherwise indicated.
4. Tube: Glass with magnifying lens and blue or red organic liquid.
5. Tube Background: As directed, Nonreflective with permanently etched scale markings graduated in deg F (deg C) or deg F and deg C.
6. Window: Glass or plastic.
7. Stem: Aluminum or brass and of length to suit installation.

    a. Design for Thermowell Installation: Bare stem.

8. Connector: 3/4 inch (19 mm), with ASME B1.1 screw threads.
9. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

C. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:
1. Standard: ASME B40.200.
2. Case: As directed Cast aluminum; 7-inch (178-mm) or 9-inch (229-mm) nominal size unless otherwise indicated.
3. Case Form: As directed, Adjustable angle, Back angle or Straight unless otherwise indicated.
4. Tube: Glass with magnifying lens and blue or red organic liquid.
5. Tube Background: As directed, Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C) or deg F and deg C.
6. Window: Glass or plastic.
7. Stem: Aluminum and of length to suit installation.

a. Design for Thermowell Installation: Bare stem.

8. Connector: 1-1/4 inches (32 mm), with ASME B1.1 screw threads.
9. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

D. Plastic-Case, Industrial-Style, Liquid-in-Glass Thermometers:
1. Standard: ASME B40.200.
2. Case: Plastic; 7-inch (178-mm) or 9-inch (229-mm) nominal size unless otherwise indicated.
3. Case Form: As directed, Adjustable angle, Back angle or Straight unless otherwise indicated.
4. Tube: Glass with magnifying lens and blue or red organic liquid.
5. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C) or deg F and deg C.
6. Window: Glass or plastic.
7. Stem: As directed, Aluminum, Brass, Stainless steel or Aluminum, brass, or stainless steel and of length to suit installation.

a. Design for Thermowell Installation: Bare stem.

8. Connector: 1-1/4 inches (32 mm), with ASME B1.1 screw threads.
9. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.3 THERMOWELLS

A. Thermowells:

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
3. Material for Use with Copper Tubing: CNR or CUNI.
4. Material for Use with Steel Piping: As directed CRES or CSA.
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1 (DN 15, DN 20, or NPS 25), ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and 1 inch (13, 19, and 25 mm), with ASME B1.1 screw threads.

8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

B. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.4 PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:
1. Standard: ASME B40.100.
2. Case: As directed, Liquid-filled, Sealed, Open-front, pressure relief, Solid-front, pressure relief type(s); cast aluminum or drawn steel; 4-1/2-inch (114-mm) or 6-inch (152-mm) nominal diameter.
3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
4. Pressure Connection: As directed Brass, with NPS 1/4 (DN 8), NPS 1/4 or NPS 1/2 (DN 8 or DN 15) or NPS 1/2 (DN 15), ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: As directed, Nonreflective aluminum with permanently etched scale markings graduated in psi (kPa) or psi and kPa.
7. Pointer: Dark-colored metal.
8. Window: Glass or plastic.
9. Ring: Metal, Brass or Stainless steel.
10. Accuracy: Grade A, plus or minus 1 percent of middle half of Grade B, plus or minus 2 percent of middle half of Grade C, plus or minus 3 percent of middle half of or Grade D, plus or minus 5 percent of whole scale range.

B. Direct-Mounted, Plastic-Case, Dial-Type Pressure Gages:
1. Standard: ASME B40.100.
2. Case: Sealed type; plastic; As directed 4-1/2-inch (114-mm) or 6-inch (152-mm) nominal diameter.
3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
4. Pressure Connection: As directed Brass, with NPS 1/4 (DN 8), NPS 1/4 or NPS 1/2 (DN 8 or DN 15) or NPS 1/2 (DN 15), ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: As directed Nonreflective aluminum with permanently etched scale markings graduated in psi (kPa) or psi and kPa.
7. Pointer: Dark-colored metal.
8. Window: Glass or plastic.
9. Accuracy: As directed, Grade A, plus or minus 1 percent of middle half of Grade B, plus or minus 2 percent of middle half of Grade C, plus or minus 3 percent of middle half of Grade D, plus or minus 5 percent of whole scale range.

C. Remote-Mounted, Metal-Case, Dial-Type Pressure Gages:
1. Standard: ASME B40.100.

2. Case: As directed Liquid-filled or Sealed type; cast aluminum or drawn steel or metal; 4-1/2-inch (114-mm) or 6-inch (152-mm) nominal diameter with back or front flange and holes for panel mounting.
3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
4. Pressure Connection: As directed, Brass, with NPS 1/4 (DN 8), NPS 1/4 or NPS 1/2 (DN 8 or DN 15) or NPS 1/2 (DN 15), ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: As directed, Nonreflective aluminum with permanently etched scale markings graduated in psi (kPa) or psi and kPa.
7. Pointer: Dark-colored metal.
8. Window: Glass or plastic.
9. Ring: As directed, Metal or Stainless steel.
10. Accuracy: As directed, Grade A, plus or minus 1 percent of middle half of Grade B, plus or minus 2 percent of middle half of Grade C, plus or minus 3 percent of middle half of Grade D, plus or minus 5 percent of whole scale range.

D. Remote-Mounted, Plastic-Case, Dial-Type Pressure Gages:
1. Standard: ASME B40.100.
2. Case: As directed, Sealed type; plastic; 4-1/2-inch (114-mm) or 6-inch (152-mm) nominal diameter with back or front flange and holes for panel mounting.
3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
4. Pressure Connection: As directed, Brass, with NPS 1/4 (DN 8), NPS 1/4 or NPS 1/2 (DN 8 or DN 15) or NPS 1/2 (DN 15), ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: As directed, Nonreflective aluminum with permanently etched scale markings graduated in psi (kPa) or psi and kPa.
7. Pointer: Dark-colored metal.
8. Window: Glass or plastic.
9. Accuracy: As directed, Grade A, plus or minus 1 percent of middle half of Grade B, plus or minus 2 percent of middle half of Grade C, plus or minus 3 percent of middle half of Grade D, plus or minus 5 percent of whole scale range.

2.5 GAGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; As directed, with NPS 1/4 (DN 8), NPS 1/4 or NPS 1/2 (DN 8 or DN 15) or NPS 1/2 (DN 15), ASME B1.20.1 pipe threads and piston or porous-metal-type surge-dampening device. Include extension for use on insulated piping.

B. Valves: As directed Brass ball or Brass or stainless-steel needle, with NPS 1/4 (DN 8), NPS 1/4 or NPS 1/2 (DN 8 or DN 15) or NPS 1/2 (DN 15), ASME B1.20.1 pipe threads.

PART 3 - EXECUTION

3.1 INSTALLATION

A. As directed, Install thermowells with socket extending a minimum of 2 inches (51 mm) into fluid, one-third of pipe diameter or to center of pipe and in vertical position in piping tees.

B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.

G. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

H. Install remote-mounted pressure gages on panel.

I. Install valve and snubber in piping for each pressure gage for fluids.

J. Install thermometers in the following locations:

1. Inlet and outlet of each water heater.
2. Inlets and outlets of each domestic water heat exchanger.
3. Inlet and outlet of each domestic hot-water storage tank.
4. Inlet and outlet of each remote domestic water chiller.

K. Install pressure gages in the following locations:

1. Building water service entrance into building.
2. Inlet and outlet of each pressure-reducing valve.
3. Suction and discharge of each domestic water pump.

L. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.

M. Adjust faces of meters and gages to proper angle for best visibility.

3.2 THERMOMETER SCHEDULE

A. Thermometers at inlet and outlet of each domestic water heater shall be one of the following:

1. As directed, Liquid-filled or Sealed, bimetallic-actuated type.
2. As directed, Metal or Plastic case, compact or industrial-style, liquid-in-glass type.

B. Thermometers at inlets and outlets of each domestic water heat exchanger shall be one of the following:

1. As directed, Liquid-filled or Sealed, bimetallic-actuated type.
2. As directed, Metal or Plastic case, compact or industrial-style, liquid-in-glass type.

C. Thermometers at inlet and outlet of each domestic hot-water storage tank shall be one of the following:

1. As directed, Liquid-filled or Sealed, bimetallic-actuated type.
2. As directed, Metal or Plastic case, compact or industrial-style, liquid-in-glass type.

D. Thermometers at inlet and outlet of each remote domestic water chiller shall be one of the following:

1. As directed, Liquid-filled or Sealed, bimetallic-actuated type.
2. As directed, Metal or Plastic case, compact or industrial-style, liquid-in-glass type.

E. Thermometer stems shall be of length to match thermowell insertion length.

3.3 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Domestic Cold-Water Piping: As directed 0 to 100 deg F (Minus 20 to plus 50 deg C) or 0 to 100 deg F and minus 20 to plus 50 deg C.

B. Scale Range for Domestic Cold-Water Piping: As directed 0 to 150 deg F (Minus 20 to plus 70 deg C) or 0 to 150 deg F and minus 20 to plus 70 deg C.

C. Scale Range for Domestic Cold-Water Piping: As directed 30 to 240 deg F (0 to plus 115 deg C) or 30 to 240 deg F and 0 to plus 115 deg C.

D. Scale Range for Domestic Hot-Water Piping: As directed 0 to 250 deg F (0 to 150 deg C) or 0 to 250 deg F and 0 to 150 deg C.

E. Scale Range for Domestic Hot-Water Piping: As directed 20 to 240 deg F (0 to 150 deg C) or 20 to 240 deg F and 0 to 150 deg C.

F. Scale Range for Domestic Hot-Water Piping: As directed 30 to 240 deg F (0 to plus 115 deg C) or 30 to 240 deg F and 0 to plus 115 deg C.

G. Scale Range for Domestic Cooled-Water Piping: As directed 0 to 100 deg F (Minus 20 to plus 50 deg C) or 0 to 100 deg F and minus 20 to plus 50 deg C.

H. Scale Range for Domestic Cooled-Water Piping: As directed 0 to 150 deg F (Minus 20 to plus 70 deg C) or 0 to 150 deg F and minus 20 to plus 70 deg C.

3.4 PRESSURE-GAGE SCHEDULE

A. Pressure gages at discharge of each water service into building shall be one of the following:

1. As directed, Liquid-filled, Sealed, Open-front, pressure-relief, Solid-front or pressure-relief, direct or remote-mounted, metal case.
2. As directed, Sealed, direct or remote-mounted, plastic case.

B. Pressure gages at inlet and outlet of each water pressure-reducing valve shall be one of the following:

1. As directed, Liquid-filled, Sealed, Open-front, pressure-relief or Solid-front, pressure-relief, direct or remote-mounted, metal case.
2. Sealed, direct or remote-mounted, plastic case.
3. Test plug with chlorosulfonated polyethylene synthetic or EPDM self-sealing rubber inserts.

C. Pressure gages at suction and discharge of each domestic water pump shall be one of the following:

1. As directed, Liquid-filled, Sealed, Open-front, pressure-relief or Solid-front, pressure-relief, direct or remote-mounted, metal case.
2. As directed, Sealed, direct or remote-mounted, plastic case.
3. As directed, Test plug with chlorosulfonated polyethylene synthetic or EPDM self-sealing rubber inserts.

3.5 PRESSURE-GAGE SCALE-RANGE SCHEDULE

A. Scale Range for Water Service Piping: As directed 0 to 100 psi (0 to 600 kPa) or 0 to 100 psi and 0 to 600 kPa.

B. Scale Range for Water Service Piping: As directed 0 to 160 psi (0 to 1100 kPa) or 0 to 160 psi and 0 to 1100 kPa.

C. Scale Range for Water Service Piping: As directed 0 to 200 psi (0 to 1400 kPa) or 0 to 200 psi and 0 to 1400 kPa.

D. Scale Range for Domestic Water Piping: As directed 0 to 100 psi (0 to 600 kPa) or 0 to 100 psi and 0 to 600 kPa.

E. Scale Range for Domestic Water Piping: As directed 0 to 160 psi (0 to 1100 kPa) or 0 to 160 psi and 0 to 1100 kPa.

F. Scale Range for Domestic Water Piping: As directed 0 to 200 psi (0 to 1400 kPa) or 0 to 200 psi and 0 to 1400 kPa.

G. Scale Range for Domestic Water Piping: As directed 0 to 300 psi (0 to 2500 kPa) or 0 to 300 psi and 0 to 2500 kPa.

END OF SECTION 220519

SECTION 220523.12 - BALL VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Brass ball valves.
2. Bronze ball valves.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1. Certification that products comply with NSF 61 and NSF 372.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

1. ASME B1.20.1 for threads for threaded end valves.
2. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
3. ASME B16.18 for solder-joint connections.
4. ASME B31.9 for building services piping valves.

C. NSF Compliance: NSF 61 and NSF 372 for valve materials for potable-water service.

D. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

F. Valve Sizes: Same as upstream piping unless otherwise indicated.

G. Valve Actuator Types:

1. Gear Actuator: For quarter-turn valves NPS 4 (DN 100) and larger.
2. Handlever: For quarter-turn valves smaller than NPS 4 (DN 100).

H. Valves in Insulated Piping:

1. Include 2-inch (50-mm) stem extensions.
2. Extended operating handles of nonthermal-conductive material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.
3. Memory stops that are fully adjustable after insulation is applied.

2.2 BRASS BALL VALVES

A. Brass Ball Valves, One-Piece:
1. Description:

a. Standard: MSS SP-110.
b. CWP Rating: 400 psig (2760 kPa).
c. Body Design: One piece.
d. Body Material: Forged brass or bronze.
e. Ends: Threaded and soldered.
f. Seats: PTFE.
g. Stem: Brass or stainless steel.
h. Ball: Chrome-plated brass or stainless steel.
i. Port: Reduced.

B. Brass Ball Valves, Two-Piece with Full Port and Brass Trim, Threaded or Soldered Ends:
1. Description:

a. Standard: MSS SP-110 or MSS SP-145.
b. CWP Rating: 600 psig (4140 kPa).
c. Body Design: Two piece.
d. Body Material: Forged brass.
e. Ends: Threaded and soldered.
f. Seats: PTFE.
g. Stem: Brass.
h. Ball: Chrome-plated brass.
i. Port: Full.

C. Brass Ball Valves, Two-Piece with Full Port and Brass Trim, Press Ends:
1. Description:

a. Standard: MSS SP-110 or MSS SP-145.
b. CWP Rating: Minimum 200 psig (1380 kPa).
c. Body Design: Two piece.
d. Body Material: Forged brass.
e. Ends: Press.
f. Press Ends Connection Rating: Minimum 200 psig (1380 kPa).
g. Seats: PTFE or RPTFE.
h. Stem: Brass.
i. Ball: Chrome-plated brass.
j. Port: Full.
k. O-Ring: Buna-N or EPDM.

D. Brass Ball Valves, Two-Piece with Regular Port and Brass Trim:
1. Description:

a. Standard: MSS SP-110.
b. CWP Rating: 600 psig (4140 kPa).
c. Body Design: Two piece.
d. Body Material: Forged brass.
e. Ends: Threaded and soldered.
f. Seats: PTFE.
g. Stem: Brass.
h. Ball: Chrome-plated brass.
i. Port: Regular.

2.3 BRONZE BALL VALVES

A. Bronze Ball Valves, One-Piece:
1. Description:

a. Standard: MSS SP-110.
b. CWP Rating: 400 psig (2760 kPa).
c. Body Design: One piece.
d. Body Material: Bronze.
e. Ends: Threaded.
f. Seats: PTFE.
g. Stem: Bronze.
h. Ball: Chrome-plated brass.
i. Port: Reduced.

B. Bronze Ball Valves, Two-Piece with Full Port, and Bronze or Brass Trim, Threaded or Soldered Ends:
1. Description:

a. Standard: MSS SP-110 or MSS-145.
b. CWP Rating: 600 psig (4140 kPa).
c. Body Design: Two piece.
d. Body Material: Bronze.
e. Ends: Threaded and soldered.
f. Seats: PTFE.
g. Stem: Bronze or brass.
h. Ball: Chrome-plated brass.
i. Port: Full.

C. Bronze Ball Valves, Two-Piece with Full Port, and Bronze or Brass Trim, Press Ends:
1. Description:

a. Standard: MSS SP-110 or MSS-145.
b. CWP Rating: Minimum 200 psig (1380 kPa).
c. Body Design: Two piece.
d. Body Material: Bronze.
e. Ends: Press.

f. Press Ends Connections Rating: Minimum 200 psig (1380 kPa).
g. Seats: PTFE or RTPFE.
h. Stem: Bronze or brass.
i. Ball: Chrome-plated brass.
j. Port: Full.
k. O-Ring Seal: EPDM or Buna-N.

D. Bronze Ball Valves, Two-Piece with Regular Port and Bronze or Brass Trim:
1. Description:

a. Standard: MSS SP-110.
b. CWP Rating: 600 psig (4140 kPa).
c. Body Design: Two piece.
d. Body Material: Bronze.
e. Ends: Threaded.
f. Seats: PTFE.
g. Stem: Bronze or brass.
h. Ball: Chrome-plated brass.
i. Port: Regular.

PART 3 - EXECUTION

3.1 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

3.2 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.

B. Select valves with the following end connections:

1. For Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
2. For Steel Piping, NPS 2 (DN 50) and Smaller: Threaded ends.

3.3 LOW-PRESSURE, COMPRESSED-AIR VALVE SCHEDULE (150 PSIG (1035 kPa) OR LESS)

A. Pipe NPS 2 (DN 50) and Smaller:

1. Bronze and Brass Valves: May be provided with solder-joint ends instead of threaded ends.
2. Brass ball valves, one piece.
3. Bronze ball valve, one piece with bronze trim.
4. Brass ball valves, two-piece with full or regular port and brass trim as directed.
5. Bronze ball valves, two-piece with full regular port and bronze or brass trim as directed.

3.4 HIGH-PRESSURE, COMPRESSED-AIR VALVE SCHEDULE (150 TO 200 PSIG (1035 TO 1380 kPa)

A. Pipe NPS 2 (DN 50) and Smaller:

1. Bronze and Brass Valves: May be provided with solder-joint ends instead of threaded ends.
2. Brass ball valve, one piece.
3. Bronze ball valve with bronze trim, one piece.
4. Brass ball valves, two-piece with full or regular port and brass trim as directed.
5. Bronze ball valves, two-piece with full or regular port and bronze or brass trim as directed.

3.5 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:

1. Brass ball valve, one piece. Provide with threaded or solder-joint ends.
2. Bronze ball valve, one piece with bronze trim. Provide with threaded or solder-joint ends as directed.
3. Brass ball valves, two-piece with full or regular port and brass trim. Provide with threaded, solder or press connection-joint ends as directed.
4. Bronze ball valves, two-piece with full or regular port and bronze or brass trim. Provide with threaded, solder or press-connection-joint ends as directed.

END OF SECTION 220523.12

SECTION 220523.13 - BUTTERFLY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Iron, single-flange butterfly valves.
2. Chainwheels.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1. Certification that products comply with NSF 61 Annex G and NSF 372.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

1. ASME B16.1 for flanges on iron valves.
2. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
3. ASME B31.9 for building service piping valves.

C. NSF Compliance: NSF 61 Annex G and NSF 372 for valve materials for potable-water service.

D. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

E. Valve Sizes: Same as upstream piping unless otherwise indicated.

F. Valve Actuator Types:

1. Gear Actuator: For valves NPS 8 (DN 200) and larger.
2. Handlever: For valves NPS 6 (DN 150) and smaller.
3. Chainwheel: Device for attachment to gear, handlever, or stem; of size and with chain for mounting height, according to "Valve Installation" Article.

G. Valves in Insulated Piping: With 2-inch (50-mm) stem extensions.

2.2 IRON, SINGLE-FLANGE BUTTERFLY VALVES

A. Iron, Single-Flange Butterfly Valves with Aluminum-Bronze Disc:
   1. Description:

      a. Standard: MSS SP-67, Type I.
      b. CWP Rating: 200 psig (1380 kPa) or 250 psig (1725 kPa) as directed.
      c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
      d. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
      e. Seat: EPDM or NBR as directed.
      f. Stem: One- or two-piece stainless steel.
      g. Disc: Aluminum bronze.

B. Iron, Single-Flange Butterfly Valves with Ductile-Iron Disc:
   1. Description:

      a. Standard: MSS SP-67, Type I.
      b. CWP Rating: 200 psig (1380 kPa) or 250 psig (1725 kPa) as directed.
      c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
      d. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
      e. Seat: EPDM or NBR as directed.
      f. Stem: One- or two-piece stainless steel.
      g. Disc: Nickel-plated or nickel-coated ductile iron as directed.

2.3 CHAINWHEELS

A. Description: Valve actuation assembly with sprocket rim, chain guides, chain, and attachment brackets for mounting chainwheels directly to handwheels.

   1. Sprocket Rim with Chain Guides: Ductile iron, of type and size required for valve. Include zinc or epoxy coating as directed.
   2. Chain: Hot-dip, galvanized steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install chainwheels on operators for butterfly valves NPS 4 (DN 100) and larger and more than 96 inches (2400 mm) above floor. Extend chains to 60 inches (1520 mm) above finished floor.

3.2 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.3 LOW-PRESSURE, COMPRESSED-AIR VALVE SCHEDULE (150 PSIG (1035 kPa) OR LESS)

A. Iron, Single-Flange Butterfly Valves: 200 CWP, NBR seat, aluminum-bronze or ductile-iron disc as directed.

3.4 HIGH-PRESSURE, COMPRESSED-AIR VALVE SCHEDULE (150 TO 200 PSIG (1035 TO 1380 kPa)

A. Iron, Single-Flange Butterfly Valves: 200 CWP, NBR seat, aluminum-bronze or ductile-iron disc as directed.

3.5 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

A. Iron, Single-Flange Butterfly Valves: 200 CWP, EPDM or NBR seat, aluminum-bronze or ductile-iron disc as directed.

END OF SECTION 220523.13

SECTION 220523.14 - CHECK VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bronze swing check valves.
2. Bronze swing check valves, press ends.
3. Iron swing check valves.
4. Iron swing check valves with closure control.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1. Certification that products comply with NSF 61 and NSF 372.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

1. ASME B1.20.1 for threads for threaded end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
4. ASME B16.18 for solder joint.
5. ASME B31.9 for building services piping valves.

C. Drinking Water System Components - Health Effects and Drinking Water System Components - Lead Content Compliance: NSF 61 and NSF 372.

D. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

F. Valve Sizes: Same as upstream piping unless otherwise indicated.

G. Valve Bypass and Drain Connections: MSS SP-45.

2.2 BRONZE SWING CHECK VALVES

A. Bronze Swing Check Valves with Bronze Disc, Class 125:
   1. Description:

      a. Standard: MSS SP-80, Type 3.
      b. CWP Rating: 200 psig (1380 kPa).
      c. Body Design: Horizontal flow.
      d. Body Material: ASTM B62, bronze.
      e. Ends: Threaded or soldered. See valve schedule articles.
      f. Disc: Bronze.

B. Bronze Swing Check Valves with Nonmetallic Disc, Class 125:
   1. Description:

      a. Standard: MSS SP-80, Type 4.
      b. CWP Rating: 200 psig (1380 kPa).
      c. Body Design: Horizontal flow.
      d. Body Material: ASTM B62, bronze.
      e. Ends: Threaded or soldered. See valve schedule articles.
      f. Disc: PTFE.

C. Bronze Swing Check Valves, Press Ends:
   1. Description:

      a. Standard: MSS SP-80 and MSS SP-139.
      b. CWP Rating: Minimum 200 psig (1380 kPa).
      c. Body Design: Horizontal flow.
      d. Body Material: ASTM B584, bronze.
      e. Ends: Press.
      f. Press Ends Connection Rating: Minimum 200 psig (1380 kPa).
      g. Disc: Brass or bronze.

2.3 IRON SWING CHECK VALVES

A. Iron Swing Check Valves with Metal Seats, Class 125:
   1. Description:

      a. Standard: MSS SP-71, Type I.
      b. CWP Rating: 200 psig (1380 kPa).
      c. Body Design: Clear or full waterway.
      d. Body Material: ASTM A126, gray iron with bolted bonnet.
      e. Ends: Flanged or threaded. See valve schedule articles.
      f. Trim: Bronze.
      g. Gasket: Asbestos free.

B. Iron Swing Check Valves with Nonmetallic-to-Metal Seats, Class 125:
   1. Description:

      a. Standard: MSS SP-71, Type I.

b. CWP Rating: 200 psig (1380 kPa).
c. Body Design: Clear or full waterway.
d. Body Material: ASTM A126, gray iron with bolted bonnet.
e. Ends: Flanged or threaded. See valve schedule articles.
f. Trim: Composition.
g. Seat Ring: Bronze.
h. Disc Holder: Bronze.
i. Disc: PTFE.
j. Gasket: Asbestos free.

2.4 IRON SWING CHECK VALVES WITH CLOSURE CONTROL

A. Iron Swing Check Valves with Lever- and Spring-Closure Control, Class 125:
1. Description:

a. Standard: MSS SP-71, Type I.
b. CWP Rating: 200 psig (1380 kPa).
c. Body Design: Clear or full waterway.
d. Body Material: ASTM A126, gray iron with bolted bonnet.
e. Ends: Flanged or threaded. See valve schedule articles.
f. Trim: Bronze.
g. Gasket: Asbestos free.
h. Closure Control: Factory-installed exterior lever and spring.

B. Iron Swing Check Valves with Lever and Weight-Closure Control, Class 125:
1. Description:

a. Standard: MSS SP-71, Type I.
b. CWP Rating: 200 psig (1380 kPa).
c. Body Design: Clear or full waterway.
d. Body Material: ASTM A126, gray iron with bolted bonnet.
e. Ends: Flanged or threaded. See valve schedule articles.
f. Trim: Bronze.
g. Gasket: Asbestos free.
h. Closure Control: Factory-installed exterior lever and weight.

PART 3 - EXECUTION

3.1 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install swing check valves for proper direction of flow in horizontal position with hinge pin level.

3.2 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:

1. Pump-Discharge Check Valves:

a. NPS 2 (DN 50) and Smaller: Bronze swing check valves with bronze or nonmetallic disc as directed.
b. NPS 2-1/2 (DN 65) and Larger for Domestic Water: Iron swing check valves with lever and weight or spring; metal-seat or resilient-seat check valves as directed.
c. NPS 2-1/2 (DN 65) and Larger for Sanitary Waste and Storm Drainage: Iron swing check valves with lever and weight or spring.

B. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.

C. End Connections:

1. For Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded or soldered or press-ends.
2. For Copper Tubing, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged or threaded.
3. For Copper Tubing, NPS 5 (DN 125) and Larger: Flanged.
4. For Steel Piping, NPS 2 (DN 50) and Smaller: Threaded.
5. For Steel Piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged or threaded.
6. For Steel Piping, NPS 5 (DN 125) and Larger: Flanged.

3.4 LOW-PRESSURE, COMPRESSED-AIR VALVE SCHEDULE (150 PSIG (1035 kPa) OR LESS)

A. Pipe NPS 2 (DN 50) and Smaller:

1. Horizontal and Vertical Applications: Bronze swing check valves with bronze or nonmetallic disc, Class 125 or Class 150, with soldered or threaded end connections as directed.

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Iron swing check valves with metal or nonmetallic-to-metal seats, Class 125, with threaded or flanged end connections as directed.

3.5 HIGH-PRESSURE, COMPRESSED-AIR VALVE SCHEDULE (150 TO 200 PSIG (1035 TO 1380 kPa)

A. Pipe NPS 2 (DN 50) and Smaller:

1. Horizontal and Vertical Applications: Bronze swing check valves bronze or nonmetallic disc, Class 125, with soldered or threaded end connections as directed.

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Iron swing check valves with metal or nonmetallic-to-metal seats, Class 125, with threaded or flanged end connections as directed.

3.6 DOMESTIC HOT - AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:

1. Bronze swing check valves bronze or nonmetallic disc, Class 125, with soldered or threaded end connections as directed.
2. Bronze swing check valves with press-end connections.

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Iron swing check valves with metal or nonmetallic-to-metal seats, Class 125, with threaded or flanged end connections as directed.
2. Iron swing check valves with closure control, lever and spring, Class 125, with threaded or flanged end connections as directed.

END OF SECTION 220523.14

SECTION 220523.15 - GATE VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bronze gate valves.
2. Iron gate valves.
3. Chainwheels.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

1. Certification that products comply with NSF 61 and NSF 372.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

1. ASME B1.20.1 for threads for threaded end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
4. ASME B16.18 for solder joint.
5. ASME B31.9 for building services piping valves.

C. NSF Compliance: NSF 61 and NSF 372 for valve materials for potable-water service.

D. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

F. Valve Sizes: Same as upstream piping unless otherwise indicated.

G. RS Valves in Insulated Piping: With 2-inch (50-mm) stem extensions.

H. Valve Bypass and Drain Connections: MSS SP-45.

2.2 BRONZE GATE VALVES

A. Bronze Gate Valves, NRS, Class 125:
   1. Description:

      a. Standard: MSS SP-80, Type 1.
      b. CWP Rating: 200 psig (1380 kPa).
      c. Body Material: Bronze with integral seat and screw-in bonnet.
      d. Ends: Threaded or solder joint.
      e. Stem: Bronze.
      f. Disc: Solid wedge; bronze.
      g. Packing: Asbestos free.
      h. Handwheel: Malleable iron, bronze, or aluminum.

B. Bronze Gate Valves, RS, Class 125:
   1. Description:

      a. Standard: MSS SP-80, Type 2.
      b. CWP Rating: 200 psig (1380 kPa).
      c. Body Material: Bronze with integral seat and screw-in bonnet.
      d. Ends: Threaded or solder joint.
      e. Stem: Bronze.
      f. Disc: Solid wedge; bronze.
      g. Packing: Asbestos free.
      h. Handwheel: Malleable iron, bronze, or aluminum.

C. Bronze Gate Valves, Press Ends:
   1. Description:

      a. Standard: MSS SP-80 and MSS SP-139.
      b. CWP Rating: Minimum 200 psig (1380 kPa).
      c. Body Material: Bronze with integral seat and union-ring bonnet.
      d. Ends: Press.
      e. Press Ends Connection Rating: Minimum 200 psig (1380 kPa).
      f. Stem: Brass or bronze rising or non-rising as directed.
      g. Disc: Solid wedge; bronze.
      h. Packing: Graphite.
      i. Port: Full.
      j. Handwheel: Malleable iron, bronze, or aluminum.

2.3 IRON GATE VALVES

A. Iron Gate Valves, NRS, Class 125:
   1. Description:

      a. Standard: MSS SP-70, Type I.
      b. CWP Rating: 200 psig (1380 kPa).
      c. Body Material: Gray iron with bolted bonnet.
      d. Ends: Flanged.
      e. Trim: Bronze.

f. Disc: Solid wedge.
g. Packing and Gasket: Asbestos free.

B. Iron Gate Valves, OS&Y, Class 125:
1. Description:

a. Standard: MSS SP-70, Type I.
b. CWP Rating: 200 psig (1380 kPa).
c. Body Material: Gray iron with bolted bonnet.
d. Ends: Flanged.
e. Trim: Bronze.
f. Disc: Solid wedge.
g. Packing and Gasket: Asbestos free.

2.4 CHAINWHEELS

A. Description: Valve actuation assembly with sprocket rim, chain guides, chain, and attachment brackets for mounting chainwheels directly to hand wheels as directed.

1. Sprocket Rim with Chain Guides: Ductile iron, of type and size required for valve. Include zinc or epoxy coating as directed.
2. Chain: Hot-dip galvanized steel of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install chainwheels on operators for gate valves NPS 4 (DN 100) and larger and more than 96 inches (2400 mm) above floor. Extend chains to 60 inches (1520 mm) above finished floor.

3.2 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. Use gate valves for shutoff service only.

B. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.

3.4 LOW-PRESSURE, COMPRESSED-AIR VALVE SCHEDULE (150 PSIG (1035 kPa) OR LESS)

A. Pipe NPS 2 (DN 50) and Smaller: Bronze gate valves, NRS or RS, Class 125 with soldered or threaded ends.

B. Pipe NPS 2-1/2 (DN 65) and Larger: Iron gate valves, NRS or OS&Y, Class 125 with flanged ends.

3.5 HIGH-PRESSURE, COMPRESSED-AIR VALVE SCHEDULE (150 TO 200 PSIG (1035 TO 1380 kPa)

A. Pipe NPS 2 (DN 50) and Smaller: Bronze gate valves, NRS or RS, Class 125 with soldered or threaded ends.

B. Pipe NPS 2-1/2 (DN 65) and Larger: Iron gate valves, NRS or OS&Y, Class 125 with flanged ends.

3.6 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:

1. Bronze gate valves, NRS or RS, Class 125 with soldered or threaded ends.
2. Bronze gate valves, press ends.

B. Pipe NPS 2-1/2 (DN 65) and Larger: Iron gate valves, NRS or OS&Y, Class 125 with flanged ends.

END OF SECTION 220523.15

SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Thermal hanger-shield inserts.
4. Fastener systems.
5. Pipe-positioning systems.
6. Equipment supports.

B. Related Requirements:

1. Section 055000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Section 220516 "Expansion Fittings and Loops for Plumbing Piping" for pipe guides and anchors.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Show fabrication and installation details and include calculations.

C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.3 QUALITY ASSURANCE

A. Structural-Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M.

B. Pipe Welding Qualifications: Qualify procedures and operators according to "2015 ASME Boiler and Pressure Vessel Code, Section IX."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design trapeze pipe hangers and equipment supports.

B. Structural Performance: Hangers and supports for plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
3. Design seismic-restraint hangers and supports for piping and equipment.

2.2 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pre-galvanized, hot-dip galvanized, or electro-galvanized.
3. Nonmetallic Coatings: Plastic coated or epoxy powder coated.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel or stainless steel, as directed.

B. Stainless-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

C. Copper Pipe and Tube Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel or stainless steel, as directed.

2.3 TRAPEZE PIPE HANGERS

A. Description: MSS SP-58, Type 59, shop- or field-fabricated pipe-support assembly, made from structural-carbon-steel shapes, with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.4 THERMAL HANGER-SHIELD INSERTS

A. Insulation-Insert Material for Cold Piping: ASTM C552, Type II cellular glass with 100-psig (688-kPa) or ASTM C591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength and vapor barrier, as directed.

B. Insulation-Insert Material for Hot Piping: Water-repellent-treated, ASTM C533, Type I calcium silicate with 100-psig (688-kPa), ASTM C552, Type II cellular glass with 100-psig (688-kPa) or ASTM C591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength, as directed.

C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

E. Insert Length: Extend 2 inches (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Expansion Anchors: Insert-wedge-type anchors, for use in hardened portland cement concrete, with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
   1. Indoor Applications: Zinc-coated or stainless steel as directed.
   2. Outdoor Applications: Stainless steel.

2.6 PIPE-POSITIONING SYSTEMS

A. Description: IAPMO PS 42 positioning system composed of metal brackets, clips, and straps for positioning piping in pipe spaces; for plumbing fixtures in commercial applications.

2.7 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural-carbon-steel shapes.

2.8 MATERIALS

A. Aluminum: ASTM B221 (ASTM B221M).

B. Carbon Steel: ASTM A1011/A1011M.

C. Structural Steel: ASTM A36/A36M carbon-steel plates, shapes, and bars; black and galvanized.

D. Stainless Steel: ASTM A240/A240M.

E. Grout: ASTM C1107/C1107M, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Non-staining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation, for penetrations through fire-rated walls, ceilings, and assemblies.

B. Strength of Support Assemblies: Where not indicated, select sizes of components, so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg) or as directed.

3.2 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller-diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A36/A36M carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Thermal Hanger-Shield Installation: Install in pipe hanger or shield for insulated piping.

D. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick in concrete, after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete, after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

E. Pipe-Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.

F. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

G. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

H. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

I. Install lateral bracing with pipe hangers and supports to prevent swaying.

J. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 (DN 65) and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

K. Load Distribution: Install hangers and supports, so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

L. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

M. Insulated Piping:

1. Attach clamps and spacers to piping.

    a. Piping Operating Above Ambient Air Temperature: Clamp may project through insulation.
    b. Piping Operating Below Ambient Air Temperature: Use thermal hanger-shield insert with clamp sized to match OD of insert.
    c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39 protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

    a. Option: Thermal hanger-shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40 protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

    a. Option: Thermal hanger-shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:

    a. NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
    b. NPS 4 (DN 100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.

c. NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.
d. NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.
e. NPS 16 to NPS 24 (DN 400 to DN 600): 24 inches (610 mm) long and 0.105 inch (2.67 mm) thick.

5. Pipes NPS 8 (DN 200) and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal Hanger Shields: Install with insulation of same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work.

3.5 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches (40 mm).

3.6 PAINTING

A. Touchup: Clean field welds and abraded, shop-painted areas. Paint exposed areas immediately after erecting hangers and supports. Use same materials as those used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils (0.05 mm).

B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded, shop-painted areas on miscellaneous metal are as directed

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas, and apply galvanizing-repair paint to comply with ASTM A780/A780M.

3.7 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finishes.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports and metal trapeze pipe hangers and attachments for general service applications.

F. Use stainless-steel pipe hangers and stainless-steel or corrosion-resistant attachments for hostile environment applications as directed.

G. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing as directed.

H. Use padded hangers for piping that is subject to scratching.

I. Use thermal hanger-shield inserts for insulated piping and tubing.

J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of non-insulated or insulated, stationary pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F (566 deg C) pipes NPS 4 to NPS 24 (DN 100 to DN 600), requiring up to 4 inches (100 mm) of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36 (DN 20 to DN 900), requiring clamp flexibility and up to 4 inches (100 mm) of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 (DN 15 to DN 600) if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4 (DN 15 to DN 100), to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of non-insulated, stationary pipes NPS 3/4 to NPS 8 (DN 20 to DN 200).

7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
8. Adjustable Band Hangers (MSS Type 9): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of non-insulated, stationary pipes NPS 3/8 to NPS 8 (DN 10 to DN 200).
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of non-insulated, stationary pipes NPS 3/8 to NPS 3 (DN 10 to DN 80).
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 (DN 65 to DN 900) if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30 (DN 25 to DN 750), from two rods if longitudinal movement caused by expansion and contraction occurs.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24 (DN 65 to DN 600), from single rod if horizontal movement caused by expansion and contraction occurs.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 (DN 50 to DN 1050) if longitudinal movement caused by expansion and contraction occurs but vertical adjustment is unnecessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 (DN 50 to DN 600) if small horizontal movement caused by expansion and contraction occurs and vertical adjustment is unnecessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 (DN 50 to DN 750) if vertical and lateral adjustment during installation, in addition to expansion and contraction, is required.

K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24 (DN 24 to DN 600).
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 (DN 20 to DN 600) if longer ends are required for riser clamps.

L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment of up to 6 inches (150 mm) for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11 split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F (49 to 232 deg C) piping installations.

M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable-Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb (340 kg).
    b. Medium (MSS Type 32): 1500 lb (680 kg).
    c. Heavy (MSS Type 33): 3000 lb (1360 kg).

13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.

3. Thermal Hanger-Shield Inserts: For supporting insulated pipe.

O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches (32 mm).
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load, and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load, and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load, and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

    a. Horizontal (MSS Type 54): Mounted horizontally.
    b. Vertical (MSS Type 55): Mounted vertically.
    c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

P. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

Q. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction as directed.

R. Use pipe-positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

END OF SECTION 220529

SECTION 220533 - HEAT TRACING FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes plumbing piping heat tracing for freeze prevention, domestic hot-water-temperature maintenance, and snow and ice melting on roofs and in gutters and downspouts with the following electric heating cables:

1. Plastic insulated, series resistance.
2. Self-regulating, parallel resistance.

B. Related Requirements:

1. Section 210533 "Heat Tracing for Fire-Suppression Piping."
2. Section 230533 "Heat Tracing for HVAC Piping."

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For electric heating cable.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace electric heating cable that fails in materials or workmanship within specified warranty period.

1. Warranty Period: As directed Three or Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PLASTIC-INSULATED, SERIES-RESISTANCE HEATING CABLES

A. Comply with IEEE 515.1.

B. Heating Element: Single- or dual-stranded resistor wire. Terminate with waterproof, factory-assembled, non-heating leads with connectors at both ends.

C. Electrical Insulating Jacket: Minimum 4.0-mil (0.10-mm) Kapton with silicone, Tefzel, or polyolefin.

D. Cable Cover: Aluminum braid and silicone or Hylar outer jacket.

E. Maximum Operating Temperature (Power On): 300 deg F (150 deg C).

F. Maximum Exposure Temperature (Power Off): 185 deg F (85 deg C).

G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

H. Capacities and Characteristics:

1. Maximum Heat Output: As directed 6 W/ft. (19.7 W/m) or 7.5 W/ft. (24.6 W/m).
2. Piping Diameter: As directed.
3. Number of Parallel Cables: As directed.
4. Spiral Wrap Pitch: As directed.
5. Electrical Characteristics for Single-Circuit Connection:

    a. Volts: As directed 120, 208, 240, 277 or 480.
    b. Phase: As directed.
    c. Hertz: As directed.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed.
    f. Maximum Overcurrent Protection: As directed.

2.2 SELF-REGULATING, PARALLEL-RESISTANCE HEATING CABLES

A. Comply with IEEE 515.1.

B. Heating Element: As directed, pair of parallel No. 16 or No. 18 AWG, tinned or nickel-coated, stranded copper bus wires embedded in crosslinked conductive polymer core, which varies heat output in response to temperature along its length. Terminate with waterproof, factory-assembled, non-heating leads with connectors at one end, and seal the opposite end watertight. Cable shall be capable of crossing over itself once without overheating.

C. Electrical Insulating Jacket: Flame-retardant polyolefin.

D. Cable Cover: As directed Tinned-copper or Stainless-steel braid and polyolefin outer jacket with ultraviolet inhibitor.

E. Maximum Operating Temperature (Power On): 150 deg F (65 deg C).

F. Maximum Exposure Temperature (Power Off): 185 deg F (85 deg C).

G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

H. Capacities and Characteristics:

1. Maximum Heat Output: As directed 3 W/ft. (9.8 W/m), 5 W/ft. (16.4 W/m), 8 W/ft. (26 W/m), 10 W/ft. (32.8 W/m) or 12 W/ft. (39.4 W/m).
2. Piping Diameter: As directed.
3. Number of Parallel Cables: As directed.
4. Spiral Wrap Pitch: As directed.
5. Electrical Characteristics for Single-Circuit Connection:

    a. Volts: As directed 120, 208, 240, 277 or 480.
    b. Phase: As directed.
    c. Hertz: As directed.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed.
    f. Maximum Overcurrent Protection: As directed.

2.3 CONTROLS

A. Pipe-Mounted Thermostats for Freeze Protection:

1. Remote bulb unit with adjustable temperature range from 30 to 50 deg F (minus 1 to plus 10 deg C).
2. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected cable.
3. Remote bulb on capillary, resistance temperature device, or thermistor for directly sensing pipe-wall temperature.
4. Corrosion-resistant, waterproof control enclosure.

B. Precipitation and Temperature Sensor for Snow Melting on Roofs and in Gutters:

1. As directed, microprocessor-based or Automatic control with manual on, automatic, and standby/reset switch.
2. Precipitation and temperature sensors shall sense the surface conditions of roof and gutters and shall be programmed to energize the cable as follows:

    a. Temperature Span: 34 to 44 deg F (1 to 7 deg C).
    b. Adjustable Delay-Off Span: 30 to 90 minutes.
    c. Energize Cables: Following two-minute delay if ambient temperature is below set point and precipitation is detected.
    d. De-Energize Cables: On detection of a dry surface plus time delay.

3. Corrosion-proof and waterproof enclosure suitable for outdoor mounting, for controls and precipitation and temperature sensors.

4. Minimum 30-A contactor to energize cable or close other contactors.
5. Precipitation sensor shall be freestanding.
6. Provide relay with contacts to indicate operational status, on or off, for interface with central HVAC control-system workstation.

C. Programmable Timer for Domestic Hot-Water-Temperature Maintenance:

1. Microprocessor based.
2. Minimum of four separate schedules.
3. Minimum 24-hour battery carryover.
4. On-off-auto switch.
5. 365-day calendar with 20 programmable holidays.
6. Relays with contacts to indicate operational status, on or off, and for interface with central HVAC control-system workstation.

2.4 ACCESSORIES

A. Cable Installation Accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer.

B. Warning Labels: Refer to Section 220553 "Identification for Plumbing Piping and Equipment."

C. Warning Tape: Continuously printed "Electrical Tracing"; vinyl, at least 3 mils (0.08 mm) thick, and with pressure-sensitive, permanent, waterproof, self-adhesive back.

1. Width for Markers on Pipes with OD, including insulation, less than 6-inches (150 mm): ¾- inch (19 mm) minimum.
2. Width for Markers on Pipes with OD, including insulation, 6-inches (150 mm) or Larger: 1-1/2 inches (38 mm) minimum.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Install the following types of electric heating cable for the applications described:

1. Snow and Ice Melting on Roofs and in Gutters and Downspouts: As directed Plastic-insulated, series-resistance or Self-regulating, parallel-resistance heating cable.
2. Temperature Maintenance for Domestic Hot Water: Self-regulating, parallel-resistance heating cable.

3.2 INSTALLATION

A. Install electric heating cable across expansion, construction, and control joints according to manufacturer's written instructions; use cable-protection conduit and slack cable to allow movement without damage to cable.

B. Electric Heating-Cable Installation for Snow and Ice Melting on Roofs and in Gutters and Downspouts: Install on roof and in gutters and downspouts with clips furnished by manufacturer that are compatible with roof, gutters, and downspouts.

C. Electric Heating-Cable Installation for Freeze Protection for Piping:

1. Install electric heating cables after piping has been tested and before insulation is installed.
2. Install electric heating cables according to IEEE 515.1.
3. Install insulation over piping with electric cables according to Section 220719 "Plumbing Piping Insulation."
4. Install warning tape on piping insulation where piping is equipped with electric heating cables.

D. Electric Heating-Cable Installation for Temperature Maintenance for Domestic Hot Water:

1. Install electric heating cables after piping has been tested and before insulation is installed.
2. Install insulation over piping with electric heating cables according to Section 220719 "Plumbing Piping Insulation."
3. Install warning tape on piping insulation where piping is equipped with electric heating cables.

E. Set field-adjustable switches and circuit-breaker trip ranges.

F. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

G. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform tests after cable installation but before application of coverings such as insulation, wall or ceiling construction, or concrete.
2. Test cables for electrical continuity and insulation integrity before energizing.
3. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.

B. Repeat tests for continuity, insulation resistance, and input power after applying thermal insulation on pipe-mounted cables.

C. Cables will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

E. Remove and replace damaged heat-tracing cables.

END OF SECTION 220533

SECTION 220548 - VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Open-spring isolators.
5. Housed-spring isolators.
6. Restrained-spring isolators.
7. Housed-restrained-spring isolators.
8. Pipe-riser resilient supports.
9. Resilient pipe guides.
10. Elastomeric hangers.
11. Spring hangers.
12. Snubbers.
13. Restraint channel bracings.
14. Restraint cables.
15. Seismic-restraint accessories.
16. Mechanical anchor bolts.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Delegated-Design Submittal: For each vibration isolation and seismic-restraint device.

1. Include design calculations and details for selecting vibration isolators and seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.3 QUALITY ASSURANCE

A. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

B. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum

seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are unavailable, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:

1. Site Class as Defined in the IBC: A, B, C, D, E or F as directed.
2. Assigned Seismic Use Group or Building Category as Defined in the IBC: I, II or III as directed.

    a. Component Importance Factor: 1.5.
    b. Component Response Modification Factor: As directed.
    c. Component Amplification Factor: As directed.

3. Design Spectral Response Acceleration at Short Periods (0.2 Second): As directed.
4. Design Spectral Response Acceleration at 1.0-Second Period: As directed.

2.2 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:
1. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
2. Size: Factory or field cut to match requirements of supported equipment.
3. Pad Material: Oil and water resistant with elastomeric properties.
4. Surface Pattern: Smooth, Ribbed or Waffle pattern as directed.
5. Infused nonwoven cotton or synthetic fibers.
6. Load-bearing metal plates adhered to pads.

2.3 ELASTOMERIC ISOLATION MOUNTS

A. Double-Deflection, Elastomeric Isolation Mounts.
1. Mounting Plates:

    a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.
    b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.

2. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.4 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts:
   1. Description: All-directional isolator with seismic restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.

      a. Housing: Cast-ductile iron or welded steel.
      b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.5 OPEN-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators:
   1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   5. Baseplates: Factory-drilled steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates shall limit floor load to 500 psig (3447 kPa).
   6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

2.6 HOUSED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing
   1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   5. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.

      a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig (3447 kPa).
      b. Top housing with attachment and leveling bolt, threaded mounting holes and internal leveling device and/or elastomeric pad as directed.

2.7 RESTRAINED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint.
   1. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.

a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig (3447 kPa).
b. Top plate with threaded mounting holes or elastomeric pad.
c. Internal leveling bolt that acts as blocking during installation.

2. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.8 HOUSED-RESTRAINED-SPRING ISOLATORS

A. Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing
1. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with snubbers to limit vertical movement as directed.

a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig (3447 kPa).
b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.9 PIPE-RISER RESILIENT SUPPORT

A. Description: All-directional, acoustical pipe anchor consisting of two steel tubes separated by a minimum 1/2-inch (13-mm) thick neoprene.

1. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
2. Maximum Load Per Support: 500 psig (3.45 MPa) on isolation material providing equal isolation in all directions.

2.10 RESILIENT PIPE GUIDES

A. Description: Telescopic arrangement of two steel tubes or post and sleeve arrangement separated by a minimum 1/2-inch (13-mm) thick neoprene.

1. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and re-insertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.11 ELASTOMERIC HANGERS

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods
   1. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
   2. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.12 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression
   1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
   2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
   7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
   8. Self-centering hanger-rod cap to ensure concentricity between hanger rod and support spring coil.

2.13 SNUBBERS

A. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

   1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
   2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
   3. Maximum 1/4-inch (6-mm) air gap, and minimum 1/4-inch (6-mm-) thick resilient cushion.

2.14 RESTRAINT CHANNEL BRACINGS

A. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.15 RESTRAINT CABLES

A. Restraint Cables: ASTM A603 galvanized steel or ASTM A492 stainless steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.16 SEISMIC-RESTRAINT ACCESSORIES

A. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or Reinforcing steel angle clamped to hanger rod as directed.

B. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings and matched to type and size of anchor bolts and studs.

C. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings and matched to type and size of attachment devices used.

D. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

E. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry present and future static and seismic loads within specified loading limits.

3.2 VIBRATION CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork as directed.

B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

C. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

D. Equipment Restraints:

1. Install seismic snubbers on plumbing equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.

E. Piping Restraints:

1. Comply with requirements in MSS SP-127.
2. Space lateral supports a maximum of 40 feet (12 m) o.c., and longitudinal supports a maximum of 80 feet (24 m) o.c.
3. Brace a change of direction longer than 12 feet (3.7 m).

F. Install cables so they do not bend across edges of adjacent equipment or building structure.

G. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.

H. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

I. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

J. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

K. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.

2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.3 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 221116 "Domestic Water Piping" for piping flexible connections.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post connection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Owner.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust limit stops on restrained-spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

END OF SECTION 220548

SECTION 220548.13 - VIBRATION CONTROLS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Open-spring isolators.
5. Housed-spring isolators.
6. Restrained-spring isolators.
7. Housed-restrained-spring isolators.
8. Pipe-riser resilient supports.
9. Resilient pipe guides.
10. Elastomeric hangers.
11. Spring hangers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Delegated-Design Submittal: For each vibration isolation device.

1. Include design calculations for selecting vibration isolators.

PART 2 - PRODUCTS

2.1 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads
1. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
2. Size: Factory or field cut to match requirements of supported equipment.
3. Pad Material: Oil and water resistant with elastomeric properties.
4. Surface Pattern: Smooth, Ribbed or Waffle pattern as directed.
5. Infused nonwoven cotton or synthetic fibers.
6. Load-bearing metal plates adhered to pads.

2.2 ELASTOMERIC ISOLATION MOUNTS

A. Double-Deflection, Elastomeric Isolation Mounts

1. Mounting Plates:

    a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.
    b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.

2. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.3 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts
1. Description: All-directional isolator with restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.

    a. Housing: Cast-ductile iron or welded steel.
    b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.4 OPEN-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators
1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Baseplates: Factory-drilled steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates shall limit floor load to 500 psig (3447 kPa).
6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

2.5 HOUSED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing
1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.

a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig (3447 kPa).
b. Top housing with attachment and leveling bolt, threaded mounting holes and internal leveling device or elastomeric pad as directed.

2.6 RESTRAINED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint
1. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.

a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig (3447 kPa).
b. Top plate with threaded mounting holes or elastomeric pad as directed.
c. Internal leveling bolt that acts as blocking during installation.

2. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.7 HOUSED-RESTRAINED-SPRING ISOLATORS

A. Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing
1. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with snubbers to limit vertical movement as directed.

a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig (3447 kPa).
b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.8 PIPE-RISER RESILIENT SUPPORT

A. Description: All-directional, acoustical pipe anchor consisting of two steel tubes separated by a minimum 1/2-inch- (13-mm-) thick neoprene.

1. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
2. Maximum Load Per Support: 500 psig (3.45 MPa) on isolation material providing equal isolation in all directions.

2.9 RESILIENT PIPE GUIDES

A. Description: Telescopic arrangement of two steel tubes or post and sleeve arrangement separated by a minimum 1/2-inch- (13-mm-) thick neoprene.

1. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and re-insertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.10 ELASTOMERIC HANGERS

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods
1. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
2. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.11 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression
1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
8. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

PART 3 - EXECUTION

3.1 VIBRATION CONTROL DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified as directed.

B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

END OF SECTION 220548.13

SECTION 220553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Material and Thickness: As directed, Brass, 0.032-inch (0.8-mm), stainless steel, 0.025-inch (0.64-mm), aluminum, 0.032-inch (0.8-mm) or anodized aluminum, 0.032-inch (0.8-mm) minimum thickness and having predrilled or stamped holes for attachment hardware.
2. Letter Color: As directed, Black, Blue, Red, White or Yellow.
3. Background Color: As directed Black, Blue, Red, White or Yellow.
4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
5. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
6. Fasteners: Stainless-steel rivets or self-tapping screws.
7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch (1.6 mm) or 1/8 inch (3.2 mm) thick as directed and having predrilled holes for attachment hardware.
2. Letter Color: As directed, Black, Blue, Red, White or Yellow.
3. Background Color: As directed, Black, Blue, Red, White or Yellow.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).

6. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch (A4) bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch (1.6 mm) or 1/8 inch (3.2 mm) thick and having predrilled holes for attachment hardware.

B. Letter Color: As directed, Black, Blue, Red, White or Yellow.

C. Background Color: As directed, Black, Blue, Red, White or Yellow.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).

F. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

B. Pretensioned Pipe Labels: As directed, pre-coiled, semirigid plastic formed to partially cover or cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping-system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: As directed Size letters according to ASME A13.1 for piping or At least 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm) and proportionately larger lettering for greater viewing distances.

PART 3 - EXECUTION

3.1 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.2 PIPE LABEL INSTALLATION

A. Piping Color Coding: Painting of piping is specified in Section 099123 "Interior Painting" or Section 099600 "High-Performance Coatings", as directed.

B. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet (15 m) along each run. Reduce intervals to 25 feet (7.6 m) in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

C. Pipe Label Color Schedule:

1. Low-Pressure Compressed Air Piping:

a. Background: Safety blue.
b. Letter Colors: White.

2. High-Pressure Compressed Air Piping:

a. Background: Safety blue.
b. Letter Colors: White.

3. Domestic Water Piping

a. Background: Safety green.
b. Letter Colors: White.

4. Sanitary Waste and Storm Drainage Piping:

a. Background Color: As directed, Safety black, Safety purple, Safety white or Safety gray.
b. Letter Color: As directed, Black or White.

END OF SECTION 220553

SECTION 220716 - PLUMBING EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following plumbing equipment:

1. Domestic water heat exchangers.
2. Domestic water converters.

B. Related Sections:

1. Section 220719 "Plumbing Piping Insulation."

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail attachment and covering of heat tracing inside insulation.
3. Detail removable insulation at equipment connections and access panels.
4. Detail application of field-applied jackets.
5. Detail application at linkages of control devices.
6. Detail field application for each equipment type.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Products shall not contain asbestos, lead, mercury, or mercury compounds.

B. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C871.

C. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

D. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

E. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534, Type I for tubular materials and Type II for sheet materials.

F. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ or FSK jacket complying with ASTM C1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C612, Type IB. Nominal density is 2.5 lb/cu. ft. (40 kg/cu. m) or more. Thermal conductivity (k-value) at 100 deg F (55 deg C) is 0.29 Btu x in./h x sq. ft. x deg F (0.042 W/m x K) or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

G. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C534 or ASTM C1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.

2.2 INSULATING CEMENTS

A. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C449.

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

D. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

E. PVC Jacket Adhesive: Compatible with PVC jacket.

2.4 MASTICS AND COATINGS

A. Materials shall be compatible with insulation materials, jackets, and substrates.

B. Vapor-Retarder Mastic: Water based; suitable for indoor use on below ambient services.
   1. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
   2. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
   3. Comply with MIL-PRF-19565C, Type II, for permeance requirements.
   4. Color: White or as directed.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
   1. Water-Vapor Permeance: ASTM E96, greater than 1.0 perm (0.66 metric perms) at manufacturer's recommended dry film thickness.
   2. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
   3. Color: White or as directed.

2.5 SEALANTS

A. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Fire- and water-resistant, flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
   4. Color: White.

2.6 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

   1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
   2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
   3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.
   4. PVDC Jacket for Indoor Applications: 4-mil- (0.10-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perm (0.013 metric perm) when tested according to ASTM E96/E96M and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E84.

   5. PVDC Jacket for Outdoor Applications: 6-mil- (0.15-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perm (0.007 metric perm) when tested according to ASTM E96/E96M and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E84.

   6. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

2.7 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm), in a Leno weave, for equipment.

2.8 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C921, Type I, unless otherwise indicated.

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
   1. Adhesive: As recommended by jacket material manufacturer.
   2. Color: White or as directed.
   3. Factory-fabricated tank heads and tank side panels.

2.9 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
   1. Width: 3 inches (75 mm).
   2. Thickness: 11.5 mils (0.29 mm).
   3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
   4. Elongation: 2 percent.
   5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
   6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.
   1. Width: 3 inches (75 mm).
   2. Thickness: 6.5 mils (0.16 mm).
   3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
   4. Elongation: 2 percent.
   5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
   6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
   1. Width: 2 inches (50 mm).
   2. Thickness: 6 mils (0.15 mm).
   3. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
   4. Elongation: 500 percent.
   5. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
   1. Width: 2 inches (50 mm).
   2. Thickness: 3.7 mils (0.093 mm).
   3. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.

4. Elongation: 5 percent.
5. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.

E. PVDC Tape: White vapor-retarder PVDC tape with acrylic adhesive.
1. Width: 3 inches (75 mm).
2. Film Thickness: 4 mils (0.10 mm) or 6 mils (0.15 mm) as directed.
3. Adhesive Thickness: 1.5 mils (0.04 mm).
4. Elongation at Break: 145 percent.
5. Tensile Strength: 55 lbf/inch (10.1 N/mm) in width.

2.10 SECUREMENTS

A. Aluminum Bands: ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) or 3/4 inch (19 mm) wide with wing seal or closed seal as directed.

B. Insulation Pins and Hangers:

1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
   a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
   b. Spindle: Copper- or zinc-coated, low-carbon steel, Aluminum or Stainless steel, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated as directed.
   c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

2. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
   a. Baseplate: Perforated, nylon sheet, 0.030 inch (0.76 mm) thick by 1-1/2 inches (38 mm) in diameter.
   b. Spindle: Nylon, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches (63 mm).
   c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

3. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
   a. Baseplate: Galvanized carbon-steel sheet, 0.030-inch (0.76 mm) thick by 2 inches (50 mm) square.
   b. Spindle: Copper- or zinc-coated, low-carbon steel, Aluminum or Stainless steel, fully annealed, 0.106-inch (2.6-mm) diameter shank, length to suit depth of insulation indicated as directed.
   c. Adhesive-backed base with a peel-off protective cover.

4. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch (0.41-mm) thick, galvanized-steel, aluminum or stainless-steel sheet as directed, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
   a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

5. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch (0.41-mm) thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch (19-mm) wide, stainless steel or Monel.

D. Wire: 0.080-inch (2.0-mm) nickel-copper alloy, 0.062-inch (1.6-mm) soft-annealed, stainless steel or 0.062-inch (1.6-mm) soft-annealed, galvanized steel as directed.

2.11 CORNER ANGLES

A. PVC Corner Angles: 30 mils (0.8 mm) thick, minimum 1 by 1 inch (25 by 25 mm), PVC according to ASTM D1784, Class 16354-C. White or color-coded to match adjacent surface.

B. Aluminum Corner Angles: 0.040 inch (1.0 mm) thick, minimum 1 by 1 inch (25 by 25 mm), aluminum according to ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14.

PART 3 - EXECUTION

3.1 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches (50 mm) or 4 inches (100 mm) o.c. as directed.

    a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

O. For above ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.3 INSTALLATION OF EQUIPMENT, TANK, AND VESSEL INSULATION

A. Mineral-Fiber, Pipe, and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.
4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:

    a. Do not weld anchor pins to ASME-labeled pressure vessels.
    b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
    c. On tanks and vessels, maximum anchor-pin spacing is 3 inches (75 mm) from insulation end joints, and 16 inches (400 mm) o.c. in both directions.
    d. Do not over compress insulation during installation.
    e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
    f. Impale insulation over anchor pins and attach speed washers.
    g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches (150 mm) from each end. Install wire or cable

between two circumferential girdles 12 inches (300 mm) o.c. Install a wire ring around each end and around outer periphery of center openings and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches (1200 mm) o.c. Use this network for securing insulation with tie wire or bands.

7. Stagger joints between insulation layers at least 3 inches (75 mm).
8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.

1. Apply 50 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
2. Seal longitudinal seams and end joints.

3.4 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.5 FIELD-APPLIED JACKET INSTALLATION

A. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch (75-mm) wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

B. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

C. Where PVDC jackets are indicated, install as follows:

1. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches (850 mm) or less. 33-1/2-inch (850-mm)

circumference limit allows for 2-inch (50-mm) overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.

2. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.6 FINISHES

A. Insulation with ASJ or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.8 EQUIPMENT INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

B. Insulate indoor and outdoor equipment that is not factory insulated.

C. Heat-Exchanger (Water-to-Water for Domestic Water Heating Service) Insulation:

1. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.

D. Domestic water, domestic chilled-water (potable), and domestic hot-water hydropneumatic tank insulation shall be one of the following:

1. Flexible Elastomeric: 1 inch (25 mm) thick.
2. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
3. Polyolefin: 1 inch (25 mm) thick.

E. Domestic Hot-Water Storage Tank Insulation:

1. Mineral-Fiber Pipe and Tank: Of thickness to provide an R-value of 12.5.

F. Domestic Water Filter-Housing Insulation:

1. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.

3.9 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Equipment, Concealed:
1. PVC, 20 mils (0.5 mm) or 30 mils (0.8 mm) thick as directed.

D. Equipment, Exposed, up to 48 Inches (1200 mm) in Diameter or with Flat Surfaces up to 72 Inches (1800 mm):
1. PVC 20 mils (0.5 mm) or 30 mils (0.8 mm) thick as directed.

3.10 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. If more than one material is listed, selection from materials listed is Contractor's option.

B. Equipment, Concealed:
1. PVC 20 mils (0.5 mm) or 30 mils (0.8 mm) thick as directed.

END OF SECTION 220716

SECTION 220719 - PLUMBING PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following plumbing piping services:

1. Domestic hot-water piping.
2. Domestic recirculating hot-water piping.
3. Sanitary waste piping exposed to freezing conditions.
4. Storm-water piping exposed to freezing conditions.
5. Roof drains and rainwater leaders.
6. Supplies and drains for handicap-accessible lavatories and sinks.

B. Related Sections:

1. Section 220716 "Plumbing Equipment Insulation."

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail attachment and covering of heat tracing inside insulation.
3. Detail insulation application at pipe expansion joints for each type of insulation.
4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
5. Detail removable insulation at piping specialties, equipment connections, and access panels.
6. Detail application of field-applied jackets.
7. Detail application at linkages of control devices.

1.3 QUALITY ASSURANCE

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

B. Comply with the following applicable standards and other requirements specified for miscellaneous components:

1. Supply and Drain Protective Shielding Guards: ICC A117.1.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
1. Special-Shaped Insulation: ASTM C552, Type III.
2. Preformed Pipe Insulation without Jacket: Comply with ASTM C552, Type II, Class 1.
3. Preformed Pipe Insulation with Factory-Applied ASJ or ASJ-SS: Comply with ASTM C552, Type II, Class 2.
4. Factory fabricate shapes according to ASTM C450 and ASTM C585.

G. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534, Type I for tubular materials.

H. Mineral-Fiber, Preformed Pipe Insulation:
1. Type I, 850 Deg F (454 Deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C547, Type I, Grade A, as directed. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

I. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C534 or ASTM C1427, Type I, Grade 1 for tubular materials.

2.2 INSULATING CEMENTS

A. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C449.

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.

B. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F (minus 73 to plus 93 deg C).
   1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

D. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

E. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

F. PVC Jacket Adhesive: Compatible with PVC jacket.

2.4 MASTICS AND COATINGS

A. Materials shall be compatible with insulation materials, jackets, and substrates.

B. Vapor-Retarder Mastic: Water based; suitable for indoor use on below-ambient services.
   1. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
   2. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
   3. Comply with MIL-PRF-19565C, Type II, for permeance requirements, with supplier listing on DOD QPD - Qualified Products Database.
   4. Color: White.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.
   1. Water-Vapor Permeance: ASTM E96, greater than 1.0 perm (0.66 metric perms) at manufacturer's recommended dry film thickness.
   2. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
   3. Color: White.

2.5 SEALANTS

A. Joint Sealants for Cellular-Glass Products:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Permanently flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C).
   4. Color: White or gray.

B. FSK and Metal Jacket Flashing Sealants:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Fire- and water-resistant, flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
   4. Color: Aluminum.

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Fire- and water-resistant, flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
   4. Color: White.

2.6 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

   1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
   2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
   3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.

2.7 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm), in a Leno weave, for pipe.

2.8 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C921, Type I, unless otherwise indicated.

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
   1. Adhesive: As recommended by jacket material manufacturer.
   2. Color: White.
   3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

      a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

C. Aluminum Jacket: Comply with ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.
   1. Sheet and roll stock ready for shop or field sizing.

2. Finish and thickness are indicated in field-applied jacket schedules.
3. Moisture Barrier for Indoor Applications: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper, 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper or 2.5-mil- (0.063-mm-) thick polysurlyn as directed.
4. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper or 2.5-mil- (0.063-mm-) thick polysurlyn as directed.
5. Factory-Fabricated Fitting Covers:

    a. Same material, finish, and thickness as jacket.
    b. Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
    c. Tee covers.
    d. Flange and union covers.
    e. End caps.
    f. Beveled collars.
    g. Valve covers.
    h. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

D. Underground Direct-Buried Jacket: 125-mil- (3.2-mm-) thick vapor barrier and waterproofing membrane consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.

2.9 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
1. Width: 3 inches (75 mm).
2. Thickness: 11.5 mils (0.29 mm).
3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.
1. Width: 3 inches (75 mm).
2. Thickness: 6.5 mils (0.16 mm).
3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
1. Width: 2 inches (50 mm).
2. Thickness: 6 mils (0.15 mm).
3. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
4. Elongation: 500 percent.
5. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
   1. Width: 2 inches (50 mm).
   2. Thickness: 3.7 mils (0.093 mm).
   3. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
   4. Elongation: 5 percent.
   5. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.

2.10 SECUREMENTS

A. Aluminum Bands: ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) or 3/4 inch (19 mm) wide with wing seal or closed seal as directed.

B. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.

C. Wire: 0.080-inch (2.0-mm) nickel-copper alloy, 0.062-inch (1.6-mm) soft-annealed, stainless steel, or 0.062-inch (1.6-mm) soft-annealed, galvanized steel as directed.

2.11 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers.
   1. Description: Manufactured plastic wraps for covering plumbing hot- and cold-water supplies and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.

B. Protective Shielding Piping Enclosures
   1. Description: Manufactured plastic enclosure for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with ADA requirements.

PART 3 - EXECUTION

3.1 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches (50 mm) or 4 inches (100 mm) o.c. as directed

    a. For below-ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Cleanouts.

3.3 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches (50 mm).
4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.4 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.

7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches (50 mm) over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.5 INSTALLATION OF CELLULAR-GLASS INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient services, secure laps with outward clinched staples at 6 inches (150 mm) o.c.

4. For insulation with factory-applied jackets on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.

2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.7 INSTALLATION OF MINERAL-FIBER PREFORMED PIPE INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward clinched staples at 6 inches (150 mm) o.c.
4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.8 INSTALLATION OF POLYOLEFIN INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Seal split-tube longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyolefin sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of polyolefin pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install cut sections of polyolefin pipe and sheet insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.9 FIELD-APPLIED JACKET INSTALLATION

A. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.

3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch-(75-mm-) wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

B. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

C. Where metal jackets are indicated, install with 2-inch (50-mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches (300 mm) o.c. and at end joints.

3.10 FINISHES

A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

3.11 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. As directed.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.12 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.13 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Hot and Recirculated Hot Water: Insulation shall be one of the following:

1. Flexible Elastomeric: 3/4 inch (19 mm) or 1 inch (25 mm) thick as directed.
2. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch (13 mm) or 1 inch (25 mm) thick as directed.
3. Polyolefin: 3/4 inch (19 mm) or 1 inch (25 mm) thick.

B. Stormwater and Overflow: Insulation shall be one of the following:

1. Flexible Elastomeric: 1 inch (25 mm) thick.
2. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
3. Polyolefin: 1 inch (25 mm) thick.

C. Roof Drain and Overflow Drain Bodies: Insulation shall be one of the following:

1. Flexible Elastomeric: inch (25 mm) thick.
2. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
3. Polyolefin: 1 inch (25 mm) thick.

D. Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities: Insulation shall be one of the following:

1. Flexible Elastomeric: 1/2 inch (13 mm), 3/4 inch (19 mm) or 1 inch (25 mm) thick as directed.
2. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch (13 mm) or 1 inch (25 mm) thick as directed.
3. Polyolefin: 1/2 inch (13 mm), 3/4 inch (19 mm) or 1 inch (25 mm) thick as directed.

E. Sanitary Waste Piping Where Heat Tracing Is Installed: Mineral-fiber, preformed pipe insulation, Type I, 1-1/2 inches (38 mm) thick.

3.14 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Domestic Water Piping: Insulation shall be one of the following:

1. Cellular Glass: 2 inches (50 mm) thick.

2. Flexible Elastomeric: 2 inches (50 mm) thick.
3. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.
4. Polyolefin: 2 inches (50 mm) thick.

B. Domestic Hot and Recirculated Hot Water: Insulation shall be one of the following:

1. Cellular Glass: 2 inches (50 mm) thick.
2. Flexible Elastomeric: 2 inches (50 mm) thick.
3. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.
4. Polyolefin: 2 inches (50 mm) thick.

C. Sanitary Waste Piping Where Heat Tracing Is Installed: Insulation shall be one of the following:

1. Cellular Glass: 2 inches (50 mm) thick.
2. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.

3.15 OUTDOOR, UNDERGROUND PIPING INSULATION SCHEDULE

A. Sanitary Waste Piping, All Sizes, Where Heat Tracing Is Installed: Cellular glass, 2 inches (50 mm) thick.

3.16 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:
1. PVC: 20 mils (0.5 mm) or 30 mils (0.8 mm) thick as directed.
2. Aluminum, Smooth, Corrugated or Stucco Embossed: 0.016 inch (0.41 mm), 0.020 inch (0.51 mm), 0.024 inch (0.61 mm) or 0.032 inch (0.81 mm) thick as directed.

D. Piping, Exposed:
1. PVC: 20 mils (0.5 mm) or 30 mils (0.8 mm) thick as directed.
2. Aluminum, Smooth, Corrugated or Stucco Embossed: 0.016 inch (0.41 mm), 0.020 inch (0.51 mm), 0.024 inch (0.61 mm) or 0.032 inch (0.81 mm) thick as directed.

3.17 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:
1. PVC: 20 mils (0.5 mm) or 30 mils (0.8 mm) thick as directed.
2. Aluminum, Smooth, Corrugated or Stucco Embossed: 0.016 inch (0.41 mm), 0.020 inch (0.51 mm), 0.024 inch (0.61 mm) or 0.032 inch (0.81 mm) thick as directed.

D. Piping, Exposed:
   1. PVC: 20 mils (0.5 mm) or 30 mils (0.8 mm) thick as directed.
   2. Painted Aluminum, Smooth, Corrugated or Stucco Embossed with Z-shaped Locking seam: 0.016 inch (0.41 mm), 0.020 inch (0.51 mm), 0.024 inch (0.61 mm) or 0.032 inch (0.81 mm) thick as directed.

3.18 UNDERGROUND, FIELD-INSTALLED INSULATION JACKET

A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

END OF SECTION 220719

SECTION 220800 - COMMISSIONING OF PLUMBING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes Cx process requirements for the following plumbing systems, assemblies, and equipment:

1. Domestic hot- and cold-water piping.
2. Gray-water piping and storage.
3. Sanitary waste and vent piping.
4. Storm drainage piping.
5. Rainwater retention piping and equipment.
6. Plumbing pumps.
7. General-service compressed air piping and equipment.
8. Plumbing equipment.
9. Compressed-air piping and equipment for laboratory and healthcare facilities.
10. Vacuum piping and equipment for laboratory and healthcare facilities.
11. Medical gases piping, equipment, and alarms.
12. Chemical waste systems for laboratory and healthcare facilities.
13. Processed water systems for laboratory and healthcare facilities.

B. Related Requirements:

1. Section 019113 "General Commissioning Requirements" for general Cx process requirements and CxA responsibilities.
2. For construction checklists, comply with requirements in various Division 22 Sections specifying plumbing systems, system components, equipment, and products.

1.2 DEFINITIONS

A. Cx: Commissioning, as defined in Section 019113 "General Commissioning Requirements."

B. CxA: Commissioning Authority, as defined in Section 019113 "General Commissioning Requirements."

C. "Systems," "Assemblies," "Subsystems," "Equipment," and "Components": Where these terms are used together or separately, they shall mean "as-built" systems, assemblies, subsystems, equipment, and components.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 CONSTRUCTION CHECKLIST REVIEW

A. Review and provide written comments on draft construction checklists. CxA will create required draft construction checklists and provide them to Contractor.

B. Return draft construction checklist review comments within 10 days of receipt.

C. When review comments have been resolved, the CxA will provide final construction checklists, marked "Approved for Use, (date)."

D. Use only construction checklists, marked "Approved for Use, (date)."

3.2 Cx TESTING PREPARATION

A. Certify that plumbing systems, subsystems, and equipment have been installed, calibrated, and started and that they are operating according to the Contract Documents and approved submittals.

B. Certify that plumbing systems instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents and approved submittals, and that pretest set points have been recorded.

C. Set systems, subsystems, and equipment into operating mode to be tested according to approved test procedures (for example, normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

3.3 Cx TEST CONDITIONS

A. Perform tests using design conditions, whenever possible.

1. Simulated conditions may, with approval of Architect, be imposed using an artificial load when it is impractical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by CxA and document simulated conditions and methods of simulation. After tests, return configurations and settings to normal operating conditions.
2. Cx test procedures may direct that set points be altered when simulating conditions is impractical.
3. Cx test procedures may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are impractical.

B. If tests cannot be completed because of a deficiency outside the scope of the plumbing system, document the deficiency and report it to Architect. After deficiencies are resolved, reschedule tests.

C. If seasonal testing is specified, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.4 Cx TESTS COMMON TO PLUMBING

A. Measure capacities and effectiveness of systems, assemblies, subsystems, equipment, and components, including operational and control functions, to verify compliance with acceptance criteria.

B. Test systems, assemblies, subsystems, equipment, and components operating modes, interlocks, control responses, responses to abnormal or emergency conditions, and response according to acceptance criteria.

C. Coordinate schedule with, and perform Cx activities at the direction of, CxA.

D. Comply with construction checklist requirements, including material verification, installation checks, startup, and performance tests requirements specified in Division 22 Sections specifying plumbing systems and equipment.

E. Provide technicians, instrumentation, tools, and equipment to perform and document the following:

1. Construction checklist verification tests.
2. Construction checklist verification test demonstrations.
3. Cx tests.
4. Cx test demonstrations.

F. Vibration Isolation in Plumbing Systems:

1. Prerequisites: Acceptance of results of construction checklists for vibration and seismic control devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" or Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment" as directed.
2. Components to Be Tested:

    a. Vibration isolation and seismic control devices in plumbing systems.
    b. Structural systems.

3. Test Purpose: Evaluate effectiveness of vibration isolation and seismic control devices.
4. Test Conditions: Measure vibration of the facility structure at three locations designated by Owner's witness while the isolated equipment operates.
5. Test Conditions: Measure vibration of the facility structure at three locations designated by Owner's witness at the following operating conditions:

    a. Maximum speed.
    b. Minimum speed.
    c. Critical speed.

6. Acceptance Criteria: Structure-borne vibration not to exceed specified performance.

G. Supervision of Alarms in Plumbing Systems:

1. Prerequisites: Acceptance of results of construction checklists for plumbing systems specified in the Sections listed below:

   a. Section 221113 "Facility Water Distribution Piping."
   b. Section 221216 "Facility Elevated, Potable-Water Storage Tanks."
   c. Section 226113 "Compressed-Air Piping for Laboratory and Healthcare Facilities."
   d. Section 226313 "Gas Piping for Laboratory and Healthcare Facilities."
   e. Section 226400 "Medical Gas Alarms."

2. Scope:

   a. As directed, Supervised or Monitored plumbing system alarms.

3. Purpose:

   a. Verify reporting of supervised or monitored plumbing alarm at building management system, security monitoring service, alarm monitoring service or other alarm monitoring system.

4. Conditions of the Test:

   a. Alarm monitoring systems operating in normal, automatic mode.
   b. As directed Activate supervised or monitored plumbing alarms, one at a time.

5. Acceptance Criteria:

   a. Activation of supervised or monitored plumbing alarm generates alarm at building management system, security monitoring service, alarm monitoring service or other alarm monitoring system control panel.

H. Plumbing Meter Reporting:

1. Prerequisites: Acceptance of results of construction checklists for plumbing systems specified in the Sections listed below:

   a. Section 221113 "Facility Water Distribution Piping."
   b. Section 221119 "Domestic Water Piping Specialties."
   c. Section 223100 "Domestic Water Softeners."

2. Scope:

   a. As directed, Supervised or Monitored plumbing system water meters.

3. Purpose:

   a. Verify accuracy of reporting of supervised or monitored plumbing system water meters at building management system, utility management service or other utility consumption management system.

4. Conditions of the Test:

a. Plumbing system water meter recording systems operating in normal, automatic mode.
b. Compare cumulative consumption data at plumbing system water meter recording systems with independent, calibrated flow-measuring instrumentation under the following conditions:

1) Low Flow: 1 percent of maximum design flow rate for a period of four hours.
2) High Flow: 80 percent of maximum design flow rate for a period of 20 minutes.

c. As directed, activate supervised or monitored plumbing alarms, one at a time.

5. Acceptance Criteria:

a. Cumulative flow reported for low-flow condition is within 5 percent flow recorded by calibrated flow-measuring instrumentation.
b. Cumulative flow reported for high-flow condition is within 1 percent flow recorded by calibrated flow-measuring instrumentation.

I. Heat Tracing in Plumbing Systems:

1. Prerequisites: Acceptance of results of construction checklists for heat tracing specified in heat-tracing systems. Comply with requirements listed in Section 220533 "Heat Tracing for Plumbing Piping."
2. Equipment and Systems to Be Tested:

a. Self-regulating, parallel-resistance heating cables.
b. Heater trace circuit controller.

3. Test Purpose:

a. Evaluate response to ambient temperature below freeze-protection set point.
b. Evaluate heating cable fault alarm.

4. Test Conditions:

a. Subject temperature sensor to temperature approximately 3 deg F (2 deg C) above freeze-protection set point (initial set point 41 deg F (5 deg C). Monitor sensed temperature with a calibration-grade thermometer. Gradually change set point or sensed temperature until freeze-protection circuit is energized.
b. Subject temperature sensor to temperature approximately 3 deg F (2 deg C) below freeze-protection set point (initial set point 41 deg F (5 deg C). Monitor sensed temperature with a calibration-grade thermometer. Gradually change set point or sensed temperature until freeze-protection circuit is de-energized.
c. Simulate an electrical fault on the heating cable.

5. Acceptance Criteria:

a. Freeze-protection circuit is energized at set-point temperature minus 2 deg F (1 deg C).

b. Freeze-protection circuit is de-energized at set-point temperature plus 2 deg F (1 deg C).
c. Heater trace circuit controller initiates an alarm of cable fault. Alarm is correctly reported at the fire-alarm control panel.

3.5 Cx TESTS FOR COMPRESSED AIR SYSTEMS

A. Air Compressor Run Time:

1. Prerequisites:

a. Acceptance of results of construction checklists specified in the following:

1) Section 221519 "General-Service Packaged Air Compressors and Receivers."
2) Section 226119 "Compressed-Air Equipment for Laboratory and Healthcare Facilities."

2. Scope:

a. Air compressors in plumbing systems.
b. Associated compressed air piping, valves, and appurtenances.
c. Associated air pressure controllers.

3. Purpose: Evaluate air compressor run time and number of compressor starts.
4. Conditions of the Test:

a. Keep compressed air openings closed during test.
b. For systems with multiple compressors, lock out compressor motors on all but one compressor. Repeat test for each compressor in turn.
c. Record number of air compressor motor starts during a 14-day period.
d. Record air compressor motor run time during the same 14-day period.

5. Acceptance Criteria:

a. Number of compressor motor starts during test period shall not exceed 20.
b. Compressor motor run time during test period shall not exceed 60 minutes.

3.6 Cx TESTS FOR VACUUM SYSTEMS

A. Vacuum Pump Run Time:

1. Prerequisites:

a. Acceptance of results of construction checklists for vacuum equipment for laboratory and healthcare facilities.

2. Scope:

a. Vacuum pumps in plumbing systems.

b. Associated vacuum piping, valves, and appurtenances.
c. Associated vacuum pressure controllers.

3. Purpose:

a. Evaluate vacuum pump run time and number of vacuum pump starts.

4. Conditions of the Test:

a. Keep vacuum piping openings closed during test.
b. For systems with multiple vacuum pumps, lock out vacuum pump motors on all but one pump. Repeat test for each vacuum pump in turn.
c. Record number of vacuum pump motor starts during a 14-day period.
d. Record vacuum pump motor run time during the same 14-day period.

5. Acceptance Criteria:

a. Number of vacuum pump motor starts during test period shall not exceed 20.
b. Vacuum pump motor run time during test period shall not exceed 60 minutes.

3.7 Cx TESTS FOR PROCESSED WATER SYSTEMS

A. Air Compressor Run Time:

1. Prerequisites: Acceptance of results of construction checklists specified for processed-water systems. Comply with requirements in Section 226700 "Processed Water Systems for Laboratory and Healthcare Facilities."
2. Scope:

a. Processed water equipment in plumbing systems.
b. Associated processed water piping, valves, and appurtenances.
c. Processed water point-of-use fixtures.

3. Purpose: Evaluate processed water quality at points-of-use.
4. Conditions of the Test:

a. Operate water processing equipment and circulation pumps in normal automatic mode for seven days prior to the test.
b. Collect process water samples from points-of-use.
c. Collect and handle water samples according to analytical laboratory recommendations.
d. Document that the following parameters meet minimum standards required for the specified grade of process water, as applicable:

1) Resistivity.
2) pH.
3) Total organic carbon (TOC).
4) Sodium.
5) Chloride.
6) Total silica.

7) Microbial.
8) Endotoxin.
9) Bacteria.

5. Acceptance Criteria:

a. Measured process water parameters shall meet the following criteria:

1) Resistivity: 10 megohms.
2) pH: 6 units.
3) TOC: 500 ppb.
4) Sodium: 5 ug/L.
5) Chloride: 5 ug/L.
6) Total Silica: 3 ug/L.
7) Microbial: 10 CFU/mL.
8) Endotoxin: 0.01 EU/mL.
9) Bacteria: 10 CFU/100 mL.

END OF SECTION 220800

SECTION 221113 - FACILITY WATER DISTRIBUTION PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes water-distribution piping and related components outside the building for water service, fire-service mains and combined water service and fire-service mains.

B. Utility-furnished products include water meters that will be furnished to the site, ready for installation.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Detail precast concrete vault assemblies and indicate dimensions, method of field assembly, and components.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control test reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Comply with requirements of utility company supplying water. Include tapping of water mains and backflow prevention.
2. Comply with standards of authorities having jurisdiction for potable-water-service piping, including materials, installation, testing, and disinfection.
3. Comply with standards of authorities having jurisdiction for fire-suppression water-service piping, including materials, hose threads, installation, and testing.

B. Piping materials shall bear label, stamp, or other markings of specified testing agency.

C. Comply with ASTM F645 for selection, design, and installation of thermoplastic water piping.

D. Comply with FMG's "Approval Guide" or UL's "Fire Protection Equipment Directory" for fire-service-main products.

E. NFPA Compliance: Comply with NFPA 24 for materials, installations, tests, flushing, and valve and hydrant supervision for fire-service-main piping for fire suppression.

F. NSF Compliance:

1. Comply with NSF 14 for plastic potable-water-service piping.
2. Comply with NSF 61 Annex G for materials for water-service piping and specialties for domestic water.

1.6 PROJECT CONDITIONS

A. Interruption of Existing Water-Distribution Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water-distribution service according to requirements indicated:
1. Do not proceed with interruption of water-distribution service without Owner's written permission.

1.7 COORDINATION

A. Coordinate connection to water main with utility company.

PART 2 - PRODUCTS

2.1 PIPE AND FITTINGS

A. Soft Copper Tube: ASTM B88, Type K (ASTM B88M, Type A) and ASTM B88, Type L (ASTM B88M, Type B), water tube, annealed temper.

1. Copper, Solder-Joint Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint pressure type. Furnish only wrought-copper fittings if indicated.

B. Hard Copper Tube: ASTM B88, Type K (ASTM B88M, Type A) and ASTM B88, Type L (ASTM B88M, Type B), water tube, drawn temper.

1. Copper, Solder-Joint Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint pressure type. Furnish only wrought-copper fittings if indicated.

C. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.

1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
2. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

D. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell and plain spigot end unless grooved or flanged ends are indicated.

1. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
2. Gaskets: AWWA C111, rubber.

E. Grooved-Joint, Ductile-Iron Pipe: AWWA C151, with cut, rounded-grooved ends.

1. Grooved-End, Ductile-Iron Pipe Appurtenances:

F. PE, Fire-Service Pipe: ASTM F714, AWWA C906, or equivalent for PE water pipe; FMG approved, with minimum thickness equivalent to FMG Class 150 and Class 200.

1. Molded PE Fittings: ASTM D3350, PE resin, socket- or butt-fusion type, made to match PE pipe dimensions and class.

G. PVC, AWWA Pipe: AWWA C900, Class 150 and Class 200, with bell end with gasket, and with spigot end.

1. Comply with UL 1285 for fire-service mains if indicated.
2. PVC Fabricated Fittings: AWWA C900, Class 150 and Class 200, with bell-and-spigot or double-bell ends. Include elastomeric gasket in each bell.
3. PVC Molded Fittings: AWWA C907, Class 150, with bell-and-spigot or double-bell ends. Include elastomeric gasket in each bell.
4. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.

    a. Gaskets: AWWA C111, rubber.

5. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.

    a. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

2.2 JOINING MATERIALS

A. Refer to Section 330500 "Common Work Results for Utilities" for commonly used joining materials.

B. Brazing Filler Metals: AWS A5.8, BCuP Series.

C. Bonding Adhesive for Fiberglass Piping: As recommended by fiberglass piping manufacturer.

D. Plastic Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

2.3 PIPING SPECIALTIES

A. Transition Fittings: Manufactured fitting or coupling same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

B. Tubular-Sleeve Pipe Couplings:

1. Description: Metal, bolted, sleeve-type, reducing or transition coupling, with center sleeve, gaskets, end rings, and bolt fasteners and with ends of same sizes as piping to be joined.

a. Standard: AWWA C219.

2.4 GATE VALVES

A. AWWA, Cast-Iron Gate Valves:

1. Non-rising-Stem, Metal-Seated Gate Valves:

a. Description: Gray- or ductile-iron body and bonnet; with cast-iron or bronze double-disc gate, bronze gate rings, bronze stem, and stem nut.

1) Standard: AWWA C500.
2) Minimum Pressure Rating: 200 psig (1380 kPa).
3) End Connections: Mechanical joint.
4) Interior Coating: Complying with AWWA C550.

2. Non-rising-Stem, Resilient-Seated Gate Valves:

a. Description: Gray- or ductile-iron body and bonnet; with bronze or gray- or ductile-iron gate, resilient seats, bronze stem, and stem nut.

1) Standard: AWWA C509.
2) Minimum Pressure Rating: 200 psig (1380 kPa).
3) End Connections: Mechanical joint.
4) Interior Coating: Complying with AWWA C550.

3. Non-rising-Stem, High-Pressure, Resilient-Seated Gate Valves:

a. Description: Ductile-iron body and bonnet; with bronze or ductile-iron gate, resilient seats, bronze stem, and stem nut.

1) Standard: AWWA C509.
2) Minimum Pressure Rating: 250 psig (1725 kPa).
3) End Connections: Push on or mechanical joint.
4) Interior Coating: Complying with AWWA C550.

4. OS&Y, Rising-Stem, Metal-Seated Gate Valves:

a. Description: Cast- or ductile-iron body and bonnet, with cast-iron double disc, bronze disc and seat rings, and bronze stem.

1) Standard: AWWA C500.
2) Minimum Pressure Rating: 200 psig (1380 kPa).
3) End Connections: Flanged.

5. OS&Y, Rising-Stem, Resilient-Seated Gate Valves:

a. Description: Cast- or ductile-iron body and bonnet, with bronze or gray- or ductile-iron gate, resilient seats, and bronze stem.

1) Standard: AWWA C509.
2) Minimum Pressure Rating: 200 psig (1380 kPa).
3) End Connections: Flanged.

B. UL/FMG, Cast-Iron Gate Valves:

1. UL/FMG, Non-rising-Stem Gate Valves:

a. Description: Iron body and bonnet with flange for indicator post, bronze seating material, and inside screw.

1) Standards: UL 262 and FMG approved.
2) Minimum Pressure Rating: 175 psig (1207 kPa).
3) End Connections: Flanged.

2. OS&Y, Rising-Stem Gate Valves:

a. Description: Iron body and bonnet and bronze seating material.

1) Standards: UL 262 and FMG approved.
2) Minimum Pressure Rating: 175 psig (1207 kPa).
3) End Connections: Flanged.

C. Bronze Gate Valves:

1. OS&Y, Rising-Stem Gate Valves:

a. Description: Bronze body and bonnet and bronze stem.

1) Standards: UL 262 and FMG approved.
2) Minimum Pressure Rating: 175 psig (1207 kPa).
3) End Connections: Threaded.

2. Non-rising-Stem Gate Valves:

a. Description: Class 125, Type 1, bronze with solid wedge, threaded ends, and malleable-iron handwheel.

1) Standard: MSS SP-80.

2.5 GATE VALVE ACCESSORIES AND SPECIALTIES

A. Tapping-Sleeve Assemblies:
   1. Description: Sleeve and valve compatible with drilling machine.

      a. Standard: MSS SP-60.
      b. Tapping Sleeve: Cast- or ductile-iron or stainless-steel, two-piece bolted sleeve with flanged outlet for new branch connection. Include sleeve matching size and type of pipe material being tapped and with recessed flange for branch valve.
      c. Valve: AWWA, cast-iron, non-rising-stem, metal or resilient-seated gate valve with one raised face flange mating tapping-sleeve flange.

B. Valve Boxes: Comply with AWWA M44 for cast-iron valve boxes. Include top section, adjustable extension of length required for depth of burial of valve, plug with lettering "WATER," and bottom section with base that fits over valve and with a barrel approximately 5 inches (125 mm) in diameter.

   1. Operating Wrenches: Steel, tee-handle with one pointed end, stem of length to operate deepest buried valve, and socket matching valve operating nut.

C. Indicator Posts: UL 789, FMG-approved, vertical-type, cast-iron body with operating wrench, extension rod, and adjustable cast-iron barrel of length required for depth of burial of valve.

2.6 CORPORATION VALVES AND CURB VALVES

A. Service-Saddle Assemblies: Comply with AWWA C800. Include saddle and valve compatible with tapping machine.

   1. Service Saddle: Copper alloy with seal and AWWA C800, threaded outlet for corporation valve.
   2. Corporation Valve: Bronze body and ground-key plug, with AWWA C800, threaded inlet and outlet matching service piping material.
   3. Manifold: Copper fitting with two to four inlets as required, with ends matching corporation valves and outlet matching service piping material.

B. Curb Valves: Comply with AWWA C800. Include bronze body, ground-key plug or ball, and wide tee head, with inlet and outlet matching service piping material.

C. Service Boxes for Curb Valves: Similar to AWWA M44 requirements for cast-iron valve boxes. Include cast-iron telescoping top section of length required for depth of burial of valve, plug with lettering "WATER," and bottom section with base that fits over curb valve and with a barrel approximately 3 inches (75 mm) in diameter.

   1. Shutoff Rods: Steel, tee-handle with one pointed end, stem of length to operate deepest buried valve, and slotted end matching curb valve.

2.7 WATER METERS

A. Water meters will be furnished by utility company.

B. Displacement-Type Water Meters:

1. Description: With bronze main case.

a. Standard: AWWA C700.
b. Registration: Flow in gallons (liters) or cubic feet (cubic meters) as directed.

C. Compound-Type Water Meters:

1. Description:

a. Standard: AWWA C702.
b. Registration: Flow in gallons (liters) or cubic feet (cubic meters) as directed.

2.8 BACKFLOW PREVENTERS

A. Reduced-Pressure-Principle Backflow Preventers:
1. Standard: ASSE 1013 or AWWA C511.
2. Operation: Continuous-pressure applications.
3. Pressure Loss: 12 psig (83 kPa) maximum, through middle 1/3 of flow range.
4. Size: As directed.
5. Design Flow Rate: As directed.
6. Selected Unit Flow Range Limits: As directed.
7. Pressure Loss at Design Flow Rate: As directed
8. Body: Bronze for NPS 2 (DN 50) and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved or steel with interior lining complying with AWWA C550 or that is FDA approved or stainless steel for NPS 2-1/2 (DN 65) and larger.
9. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 (DN 65) and larger.
10. Configuration: Designed for horizontal, straight through or vertical inlet, horizontal center section, and vertical outlet or vertical flow.
11. Accessories:

a. Valves: Ball type with threaded ends on inlet and outlet of NPS 2 (DN 50) and smaller; OS&Y gate type with flanged ends on inlet and outlet of NPS 2-1/2 (DN 65) and larger.
b. Air-Gap Fitting: ASME A112.1.2, matching backflow preventer connection.

B. Double-Check, Backflow-Prevention Assemblies:
1. Standard: ASSE 1015 or AWWA C510.
2. Operation: Continuous-pressure applications, unless otherwise indicated.
3. Pressure Loss: 5 psig (35 kPa) maximum, through middle 1/3 of flow range.
4. Size: as directed.
5. Design Flow Rate: As directed.
6. Selected Unit Flow Range Limits: As directed.
7. Pressure Loss at Design Flow Rate: As directed.
8. Body: Bronze for NPS 2 (DN 50) and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved, steel with interior lining complying with

AWWA C550 or that is FDA approved and stainless steel for NPS 2-1/2 (DN 65) and larger.

9. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 (DN 65) and larger.
10. Configuration: Designed for horizontal, straight through flow.
11. Accessories: Ball valves with threaded ends on inlet and outlet of NPS 2 (DN 50) and smaller; OS&Y gate valves with flanged ends on inlet and outlet of NPS 2-1/2 (DN 65) and larger.

2.9 WATER METER BOXES

A. Description: Cast-iron body and cover for disc-type water meter, with lettering "WATER METER" in cover; and with slotted, open-bottom base section of length to fit over service piping.

1. Option: Base section may be cast-iron, PVC, clay, or other pipe, as directed.

B. Description: Cast-iron body and double cover for disc-type water meter, with lettering "WATER METER" in top cover; and with separate inner cover; air space between covers; and slotted, open-bottom base section of length to fit over service piping.

C. Description: Polymer-concrete body and cover for disc-type water meter, with lettering "WATER" in cover; and with slotted, open-bottom base section of length to fit over service piping. Include vertical and lateral design loadings of 15,000 lb minimum over 10 by 10 inches (6800 kg minimum over 254 by 254 mm) square.

2.10 CONCRETE VAULTS

A. Description: Precast, reinforced-concrete vault, designed for A-16 load designation according to ASTM C857 and made according to ASTM C858.

1. Ladder: ASTM A36/A36M, steel or polyethylene-encased steel steps.
2. Manhole: ASTM A48/A48M Class No. 35A minimum tensile strength, gray-iron traffic frame and cover.

a. Dimension: 24-inch (610-mm) minimum diameter, unless otherwise indicated.

3. Manhole: ASTM A536, Grade 60-40-18, ductile-iron traffic frame and cover.

a. Dimension: 24-inch- (610-mm-) minimum diameter, unless otherwise indicated.

4. Drain: ASME A112.6.3, cast-iron floor drain with outlet of size indicated. Include body anchor flange, light-duty cast-iron grate, bottom outlet, and integral or field-installed bronze ball or clapper-type backwater valve.

2.11 FIRE HYDRANTS

A. Dry-Barrel Fire Hydrants:

1. Description: Freestanding, with one NPS 4-1/2 (DN 115) and two NPS 2-1/2 (DN 65) outlets, 5-1/4-inch (133-mm) main valve, drain valve, and NPS 6 (DN 150) mechanical-joint inlet. Include interior coating according to AWWA C550. Hydrant shall have cast-iron body, compression-type valve opening against pressure and closing with pressure.

    a. Standard: AWWA C502.
    b. Pressure Rating: 150 psig (1035 kPa) minimum or 250 psig (1725 kPa) as directed.

2. Description: Freestanding, with one NPS 4-1/2 (DN 115) and two NPS 2-1/2 (DN 65) outlets, 5-1/4-inch (133-mm) main valve, drain valve, and NPS 6 (DN 150) mechanical-joint inlet. Hydrant shall have cast-iron body, compression-type valve opening against pressure and closing with pressure.

    a. Standards: UL 246, FMG approved.
    b. Pressure Rating: 150 psig (1035 kPa) or 250 psig (1725 kPa) as directed.
    c. Outlet Threads: NFPA 1963, with external hose thread used by local fire department. Include cast-iron caps with steel chains.
    d. Operating and Cap Nuts: Pentagon, 1-1/2 inches (38 mm) point to flat.
    e. Direction of Opening: Open hydrant valve by turning operating nut to left or counterclockwise.
    f. Exterior Finish: Red alkyd-gloss enamel paint, unless otherwise indicated.

B. Wet-Barrel Fire Hydrants:
1. Description: Freestanding, with one NPS 4-1/2 (DN 115) and two NPS 2-1/2 (DN 65) outlets, NPS 6 (DN 150) threaded or flanged inlet, and base section with NPS 6 (DN 150) mechanical-joint inlet. Include interior coating according to AWWA C550.

    a. Standard: AWWA C503.
    b. Pressure Rating: 150 psig (1035 kPa) minimum.

2. Description: Freestanding, with one NPS 4-1/2 (DN 115) and two NPS 2-1/2 (DN 65) outlets, NPS 6 (DN 150) threaded or flanged inlet, and base section with NPS 6 (DN 150) mechanical-joint inlet.

    a. Standards: UL 246 and FMG approved.
    b. Pressure Rating: 150 psig (1035 kPa) minimum.
    c. Outlet Threads: NFPA 1963, with external hose thread used by local fire department. Include cast-iron caps with steel chains.
    d. Operating and Cap Nuts: Pentagon, 1-1/2 inches (38 mm) point to flat.
    e. Direction of Opening: Open hydrant valves by turning operating nut to left or counterclockwise.
    f. Exterior Finish: Red alkyd-gloss enamel paint, unless otherwise indicated.

2.12 FIRE DEPARTMENT CONNECTIONS

A. Fire Department Connections:
1. Description: Freestanding, with cast-bronze body, thread inlets according to NFPA 1963 and matching local fire department hose threads, and threaded bottom outlet. Include

lugged caps, gaskets, and chains; lugged swivel connection and drop clapper for each hose-connection inlet; 18-inch- (460-mm-) high brass sleeve; and round escutcheon plate.

a. Standard: UL 405.
b. Connections: Two NPS 2-1/2 (DN 65) inlets and one NPS 4 (DN 100) or NPS 6 (DN 150) outlet as directed.
c. Connections: Three or Four NPS 2-1/2 (DN 65) inlets and one NPS 6 (DN 150) outlet as directed.
d. Connections: Six NPS 2-1/2 (DN 65) inlets and one NPS 6 (DN 150) or NPS 8 (DN 200) outlet as directed.
e. Inlet Alignment: Inline, horizontal or Square as directed.
f. Finish Including Sleeve: Polished chrome-plated or Rough chrome-plated or Polished bronze as directed.
g. Escutcheon Plate Marking: "AUTO SPKR & STANDPIPE" as directed.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Refer to Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

A. General: Use pipe, fittings, and joining methods for piping systems according to the following applications.

B. Transition couplings and special fittings with pressure ratings at least equal to piping pressure rating may be used, unless otherwise indicated.

C. Do not use flanges or unions for underground piping.

D. Flanges, unions, and special fittings may be used, instead of joints indicated, on aboveground piping and piping in vaults.

E. Underground water-service piping NPS 3/4 to NPS 3 (DN 20 to DN 80) shall be soft copper tube, ASTM B88, Type K (ASTM B88M, Type A) or ASTM B88, Type L (ASTM B88M, Type B); wrought-copper, solder-joint fittings; and brazed joints as directed.

F. Underground water-service piping NPS 4 and NPS 6 (DN 100 and DN 150) shall be any of the following:

1. Soft copper tube, ASTM B88, Type K (ASTM B88M, Type A) or ASTM B88, Type L (ASTM B88M, Type B); wrought-copper, solder-joint fittings; and brazed joints.
2. Ductile-iron, push-on-joint pipe; ductile-iron, push-on-joint fittings; and gasketed or mechanical-joint pipe; ductile-iron, mechanical-joint fittings; and mechanical joints.
3. NPS 4 and NPS 6 (DN 100 and DN 150): NPS 6 (DN 150) PVC, AWWA Class 150 pipe; PVC, AWWA Class 150 molded fittings; and gasketed joints.

G. Water Meter Box Water-Service Piping NPS 3/4 to NPS 2 (DN 20 to DN 50) shall be same as underground water-service piping.

H. Aboveground and Vault Water-Service Piping NPS 3/4 to NPS 3 (DN 20 to DN 80) shall be hard copper tube, ASTM B88, Type K (ASTM B88M, Type A) or ASTM B88, Type L (ASTM B88M, Type B); wrought-copper, solder-joint fittings; and brazed joints.

I. Aboveground and vault water-service piping NPS 4 and NPS 6 (DN 100 and DN 150) shall be any of the following:

1. Hard copper tube, ASTM B88, Type K (ASTM B88M, Type A) or ASTM B88, Type L (ASTM B88M, Type B); wrought-copper, solder-joint fittings; and brazed joints.
2. Ductile-iron, grooved-end pipe; ductile-iron, grooved-end appurtenances; and grooved joints.

J. Underground Fire-Service-Main Piping NPS 4 to NPS 8 (DN 100 to DN 200) shall be any of the following:

1. Ductile-iron, push-on-joint pipe; ductile-iron, push-on-joint fittings; and gasketed, mechanical-joint pipe; ductile-iron, mechanical-joint fittings; and mechanical or grooved-end pipe; ductile-iron-pipe appurtenances; and grooved joints as directed.
2. PE, Class 150 or 200, fire-service pipe; molded PE fittings; and heat-fusion joints.
3. PVC, AWWA Class 150 pipe listed for fire-protection service; PVC Class 150 fabricated or molded fittings; and gasketed joints.
4. PVC, AWWA Class 200 pipe listed for fire-protection service; PVC Class 200 fabricated fittings; and gasketed joints.

K. Aboveground and Vault Fire-Service-Main Piping NPS 4 to NPS 8 (DN 100 to DN 200) shall be ductile-iron, grooved-end pipe; ductile-iron-pipe appurtenances; and grooved joints.

L. Underground Combined Water-Service and Fire-Service-Main Piping NPS 6 to NPS 10 (DN 150 to DN 250) shall be any of the following:

1. Ductile-iron, push-on-joint pipe; ductile-iron, push-on-joint fittings; and gasketed, mechanical-joint pipe; ductile-iron, mechanical-joint fittings; and mechanical or grooved-end pipe; ductile-iron-pipe appurtenances; and grooved joints as directed.
2. PVC, AWWA Class 150 or 200 pipe listed for fire-protection service; PVC fabricated or molded fittings of same class as pipe; and gasketed joints.

M. Aboveground and Vault Combined Water Service and Fire-Service-Main Piping NPS 6 to NPS 10 (DN 150 to DN 250) shall be ductile-iron, grooved-end pipe; ductile-iron-pipe appurtenances; and grooved joints.

3.3 VALVE APPLICATIONS

A. General Application: Use mechanical-joint-end valves for NPS 3 (DN 80) and larger underground installation. Use threaded- or flanged-end valves for installation in vaults. Use UL/FMG, non-rising-stem gate valves for installation with indicator posts. Use corporation valves and curb valves with ends compatible with piping, for NPS 2 (DN 50) and smaller installation.

B. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

1. Underground Valves, NPS 3 (DN 80) and Larger: AWWA, cast-iron, non-rising-stem, metal, resilient or high-pressure, resilient-seated gate valves with valve box.
2. Underground Valves, NPS 4 (DN 100) and Larger, for Indicator Posts: UL/FMG, cast-iron, non-rising-stem gate valves with indicator post.
3. Use the following for valves in vaults and aboveground:

    a. Gate Valves, NPS 2 (DN 50) and Smaller: Bronze, non-rising or rising stem as directed.
    b. Gate Valves, NPS 3 (DN 80) and Larger: AWWA, cast iron, OS&Y rising stem, metal seated, AWWA, cast iron, OS&Y rising stem, resilient seated or UL/FMG, cast iron, OS&Y rising stem as directed.

3.4 PIPING SYSTEMS - COMMON REQUIREMENTS

A. See Section 330500 "Common Work Results for Utilities" for piping-system common requirements.

3.5 PIPING INSTALLATION

A. Water-Main Connection: Arrange with utility company for tap of size and in location indicated in water main.

B. Water-Main Connection: Tap water main according to requirements of water utility company and of size and in location indicated.

C. Make connections larger than NPS 2 (DN 50) with tapping machine according to the following:

1. Install tapping sleeve and tapping valve according to MSS SP-60.
2. Install tapping sleeve on pipe to be tapped. Position flanged outlet for gate valve.
3. Use tapping machine compatible with valve and tapping sleeve; cut hole in main. Remove tapping machine and connect water-service piping.
4. Install gate valve onto tapping sleeve. Comply with MSS SP-60. Install valve with stem pointing up and with valve box.

D. Make connections NPS 2 (DN 50) and smaller with drilling machine according to the following:

1. Install service-saddle assemblies and corporation valves in size, quantity, and arrangement required by utility company standards.
2. Install service-saddle assemblies on water-service pipe to be tapped. Position outlets for corporation valves.
3. Use drilling machine compatible with service-saddle assemblies and corporation valves. Drill hole in main. Remove drilling machine and connect water-service piping.
4. Install corporation valves into service-saddle assemblies.
5. Install manifold for multiple taps in water main.
6. Install curb valve in water-service piping with head pointing up and with service box.

E. Comply with NFPA 24 for fire-service-main piping materials and installation.

1. Install copper tube and fittings according to CDA's "Copper Tube Handbook."

F. Install ductile-iron, water-service piping according to AWWA C600 and AWWA M41.

G. Install PE pipe according to ASTM D2774 and ASTM F645.

H. Install PVC, AWWA pipe according to ASTM F645 and AWWA M23.

I. Bury piping with depth of cover over top at least 30 inches (750 mm), with top at least 12 inches (300 mm) below level of maximum frost penetration.

J. Extend water-service piping and connect to water-supply source and building-water-piping systems at outside face of building wall in locations and pipe sizes indicated.

1. Terminate water-service piping at building wall until building-water-piping systems are installed. Terminate piping with caps, plugs, or flanges as required for piping material. Make connections to building-water-piping systems when those systems are installed.

K. Sleeves are specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

L. Mechanical sleeve seals are specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

M. Install underground piping with restrained joints at horizontal and vertical changes in direction. Use restrained-joint piping, thrust blocks, anchors, tie-rods and clamps, and other supports.

3.6 JOINT CONSTRUCTION

A. See Section 330500 "Common Work Results for Utilities" for basic piping joint construction.

B. Make pipe joints according to the following:

1. Ductile-Iron Piping, Gasketed Joints for Water-Service Piping: AWWA C600 and AWWA M41.
2. Ductile-Iron Piping, Gasketed Joints for Fire-Service-Main Piping: UL 194.
3. Ductile-Iron Piping, Grooved Joints: Cut-groove pipe. Assemble joints with grooved-end, ductile-iron-piping couplings, gaskets, lubricant, and bolts according to coupling manufacturer's written instructions.
4. PE Piping Insert-Fitting Joints: Use plastic insert fittings and fasteners according to fitting manufacturer's written instructions.
5. PVC Piping Gasketed Joints: Use joining materials according to AWWA C900. Construct joints with elastomeric seals and lubricant according to ASTM D2774 or ASTM D3139 and pipe manufacturer's written instructions.
6. Dissimilar Materials Piping Joints: Use adapters compatible with both piping materials, with OD, and with system working pressure.

3.7 ANCHORAGE INSTALLATION

A. Anchorage, General: Install water-distribution piping with restrained joints. Anchorages and restrained-joint types that may be used include the following:

1. Concrete thrust blocks.
2. Locking mechanical joints.
3. Set-screw mechanical retainer glands.
4. Bolted flanged joints.
5. Heat-fused joints.
6. Pipe clamps and tie rods.

B. Install anchorages for tees, plugs and caps, bends, crosses, valves, and hydrant branches. Include anchorages for the following piping systems:

1. Gasketed-Joint, Ductile-Iron, Water-Service Piping: According to AWWA C600.
2. Gasketed-Joint, PVC Water-Service Piping: According to AWWA M23.
3. Fire-Service-Main Piping: According to NFPA 24.

C. Apply full coat of asphalt or other acceptable corrosion-resistant material to surfaces of installed ferrous anchorage devices.

3.8 VALVE INSTALLATION

A. AWWA Gate Valves: Comply with AWWA C600 and AWWA M44. Install each underground valve with stem pointing up and with valve box.

B. UL/FMG, Gate Valves: Comply with NFPA 24. Install each underground valve and valves in vaults with stem pointing up and with vertical cast-iron indicator post.

C. MSS Valves: Install as component of connected piping system.

D. Corporation Valves and Curb Valves: Install each underground curb valve with head pointed up and with service box.

3.9 WATER METER INSTALLATION

A. Install water meters, piping, and specialties according to utility company's written instructions.

B. Water Meters: Install displacement-type water meters, NPS 2 (DN 50) and smaller, in meter boxes with shutoff valves on water meter inlets. Include valves on water meter outlets and valved bypass around meters unless prohibited by authorities having jurisdiction.

C. Water Meters: Install compound-type water meters, NPS 3 (DN 80) and larger, in meter vaults. Include shutoff valves on water meter inlets and outlets and valved bypass around meters. Support meters, valves, and piping on brick or concrete piers.

3.10 BACKFLOW PREVENTER INSTALLATION

A. Install backflow preventers of type, size, and capacity indicated. Include valves and test cocks. Install according to requirements of plumbing and health department and authorities having jurisdiction.

B. Do not install backflow preventers that have relief drain in vault or in other spaces subject to flooding.

C. Do not install bypass piping around backflow preventers.

D. Support NPS 2-1/2 (DN 65) and larger backflow preventers, valves, and piping near floor and on brick or concrete piers.

3.11 WATER METER BOX INSTALLATION

A. Install water meter boxes in paved areas flush with surface.

B. Install water meter boxes in grass or earth areas with top 2 inches (50 mm) above surface.

3.12 CONCRETE VAULT INSTALLATION

A. Install precast concrete vaults according to ASTM C891.

3.13 FIRE HYDRANT INSTALLATION

A. General: Install each fire hydrant with separate gate valve in supply pipe, anchor with restrained joints or thrust blocks, and support in upright position.

B. Wet-Barrel Fire Hydrants: Install with valve below frost line. Provide for drainage.

C. AWWA Fire Hydrants: Comply with AWWA M17.

D. UL/FMG Fire Hydrants: Comply with NFPA 24.

3.14 FIRE DEPARTMENT CONNECTION INSTALLATION

A. Install protective pipe bollards on two sides of each fire department connection or as directed. Pipe bollards are specified in Section 055000 "Metal Fabrications."

3.15 CONNECTIONS

A. See Section 330500 "Common Work Results for Utilities" for piping connections to valves and equipment.

B. Connect water-distribution piping as directed.

C. Connect water-distribution piping to interior piping as directed.

D. Connect waste piping from concrete vault drains as directed.

3.16 FIELD QUALITY CONTROL

A. Piping Tests: Conduct piping tests before joints are covered and after concrete thrust blocks have hardened sufficiently. Fill pipeline 24 hours before testing and apply test pressure to stabilize system. Use only potable water.

B. Hydrostatic Tests: Test at not less than one-and-one-half times working pressure for two hours.

1. Increase pressure in 50-psig (350-kPa) increments and inspect each joint between increments. Hold at test pressure for 1 hour; decrease to 0 psig (0 kPa). Slowly increase again to test pressure and hold for 1 more hour. Maximum allowable leakage is 2 quarts (1.89 L) per hour per 100 joints. Remake leaking joints with new materials and repeat test until leakage is within allowed limits.

C. Prepare reports of testing activities.

3.17 IDENTIFICATION

A. Install continuous underground detectable warning tape during backfilling of trench for underground water-distribution piping. Locate below finished grade, directly over piping. Underground warning tapes are specified in Section 312000 "Earth Moving."

B. Permanently attach equipment nameplate or marker indicating plastic water-service piping, on main electrical meter panel. See Section 330500 "Common Work Results for Utilities" for identifying devices.

3.18 CLEANING

A. Clean and disinfect water-distribution piping as follows:

1. Purge new water-distribution piping systems and parts of existing systems that have been altered, extended, or repaired before use.
2. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described in NFPA 24 for flushing of piping. Flush piping system with clean, potable water until dirty water does not appear at points of outlet.
3. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described in AWWA C651 or do as follows:

    a. Fill system or part of system with water/chlorine solution containing at least 50 ppm of chlorine; isolate and allow to stand for 24 hours.
    b. Drain system or part of system of previous solution and refill with water/chlorine solution containing at least 200 ppm of chlorine; isolate and allow to stand for 3 hours.

c. After standing time, flush system with clean, potable water until no chlorine remains in water coming from system.
d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedure if biological examination shows evidence of contamination.

B. Prepare reports of purging and disinfecting activities.

END OF SECTION 221113

SECTION 221116 - DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Copper tube and fittings.
2. Ductile-iron pipe and fittings.
3. Galvanized steel pipe and fittings.
4. CPVC piping.
5. PEX tube and fittings.
6. PVC pipe and fittings.
7. PP pipe and fittings.
8. Piping joining materials.
9. Transition fittings.
10. Dielectric fittings.

B. Related Requirements:

1. Section 221113 "Facility Water Distribution Piping" for water-service piping and water meters outside the building from source to the point where water-service piping enters the building.

1.2 ACTION SUBMITTALS

A. Product Data: For transition fittings and dielectric fittings.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

B. Potable-water piping and components shall comply with NSF 14, NSF 61, and NSF 372.

2.2 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B88, Type L (ASTM B88M, Type B) and ASTM B88, Type M (ASTM B88M, Type C) water tube, drawn temper.

B. Soft Copper Tube: ASTM B88, Type K (ASTM B88M, Type A) and ASTM B88, Type L (ASTM B88M, Type B) water tube, annealed temper.

C. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.

D. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.

E. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.

F. Copper Unions:

1. MSS SP-123.
2. Cast-copper-alloy, hexagonal-stock body.
3. Ball-and-socket, metal-to-metal seating surfaces.
4. Solder-joint or threaded ends.

G. Copper, Brass, or Bronze Pressure-Seal-Joint Fittings:
1. Fittings: Cast-brass, cast-bronze, or wrought-copper with EPDM O-ring seal in each end. Sizes NPS 2-1/2 (DN 65) and larger with stainless steel grip ring and EPDM O-ring seal.
2. Minimum 200-psig (1379-kPa) working-pressure rating at 250 deg F (121 deg C).

H. Copper Push-on-Joint Fittings:
1. Cast-copper fitting complying with ASME B16.18 or wrought-copper fitting complying with ASME B 16.22.
2. Stainless-steel teeth and EPDM-rubber, O-ring seal in each end instead of solder-joint ends.

2.3 DUCTILE-IRON PIPE AND FITTINGS

A. Mechanical-Joint, Ductile-Iron Pipe:

1. AWWA C151/A21.51, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.
2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

B. Standard-Pattern, Mechanical-Joint Fittings:

1. AWWA C110/A21.10, ductile or gray iron.
2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

C. Compact-Pattern, Mechanical-Joint Fittings:

1. AWWA C153/A21.53, ductile iron.
2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

2.4 GALVANIZED-STEEL PIPE AND FITTINGS

A. Galvanized-Steel Pipe:

1. ASTM A53/A53M, Type E, Grade B, Standard Weight.
2. Include ends matching joining method.

B. Galvanized-Steel Pipe Nipples: ASTM A733, made of ASTM A53/A53M or ASTM A106/A106M, Standard Weight, seamless steel pipe with threaded ends.

C. Galvanized, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.

D. Malleable-Iron Unions:

1. ASME B16.39, Class 150.
2. Hexagonal-stock body.
3. Ball-and-socket, metal-to-metal, bronze seating surface.
4. Threaded ends.

E. Flanges: ASME B16.1, Class 125, cast iron.

2.5 CPVC PIPING

A. CPVC Pipe: ASTM F441/F441M, Schedule 40 and Schedule 80.

1. CPVC Socket Fittings: ASTM F438 for Schedule 40 and ASTM F439 for Schedule 80.
2. CPVC Threaded Fittings: ASTM F437, Schedule 80.

B. CPVC Piping System: ASTM D2846/D2846M, SDR 11, pipe and socket fittings.

C. CPVC Tubing System: ASTM D2846/D2846M, SDR 11, tube and socket fittings.

2.6 PEX TUBE AND FITTINGS

A. Tube Material: PEX plastic according to ASTM F876 and ASTM F877.

B. Fittings: ASTM F1807, metal insert and copper crimp rings and ASTM F1960, cold expansion fittings and reinforcing rings.

C. Fittings: ASSE 1061, push-fit fittings.

D. Manifold: Multiple-outlet, plastic or corrosion-resistant-metal assembly complying with ASTM F876; with plastic or corrosion-resistant-metal valve for each outlet.

2.7 PVC PIPE AND FITTINGS

A. PVC Pipe: ASTM D1785, Schedule 40 and Schedule 80.

B. PVC Socket Fittings: ASTM D2466 for Schedule 40 and ASTM D2467 for Schedule 80.

C. PVC Schedule 80 Threaded Fittings: ASTM D2464.

2.8 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials:

1. AWWA C110/A21.10, rubber, flat face, 1/8 inch (3.2 mm) thick or ASME B16.21, nonmetallic and asbestos free unless otherwise indicated.
2. Full-face or ring type unless otherwise indicated.

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

C. Solder Filler Metals: ASTM B32, lead-free alloys.

D. Flux: ASTM B813, water flushable.

E. Brazing Filler Metals: AWS A5.8M/A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

F. Solvent Cements for Joining CPVC Piping and Tubing: ASTM F493.

G. Solvent Cements for Joining PVC Piping: ASTM D2564. Include primer according to ASTM F656.

H. Plastic, Pipe-Flange Gaskets, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

2.9 TRANSITION FITTINGS

A. General Requirements:

1. Same size as pipes to be joined.
2. Pressure rating at least equal to pipes to be joined.
3. End connections compatible with pipes to be joined.

B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

C. Plastic-to-Metal Transition Fittings:
1. Description:

a. CPVC or PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions.
b. One end with threaded brass insert and one solvent-cement-socket or threaded end.

D. Plastic-to-Metal Transition Unions:
1. Description:

a. CPVC or PVC four-part union.
b. Brass or stainless-steel threaded end.
c. Solvent-cement-joint or threaded plastic end.
d. Rubber O-ring.
e. Union nut.

2.10 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:
   1. Standard: ASSE 1079.
   2. Pressure Rating: 125 psig (860 kPa) minimum at 180 deg F (82 deg C) or 150 psig (1035 kPa) or as directed.
   3. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:
   1. Standard: ASSE 1079.
   2. Factory-fabricated, bolted, companion-flange assembly.
   3. Pressure Rating: 125 psig (860 kPa) minimum at 180 deg F (82 deg C), 150 psig (1035 kPa), 175 psig (1200 kPa) or 300 psig (2070 kPa) or as directed.
   4. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:
   1. Nonconducting materials for field assembly of companion flanges.
   2. Pressure Rating: 150 psig (1035 kPa).
   3. Gasket: Neoprene or phenolic.
   4. Bolt Sleeves: Phenolic or polyethylene.
   5. Washers: Phenolic with steel backing washers.

E. Dielectric Nipples:
   1. Standard: IAPMO PS 66.
   2. Electroplated steel nipple complying with ASTM F1545.
   3. Pressure Rating and Temperature: 300 psig (2070 kPa) at 225 deg F (107 deg C).
   4. End Connections: Male threaded or grooved.
   5. Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."

C. Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.

D. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve inside the building at each domestic water-service entrance. Comply with requirements for pressure gages in Section 220519 "Meters and Gages for Plumbing Piping" and with requirements for drain valves and strainers in Section 221119 "Domestic Water Piping Specialties."

E. Install shutoff valve immediately upstream of each dielectric fitting.

F. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements for pressure-reducing valves in Section 221119 "Domestic Water Piping Specialties."

G. Install domestic water piping level and plumb.

H. Rough-in domestic water piping for water-meter installation according to utility company's requirements.

I. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

J. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

K. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

L. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.

M. Install piping to permit valve servicing.

N. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than the system pressure rating used in applications below unless otherwise indicated.

O. Install piping free of sags and bends.

P. Install fittings for changes in direction and branch connections.

Q. Install PEX tubing with loop at each change of direction of more than 90 degrees.

R. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

S. Install pressure gages on suction and discharge piping for each plumbing pump and packaged booster pump as directed

T. Install thermostats in hot-water circulation piping as directed.

U. Install thermometers on outlet piping from each water heater as directed.

V. Install sleeves for piping penetrations of walls, ceilings, and floors as directed.

W. Install sleeve seals for piping penetrations of concrete walls and slabs as directed.

X. Install escutcheons for piping penetrations of walls, ceilings, and floors as directed.

3.3 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

D. Brazed Joints for Copper Tubing: Comply with CDA's "Copper Tube Handbook," "Brazed Joints" chapter.

E. Soldered Joints for Copper Tubing: Apply ASTM B813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B828 or CDA's "Copper Tube Handbook."

F. Pressure-Sealed Joints for Copper Tubing: Join copper tube and pressure-seal fittings with tools recommended by fitting manufacturer.

G. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.

H. Joint Construction for Solvent-Cemented Plastic Piping: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements. Apply primer.
2. CPVC Piping: Join according to ASTM D2846/D2846M Appendix.
3. PVC Piping: Join according to ASTM D2855.

I. Joints for PEX Tubing: Join according to ASTM F1807 for metal insert and copper crimp ring fittings and ASTM F1960 for cold expansion fittings and reinforcing rings.

J. Joints for PEX Tubing: Join according to ASSE 1061 for push-fit fittings.

K. Joints for Dissimilar-Material Piping: Make joints using adapters compatible with materials of both piping systems.

3.4 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping:

1. Fittings for NPS 1-1/2 (DN 40) and Smaller: Fitting-type coupling.
2. Fittings for NPS 2 (DN 50) and Larger: Sleeve-type coupling.

C. Transition Fittings in Aboveground Domestic Water Piping NPS 2 (DN 50) and Smaller: Plastic-to-metal transition fittings or unions.

3.5 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 (DN 50) and Smaller: Use dielectric couplings or nipples as directed.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Use dielectric flange kits or nipples as directed.

D. Dielectric Fittings for NPS 5 (DN 125) and Larger: Use dielectric flange kits.

3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for pipe hanger, support products, and installation in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

1. Vertical Piping: MSS Type 8 or 42, clamps.
2. Individual, Straight, Horizontal Piping Runs:

    a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
    b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
    c. Longer Than 100 Feet (30 m) if Indicated: MSS Type 49, spring cushion rolls.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Support vertical piping and tubing at base and at each floor.

D. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch (10 mm).

E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 3/4 (DN 20) and Smaller: 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
2. NPS 1 and NPS 1-1/4 (DN 25 and DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
3. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
4. NPS 2-1/2 (DN 65): 108 inches (2700 mm) with 1/2-inch (13-mm) rod.
5. NPS 3 to NPS 5 (DN 80 to DN 125): 10 feet (3 m) with 1/2-inch (13-mm) rod.
6. NPS 6 (DN 150): 10 feet (3 m) with 5/8-inch (16-mm) rod.
7. NPS 8 (DN 200): 10 feet (3 m) with 3/4-inch (19-mm) rod.

F. Install supports for vertical copper tubing every 10 feet (3 m).

G. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4 (DN 32) and Smaller: 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
2. NPS 1-1/2 (DN 40): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
3. NPS 2 (DN 50): 10 feet (3 m) with 3/8-inch (10-mm) rod.
4. NPS 2-1/2 (DN 65): 11 feet (3.4 m) with 1/2-inch (13-mm) rod.
5. NPS 3 and NPS 3-1/2 (DN 80 and DN 90): 12 feet (3.7 m) with 1/2-inch (13-mm) rod.
6. NPS 4 and NPS 5 (DN 100 and DN 125): 12 feet (3.7 m) with 5/8-inch (16-mm) rod.
7. NPS 6 (DN 150): 12 feet (3.7 m) with 3/4-inch (19-mm) rod.
8. NPS 8 to NPS 12 (DN 200 to DN 300): 12 feet (3.7 m) with 7/8-inch (22-mm) rod.

H. Install supports for vertical steel piping every 15 feet (4.5 m).

I. Install vinyl-coated hangers for CPVC piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1 (DN 25) and Smaller: 36 inches (900 mm) with 3/8-inch (10-mm) rod.
2. NPS 1-1/4 to NPS 2 (DN 32 to DN 50): 48 inches (1200 mm) with 3/8-inch (10-mm) rod.
3. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): 48 inches (1200 mm) with 1/2-inch (13-mm) rod.
4. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1200 mm) with 5/8-inch (16-mm) rod.
5. NPS 6 (DN 150): 48 inches (1200 mm) with 3/4-inch (19-mm) rod.
6. NPS 8 (DN 200): 48 inches (1200 mm) with 7/8-inch (22-mm) rod.

J. Install supports for vertical CPVC piping every 60 inches (1500 mm) for NPS 1 (DN 25) and smaller, and every 72 inches (1800 mm) for NPS 1-1/4 (DN 32) and larger.

K. Install vinyl-coated hangers for PEX tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1 (DN 25) and Smaller: 32 inches (815 mm) with 3/8-inch (10-mm) rod.

L. Install hangers for vertical PEX tubing every 48 inches (1200 mm).

M. Install vinyl-coated hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 2 (DN 50) and Smaller: 48 inches (1200 mm) with 3/8-inch (10-mm) rod.
2. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): 48 inches (1200 mm) with 1/2-inch (13-mm) rod.
3. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1200 mm) with 5/8-inch (16-mm) rod.
4. NPS 6 (DN 150): 48 inches (1200 mm) with 3/4-inch (19-mm) rod.
5. NPS 8 (DN 200): 48 inches (1200 mm) with 7/8-inch (22-mm) rod.

N. Install supports for vertical PVC piping every 48 inches (1200 mm).

O. Support piping and tubing not listed in this article according to MSS SP-58 and manufacturer's written instructions.

3.7 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. When installing piping adjacent to equipment and machines, allow space for service and maintenance.

C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:

1. Domestic Water Booster Pumps: Cold-water suction and discharge piping.
2. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
3. Plumbing Fixtures: Cold- and hot-water-supply piping in sizes indicated, but not smaller than that required by plumbing code.
4. Equipment: Cold- and hot-water-supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 (DN 65) and larger.

3.8 IDENTIFICATION

A. Identify system components as directed.

B. Label pressure piping with system operating pressure.

3.9 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Piping Inspections:

    a. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
    b. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:

        1) Roughing-in Inspection: Arrange for inspection of piping before concealing or closing in after roughing in and before setting fixtures.
        2) Final Inspection: Arrange for authorities having jurisdiction to observe tests specified in "Piping Tests" Subparagraph below and to ensure compliance with requirements.

    c. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
    d. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

2. Piping Tests:

    a. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
    b. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
    c. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
    d. Cap and subject piping to static water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow it to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
    e. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.
    f. Prepare reports for tests and for corrective action required.

B. Domestic water piping will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.10 ADJUSTING

A. Perform the following adjustments before operation:

1. Close drain valves, hydrants, and hose bibbs.
2. Open shutoff valves to fully open position.
3. Open throttling valves to proper setting.
4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.

a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide hot-water flow in each branch.
b. Adjust calibrated balancing valves to flows indicated.

5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
6. Remove and clean strainer screens. Close drain valves and replace drain plugs.
7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
8. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.11 CLEANING

A. Clean and disinfect potable domestic water piping as follows:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:

a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
b. Fill and isolate system according to either of the following:

1) Fill system or part thereof with water/chlorine solution with at least 50 ppm (50 mg/L) of chlorine. Isolate with valves and allow to stand for 24 hours.
2) Fill system or part thereof with water/chlorine solution with at least 200 ppm (200 mg/L) of chlorine. Isolate and allow to stand for three hours.

c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
d. Repeat procedures if biological examination shows contamination.
e. Submit water samples in sterile bottles to authorities having jurisdiction.

B. Prepare and submit reports of purging and disinfecting activities. Include copies of water-sample approvals from authorities having jurisdiction.

C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.12 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.

C. Fitting Option: Extruded-tee connections and brazed joints may be used on aboveground copper tubing.

D. Under-building-slab, domestic water, building-service piping, NPS 3 (DN 80) and smaller, shall be one of the following:

1. Soft copper tube, ASTM B88, Type K (ASTM B88M, Type A) or ASTM B88, Type L (ASTM B88M, Type B); wrought-copper, solder-joint fittings; and brazed or copper pressure-seal fittings; and pressure-sealed joints as directed.
2. PVC, Schedule 40 or Schedule 80; socket fittings; and solvent-cemented joints.

E. Under-building-slab, domestic water, building-service piping, NPS 4 to NPS 8 (DN 100 to DN 200) and larger, shall be one of the following:

1. Soft copper tube, ASTM B88, Type K (ASTM B88M, Type A) or ASTM B88, Type L (ASTM B88M, Type B); wrought-copper, solder-joint fittings; and brazed joints.
2. Plain-end, ductile-iron pipe; grooved-joint, ductile-iron-pipe appurtenances; and grooved joints.
3. PVC, Schedule 40 or Schedule 80; socket fittings; and solvent-cemented joints.

F. Under-building-slab, combined domestic water, building-service, and fire-service-main piping, NPS 6 to NPS 12 (DN 150 to DN 300), shall be one of the following:

1. Plain-end, ductile-iron pipe; grooved-joint, ductile-iron-pipe appurtenances; and grooved joints.

G. Under-building-slab, domestic water piping, NPS 2 (DN 50) and smaller shall be one of the following:

1. Hard or soft copper tube, ASTM B88, Type L (ASTM B88M, Type B); wrought-copper, solder-joint fittings; and brazed or copper pressure-seal-joint fittings; and pressure-sealed joints as directed.
2. PVC, Schedule 40 or Schedule 80; socket fittings; and solvent-cemented joints.

H. Aboveground domestic water piping, NPS 2 (DN 50) and smaller, shall be one of the following as directed:

1. Galvanized-steel pipe and nipples; galvanized, gray-iron threaded fittings; and threaded joints.
2. Hard copper tube, ASTM B88, Type L (ASTM B88M, Type B) or ASTM B88, Type M (ASTM B88M, Type C); cast or wrought-copper, solder-joint fittings; and brazed or soldered joints as directed.
3. Hard copper tube, ASTM B88, Type L (ASTM B88M, Type B) or ASTM B88, Type M (ASTM B88M, Type C); copper pressure-seal-joint fittings; and pressure-sealed joints.
4. Hard copper tube, ASTM B88, Type L (ASTM B88M, Type B) or ASTM B88, Type M (ASTM B88M, Type C); copper push-on-joint fittings; and push-on joints.
5. CPVC, Schedule 40 or Schedule 80; socket fittings; and solvent-cemented joints.
6. CPVC, Schedule 80 pipe; CPVC, Schedule 80 threaded fittings; and threaded joints.
7. CPVC Tubing System: CPVC tube; CPVC socket fittings; and solvent-cemented joints. NPS 1-1/2 (DN 40) and NPS 2 (DN 50) CPVC pipe with CPVC socket fittings may be used instead of tubing.
8. PEX tube, NPS 1 (DN 25) and smaller.

    a. Fittings for PEX tube:

1) ASTM F1807, metal insert and copper crimp rings.
2) ASTM F1960, cold expansion fittings and reinforcing rings.
3) ASSE 1061, push-fit fittings.

9. PVC, Schedule 40 or Schedule 80; socket fittings; and solvent-cemented joints.

I. Aboveground domestic water piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100), shall be one of the following as directed:

1. Hard copper tube, ASTM B88, Type L (ASTM B88M, Type B) or ASTM B88, Type M (ASTM B88M, Type C); cast or wrought-copper, solder-joint fittings; and brazed or soldered joints as directed.
2. Hard copper tube, ASTM B88, Type L (ASTM B88M, Type B) or ASTM B88, Type M (ASTM B88M, Type C); copper pressure-seal-joint fittings; and pressure-sealed joints.
3. Hard copper tube, ASTM B88, Type L (ASTM B88M, Type B) or ASTM B88, Type M (ASTM B88M, Type C); grooved-joint, copper-tube appurtenances; and grooved joints.
4. Galvanized-steel pipe and nipples; galvanized, gray-iron threaded fittings; and threaded joints.
5. CPVC, Schedule 40 or Schedule 80; socket fittings; and solvent-cemented joints.
6. CPVC, Schedule 80 pipe; CPVC, Schedule 80 threaded fittings; and threaded joints.
7. PVC, Schedule 40 or Schedule 80; socket fittings; and solvent-cemented joints.

J. Aboveground domestic water piping, NPS 5 to NPS 8 (DN 125 to DN 200), shall be one of the following as directed:

1. Hard copper tube, ASTM B88, Type L (ASTM B88M, Type B) or ASTM B88, Type M (ASTM B88M, Type C); cast or wrought-copper, solder-joint fittings; and brazed or soldered joints as directed.
2. Hard copper tube, ASTM B88, Type L (ASTM B88M, Type B) or ASTM B88, Type M (ASTM B88M, Type C); grooved-joint, copper-tube appurtenances; and grooved joints.
3. Galvanized-steel pipe and nipples; galvanized, gray-iron threaded fittings; and threaded joints.
4. CPVC, Schedule 40 or Schedule 80; socket fittings; and solvent-cemented joints.
5. CPVC, Schedule 80 pipe; CPVC, Schedule 80 threaded fittings; and threaded joints.
6. PVC, Schedule 40 or Schedule 80; socket fittings; and solvent-cemented joints.

K. Aboveground, combined domestic water-service and fire-service-main piping, NPS 6 to NPS 12 (DN 150 to (DN 300), shall be one of the following:

1. Plain-end, ductile-iron pipe; grooved-joint, ductile-iron-pipe appurtenances; and grooved joints.
2. Galvanized-steel pipe and nipples; galvanized, gray-iron threaded fittings; and threaded joints.

END OF SECTION 221116

SECTION 221117 - GRAY-WATER PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes under-building-slab and aboveground gray-water pipes, tubes, and fittings inside buildings.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Water Piping Minimum Working Pressure: 50 psig (345 kPa), 80 psig (552 kPa) or 100 psig (690 kPa) unless otherwise indicated.

2.2 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B88, Type L (ASTM B88M, Type B) and ASTM B88, Type M (ASTM B88M, Type C) water tube, drawn temper.

B. Soft Copper Tube: ASTM B88, Type K (ASTM B88M, Type A) and ASTM B88, Type L (ASTM B88M, Type B) water tube, annealed temper.

C. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.

D. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.

E. Copper Unions:

1. MSS SP-123.
2. Cast-copper-alloy, hexagonal-stock body.
3. Ball-and-socket, metal-to-metal seating surfaces.
4. Solder-joint or threaded ends.

F. Copper Pressure-Seal-Joint Fittings:

1. Fittings for NPS 2 (DN 50) and Smaller: Wrought-copper fitting with EPDM-rubber, O-ring seal in each end.
2. Fittings for NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Cast-bronze or wrought-copper fitting with EPDM-rubber, O-ring seal in each end.

G. Copper Push-on-Joint Fittings:
1. Description:

a. Cast-copper fitting complying with ASME B16.18 or wrought-copper fitting complying with ASME B 16.22.
b. Stainless-steel teeth and EPDM-rubber, O-ring seal in each end instead of solder-joint ends.

H. Copper-Tube, Extruded-Tee Connections:
1. Description: Tee formed in copper tube according to ASTM F2014.

I. Copper DWV Tube: ASTM B306, drainage tube, drawn temper.

J. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.

2.3 PVC WATER PIPE AND FITTINGS

A. PVC Water Pipe: ASTM D1785, Schedule 40 and Schedule 80 or purple in color as directed.

B. PVC Water Socket Fittings: As directed ASTM D2466 for Schedule 40 and ASTM D2467 for Schedule 80, purple in color.

C. PVC Water Schedule 80 Threaded Fittings: ASTM D2464.

2.4 PIPING JOINING MATERIALS

A. Solder Filler Metals: ASTM B32, lead-free alloys.

B. Flux: ASTM B813, water flushable.

C. Solvent Cements for Joining PVC Piping: ASTM D2564. Include primer according to ASTM F656.

D. Plastic, Pipe-Flange Gaskets, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

2.5 TRANSITION FITTINGS

A. General Requirements:

1. Same size as pipes to be joined.
2. Pressure rating at least equal to pipes to be joined.
3. End connections compatible with pipes to be joined.

B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

C. Sleeve-Type Transition Coupling: AWWA C219.

D. Plastic-to-Metal Transition Fittings:
   1. Description:

      a. PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions.
      b. One end with threaded brass insert and one solvent-cement-socket or threaded end.

E. Plastic-to-Metal Transition Unions:
   1. Description:

      a. PVC four-part union.
      b. Brass threaded end.
      c. Solvent-cement-joint or threaded plastic end.
      d. Rubber O-ring.
      e. Union nut.

2.6 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:
   1. Standard: ASSE 1079.
   2. Pressure Rating: 125 psig (860 kPa) minimum at 180 deg F (82 deg C), 150 psig (1035 kPa) or 250 psig (1725 kPa).
   3. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Nipples:
   1. Standard: IAPMO PS 66.
   2. Electroplated steel nipple complying with ASTM F1545.
   3. Pressure Rating and Temperature: 300 psig (2070 kPa) at 225 deg F (107 deg C).
   4. End Connections: Male threaded or grooved.
   5. Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of gray-water water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."

C. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

D. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.

G. Install piping to permit valve servicing.

H. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than the system pressure rating used in applications below unless otherwise indicated.

I. Install piping free of sags and bends.

J. Install fittings for changes in direction and branch connections.

K. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

L. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

M. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

N. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

O. Install pressure gages on suction and discharge piping for each plumbing pump and packaged booster pump. Comply with requirements for pressure gages in Section 220519 "Meters and Gages for Plumbing Piping."

P. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve inside the building at each gray-water water-service entrance. Comply with requirements for pressure gages in Section 220519 "Meters and Gages for Plumbing Piping" and with requirements for drain valves and strainers in Section 221119 "Domestic Water Piping Specialties."

Q. Install shutoff valve immediately upstream of each dielectric fitting.

R. Install gray-water water piping level with 0.25 percent slope downward toward drain or without pitch and plumb As directed.

S. Install pressure gages on suction and discharge piping for each plumbing pump. Comply with requirements for pressure gages in Section 220519 "Meters and Gages for Plumbing Piping."

T. Comply with requirements for pipe hangers and supports specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

3.2 WATER PIPE JOINT CONNECTIONS

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

D. Soldered Joints for Copper Tubing: Apply ASTM B813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B828 or CDA's "Copper Tube Handbook."

E. Pressure-Sealed Joints for Copper Tubing: Join copper tube and pressure-seal fittings with tools recommended by fitting manufacturer.

F. Push-on Joints for Copper Tubing: Clean end of tube. Measure insertion depth with manufacturer's depth gage. Join copper tube and push-on-joint fittings by inserting tube to measured depth.

G. Extruded-Tee Connections: Form tee in copper tube according to ASTM F2014. Use tool designed for copper tube; drill pilot hole, form collar for outlet, dimple tube to form seating stop, and braze branch tube into collar.

H. Joint Construction for Solvent-Cemented Plastic Piping: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements. Apply primer.
2. PVC Piping: Join according to ASTM D2855.

I. Joints for Dissimilar-Material Piping: Make joints using adapters compatible with materials of both piping systems.

3.3 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Couplings:

1. Install transition couplings at joints of piping with small differences in ODs.

2. In Drainage Piping: As directed Unshielded or Shielded, non-pressure transition couplings.
3. In Aboveground Force Main Piping: Fitting-type transition couplings.
4. In Underground Force Main Piping:

    a. NPS 1-1/2 (DN 40) and Smaller: Fitting-type transition couplings.
    b. NPS 2 (DN 50) and Larger: Pressure transition couplings.

C. Transition Fittings in Aboveground Gray-Water Piping NPS 2 (DN 50) and Smaller: Plastic-to-metal transition fittings or unions.

D. Dielectric Fittings:

1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
2. Dielectric Fittings for NPS 2 (DN 50) and Smaller: Use dielectric nipples or unions As directed.
3. Dielectric Fittings for NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Use dielectric flanges, flange kits or nipples as directed.

E. Dielectric Fittings for NPS 5 (DN 125) and Larger: Use dielectric flange kits.

3.4 VALVE INSTALLATION

A. General valve installation requirements are specified in the following Sections:

1. Section 220523.12, "Ball Valves for Plumbing Piping."
2. Section 220523.13, "Butterfly Valves for Plumbing Piping."
3. Section 220523.14, "Check Valves for Plumbing Piping."
4. Section 220523.15, "Gate Valves for Plumbing Piping."

B. Shutoff Valves:

1. Install gate or full-port ball valve for piping NPS 2 (DN 50) and smaller.
2. Install gate valve for piping NPS 2-1/2 (DN 65) and larger.

C. Check Valves: Install swing check valve, between pump and shutoff valve, on each sewage pump discharge.

3.5 HANGER AND SUPPORT INSTALLATION FOR WATER PIPING

A. Comply with requirements for seismic-restraint devices in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for pipe hanger, support products, and installation in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

1. Vertical Piping: MSS Type 8 or 42, clamps.
2. Individual, Straight, Horizontal Piping Runs:

    a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.

b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
c. Longer Than 100 Feet (30 m) if Indicated: MSS Type 49, spring cushion rolls.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Support vertical piping and tubing at base and at each floor.

D. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch (10 mm).

E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 3/4 (DN 20) and Smaller: 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
2. NPS 1 and NPS 1-1/4 (DN 25 and DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
3. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
4. NPS 2-1/2 (DN 65): 108 inches (2700 mm) with 1/2-inch (13-mm) rod.
5. NPS 3 to NPS 5 (DN 80 to DN 125): 10 feet (3 m) with 1/2-inch (13-mm) rod.
6. NPS 6 (DN 150): 10 feet (3 m) with 5/8-inch (16-mm) rod.
7. NPS 8 (DN 200): 10 feet (3 m) with 3/4-inch (19-mm) rod.

F. Install supports for vertical copper tubing every 10 feet (3 m).

G. Install vinyl-coated hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1 (DN 25) and Smaller: 36 inches (900 mm) with 3/8-inch (10-mm) rod.
2. NPS 1-1/4 to NPS 2 (DN 32 to DN 50): 48 inches (1200 mm) with 3/8-inch (10-mm) rod.
3. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): 48 inches (1200 mm) with 1/2-inch (13-mm) rod.
4. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1200 mm) with 5/8-inch (16-mm) rod.
5. NPS 6 (DN 150): 48 inches (1200 mm) with 3/4-inch (19-mm) rod.
6. NPS 8 (DN 200): 48 inches (1200 mm) with 7/8-inch (22-mm) rod.

H. Install supports for vertical PVC piping every 60 inches (1500 mm) for NPS 1 (DN 25) and smaller, and every 72 inches (1800 mm) for NPS 1-1/4 (DN 32) and larger.

I. Install vinyl-coated hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 2 (DN 50) and Smaller: 48 inches (1200 mm) with 3/8-inch (10-mm) rod.
2. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): 48 inches (1200 mm) with 1/2-inch (13-mm) rod.
3. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1200 mm) with 5/8-inch (16-mm) rod.

4. NPS 6 (DN 150): 48 inches (1200 mm) with 3/4-inch (19-mm) rod.
5. NPS 8 (DN 200): 48 inches (1200 mm) with 7/8-inch (22-mm) rod.

J. Install supports for vertical PVC piping every 48 inches (1200 mm).

K. Support piping and tubing not listed in this article according to MSS SP-58 and manufacturer's written instructions.

3.6 IDENTIFICATION

A. Identify system components. Comply with requirements for identification materials and installation in Section 220553 "Identification for Plumbing Piping and Equipment."

B. Label pressure piping with system operating pressure.

C. Label all non-potable water piping "NON-POTABLE, DO NOT DRINK."

3.7 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Piping Inspections:

   a. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
   b. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:

      1) Roughing-In Inspection: Arrange for inspection of piping before concealing or closing in after roughing in and before setting fixtures.
      2) Final Inspection: Arrange for authorities having jurisdiction to observe tests specified in "Water Piping Tests" Subparagraph and to ensure compliance with requirements.

   c. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
   d. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

2. Water Piping Tests:

   a. Fill gray-water piping. Check components to determine that they are not air bound and that piping is full of water.
   b. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
   c. Leave new, altered, extended, or replaced gray-water water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.

d. Cap and subject piping to static water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow it to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
e. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.
f. Prepare reports for tests and for corrective action required.

B. Gray-water piping will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.8 GRAY-WATER PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

B. Unions may be used for aboveground piping joints unless otherwise indicated.

C. Fitting Option: Extruded-tee connections may be used on aboveground copper tubing.

D. Under-building-slab, gray-water piping, NPS 3 (DN 80) and smaller, shall be one of the following:

1. Hard or soft copper tube, ASTM B88, Type K (ASTM B88M, Type A) or ASTM B88, Type L (ASTM B88M, Type B) As directed; copper pressure-seal fittings; and pressure-sealed joints.
2. PVC, Schedule 40 or Schedule 80 as directed; socket fittings; and solvent-cemented joints.

E. Under-building-slab, gray-water piping, NPS 4 (DN 100) and larger, shall be the following:

1. PVC, Schedule 40 or Schedule 80 as directed; socket fittings; and solvent-cemented joints.

F. Aboveground gray-water piping, NPS 2 (DN 50) and smaller, shall be one of the following:

1. Hard copper tube, ASTM B88, Type L (ASTM B88M, Type B) or ASTM B88, Type M (ASTM B88M, Type C) As directed; cast- or wrought-copper, solder-joint fittings; and soldered joints.
2. Hard copper tube, ASTM B88, Type L (ASTM B88M, Type B) or ASTM B88, Type M (ASTM B88M, Type C); copper pressure-seal-joint fittings; and pressure-sealed joints.
3. Hard copper tube, ASTM B88, Type L (ASTM B88M, Type B) or ASTM B88, Type M (ASTM B88M, Type C); copper push-on-joint fittings; and push-on joints.
4. PVC, Schedule 40 or Schedule 80 As directed; socket fittings; and solvent-cemented joints.

G. Aboveground gray-water piping, NPS 2-1/2to NPS 4 (DN 65 to DN 100), shall be one of the following:

1. Hard copper tube, ASTM B88, Type L (ASTM B88M, Type B) or ASTM B88, Type M (ASTM B88M, Type C) As directed; cast- or wrought-copper, solder-joint fittings; and soldered joints.
2. Hard copper tube, ASTM B88, Type L (ASTM B88M, Type B) or ASTM B88, Type M (ASTM B88M, Type C) As directed; copper pressure-seal-joint fittings; and pressure-sealed joints.
3. Hard copper tube, ASTM B88, Type L (ASTM B88M, Type B) or ASTM B88, Type M (ASTM B88M, Type C) As directed; grooved-joint, copper-tube appurtenances; and grooved joints.
4. PVC, Schedule 40 or Schedule 80 As directed; socket fittings; and solvent-cemented joints.

H. Aboveground gray-water piping, NPS 5 (DN 125) and larger, shall be PVC, Schedule 40 or Schedule 80 As directed; socket fittings; and solvent-cemented joints.

3.9 VALVE SCHEDULE

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

1. Shutoff Duty: Use ball or gate valves for piping NPS 2 (DN 50) and smaller. Use butterfly, ball, or gate valves with flanged ends for piping NPS 2-1/2 (DN 65) and larger.
2. Throttling Duty: Use ball or globe valves for piping NPS 2 (DN 50) and smaller. Use butterfly or ball valves with flanged ends for piping NPS 2-1/2 (DN 65) and larger.
3. Hot-Water Circulation Piping, Balancing Duty: As directed Calibrated or Memory-stop balancing valves.
4. Drain Duty: Hose-end drain valves.

B. Use check valves to maintain correct direction of gray-water water flow to and from equipment.

C. Iron grooved-end valves may be used with grooved-end piping.

END OF SECTION 221117

SECTION 221119 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Vacuum breakers.
2. Backflow preventers.
3. Water pressure-reducing valves.
4. Balancing valves.
5. Temperature-actuated, water mixing valves.
6. Strainers.
7. Hose bibbs.
8. Wall hydrants.
9. Drain valves.
10. Water-hammer arresters.
11. Trap-seal primer valves.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For domestic water piping specialties.

1. Include diagrams for power, signal, and control wiring.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES

A. Potable-water piping and components shall comply with NSF 61 and NSF 14.

B. Comply with NSF 372 for low lead.

2.2 PERFORMANCE REQUIREMENTS

A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 (860) unless otherwise indicated.

2.3 VACUUM BREAKERS

A. Pipe-Applied, Atmospheric-Type Vacuum Breakers
   1. Standard: ASSE 1001.
   2. Size: NPS 1/4 to NPS 3 (DN 8 to DN 80), as required to match connected piping.
   3. Body: Bronze.
   4. Inlet and Outlet Connections: Threaded.
   5. Finish: Rough bronze or Chrome plated, as directed.

B. Hose-Connection Vacuum Breakers
   1. Standard: ASSE 1011.
   2. Body: Bronze, nonremovable, with manual drain.
   3. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.
   4. Finish: Chrome or nickel plated or Rough bronze, as directed.

2.4 BACKFLOW PREVENTERS

A. Intermediate Atmospheric-Vent Backflow Preventers
   1. Standard: ASSE 1012.
   2. Operation: Continuous-pressure applications.
   3. Size: NPS 1/2 (DN 15) or NPS 3/4 (DN 20), as directed.
   4. Body: Bronze.
   5. End Connections: Union, solder joint.
   6. Finish: Chrome plated or Rough bronze, as directed.

B. Reduced-Pressure-Principle Backflow Preventers
   1. Standard: ASSE 1013.
   2. Operation: Continuous-pressure applications.
   3. Pressure Loss: 12 (83) psig (kPa) maximum, through middle third of flow range.
   4. Size: As directed.
   5. Design Flow Rate: As directed.
   6. Selected Unit Flow Range Limits: As directed.
   7. Pressure Loss at Design Flow Rate: As directed.
   8. Body: Bronze for NPS 2 (DN 50) and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved, steel with interior lining that complies with AWWA C550 or that is FDA approved or stainless steel for NPS 2-1/2 (DN 65) and larger.
   9. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 (DN 65) and larger.
   10. Configuration: Designed as directed.
   11. Accessories:
      a. Valves NPS 2 (DN 50) and Smaller: Ball type with threaded ends on inlet and outlet.

b. Valves NPS 2-1/2 (DN 65) and Larger: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.
c. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.

C. Double-Check, Backflow-Prevention Assemblies
1. Standard: ASSE 1015.
2. Operation: Continuous-pressure applications unless otherwise indicated.
3. Pressure Loss: 5 (35) psig (kPa) maximum, through middle third of flow range.
4. Size: As directed.
5. Design Flow Rate: As directed.
6. Selected Unit Flow Range Limits: As directed.
7. Pressure Loss at Design Flow Rate: As directed.
8. Body: Bronze for NPS 2 (DN 50) and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved, steel with interior lining that complies with AWWA C550 or that is FDA approved or stainless steel for NPS 2-1/2 (DN 65) and larger.
9. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 (DN 65) and larger.
10. Configuration: Designed for horizontal, straight-through flow.
11. Accessories:

a. Valves NPS 2 (DN 50) and Smaller: Ball type with threaded ends on inlet and outlet.
b. Valves NPS 2-1/2 (DN 65) and Larger: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.

2.5 WATER PRESSURE-REDUCING VALVES

A. Water Regulators
1. Standard: ASSE 1003.
2. Pressure Rating: Initial working pressure of 150 psig (1035 kPa).
3. Size: As directed.
4. Design Flow Rate: As directed.
5. Design Inlet Pressure: As directed.
6. Design Outlet Pressure Setting: As directed.
7. Body: Bronze with chrome-plated finish for NPS 2 (DN 50) and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 and NPS 3 (DN 65 and DN 80).
8. Valves for Booster Heater Water Supply: Include integral bypass.
9. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 and NPS 3 (DN 65 and DN 80).

2.6 BALANCING VALVES

A. Memory-Stop Balancing Valves
1. Standard: MSS SP-110 for two-piece, copper-alloy ball valves.
2. Pressure Rating: 400-psig (2760-kPa) minimum CWP.
3. Size: NPS 2 (DN 50) or smaller.
4. Body: Copper alloy.

5. Port: Standard or full port.
6. Ball: Chrome-plated brass.
7. Seats and Seals: Replaceable.
8. End Connections: Solder joint or threaded.
9. Handle: Vinyl-covered steel with memory-setting device.

2.7 TEMPERATURE-ACTUATED, WATER MIXING VALVES

A. Water-Temperature Limiting Devices
1. Standard: ASSE 1017.
2. Pressure Rating: 125 psig (860 kPa).
3. Type: Thermostatically controlled, water mixing valve.
4. Material: Bronze body with corrosion-resistant interior components.
5. Connections: Threaded union inlets and outlet.
6. Accessories: Check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
7. Tempered-Water Setting: As directed.
8. Tempered-Water Design Flow Rate: As directed.
9. Valve Finish: Chrome plated or Rough bronze.

B. Primary, Thermostatic, Water Mixing Valves
1. Standard: ASSE 1017.
2. Pressure Rating: 125 psig (860 kPa) minimum unless otherwise indicated.
3. Type: Exposed-mounted or Cabinet-type as directed, thermostatically controlled, water mixing valve.
4. Material: Bronze body with corrosion-resistant interior components.
5. Connections: Threaded union inlets and outlet.
6. Accessories: Manual temperature control, check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
7. Tempered-Water Setting: As directed.
8. Tempered-Water Design Flow Rate: As directed.
9. Selected Valve Flow Rate at 45-psig (310-kPa) Pressure Drop: As directed.
10. Pressure Drop at Design Flow Rate: As directed.
11. Valve Finish: Chrome plated, Polished, chrome plated or Rough bronze as directed.
12. Piping Finish: Chrome plated or Copper.
13. Cabinet: Factory fabricated, stainless steel, for recessed or surface mounting and with hinged, stainless-steel door.

2.8 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers

1. Pressure Rating: 125 psig (860 kPa) minimum unless otherwise indicated.
2. Body: Bronze for NPS 2 (DN 50) and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved, epoxy coated and for NPS 2-1/2 (DN 65) and larger.
3. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 (DN 65) and larger.
4. Screen: Stainless steel with round perforations unless otherwise indicated.

5. Perforation Size:

   a. Strainers NPS 2 (DN 50) and Smaller: 0.033 (0.84) or as directed.
   b. Strainers NPS 2-1/2 to NPS 4 (DN 65 to DN 100): 0.062 (1.57) or as directed.
   c. Strainers NPS 5 (DN 125) and Larger: 0.125 (3.18) or as directed.

6. Drain: Pipe plug or Factory-installed, hose-end drain valve as directed.

2.9 HOSE BIBBS

A. Hose Bibbs
   1. Standard: ASME A112.18.1 for sediment faucets.
   2. Body Material: Bronze.
   3. Seat: Bronze, replaceable.
   4. Supply Connections: NPS 1/2 or NPS 3/4 (DN 15 or DN 20) threaded or solder-joint inlet.
   5. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
   6. Pressure Rating: 125 psig (860 kPa).
   7. Vacuum Breaker: Integral, nonremovable, drainable, hose-connection vacuum breaker complying with ASSE 1011.
   8. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.
   9. Finish for Service Areas: Rough bronze or Chrome or nickel plated as directed.
   10. Finish for Finished Rooms: Chrome or nickel plated.
   11. Operation for Equipment Rooms: Wheel handle or operating key.
   12. Operation for Service Areas: Wheel handle.
   13. Operation for Finished Rooms: Wheel handle.
   14. Include operating key with each operating-key hose bibb.
   15. Include integral wall flange with each chrome- or nickel-plated hose bibb.

2.10 WALL HYDRANTS

A. Non-freeze Wall Hydrants
   1. Standard: ASME A112.21.3M for concealed or exposed-outlet, self-draining wall hydrants.
   2. Pressure Rating: 125 psig (860 kPa).
   3. Operation: Loose key.
   4. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
   5. Inlet: NPS 3/4 or NPS 1 (DN 20 or DN 25).
   6. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
   7. Box: Deep, flush mounted with cover.
   8. Box and Cover Finish: Polished nickel bronze or Chrome plated.
   9. Outlet: Exposed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
   10. Nozzle and Wall-Plate Finish: Polished nickel bronze or Rough bronze.
   11. Operating Keys(s): One with each wall hydrant.

B. Non-freeze, Hot- and Cold-Water Wall Hydrants

1. Standard: ASME A112.21.3M for concealed or exposed-outlet, self-draining wall hydrants.
2. Pressure Rating: 125 psig (860 kPa).
3. Operation: Loose key.
4. Casing and Operating Rods: Of length required to match wall thickness. Include wall clamps.
5. Inlet: NPS 3/4 or NPS 1 (DN 20 or DN 25).
6. Outlet: Concealed.
7. Box: Deep, flush mounted with cover.
8. Box and Cover Finish: Polished nickel bronze or Chrome plated.
9. Vacuum Breaker:

    a. Nonremovable, manual-drain-type, hose-connection vacuum breaker complying with ASSE 1011 or backflow preventer complying with ASSE 1052.
    b. Garden-hose thread complying with ASME B1.20.7 on outlet.

10. Operating Key(s): One.

C. Moderate-Climate Wall Hydrants
1. Standard: ASME A112.21.3M for concealed or exposed-outlet, self-draining wall hydrants.
2. Pressure Rating: 125 psig (860 kPa).
3. Operation: Loose key.
4. Inlet: NPS 3/4 or NPS 1 (DN 20 or DN 25).
5. Outlet:

    a. Concealed, with integral vacuum breaker or nonremovable hose-connection vacuum breaker complying with ASSE 1011 or backflow preventer complying with ASSE 1052.
    b. Garden-hose thread complying with ASME B1.20.7.

6. Box: Deep, flush mounted with cover.
7. Box and Cover Finish: Polished nickel bronze or Chrome plated
8. Outlet:

    a. Concealed, with integral vacuum breaker or nonremovable hose-connection vacuum breaker complying with ASSE 1011 or backflow preventer complying with ASSE 1052.
    b. Garden-hose thread complying with ASME B1.20.7.

9. Nozzle and Wall-Plate Finish: Polished nickel bronze or Rough bronze.
10. Operating Key(s): One with each wall hydrant.

D. Vacuum Breaker Wall Hydrants
1. Standard: ASSE 1019, Type A or Type B.
2. Type: Freeze-resistant, automatic draining with integral air-inlet valve.
3. Classification: Type A, for automatic draining with hose removed or Type B, for automatic draining with hose removed or with hose attached and nozzle closed as directed.
4. Pressure Rating: 125 psig (860 kPa).
5. Operation: Loose key or wheel handle as directed.

6. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
7. Inlet: NPS 1/2 or NPS 3/4 (DN 15 or DN 20).
8. Outlet: Exposed with garden-hose thread complying with ASME B1.20.7.

2.11 DRAIN VALVES

A. Ball-Valve-Type, Hose-End Drain Valves

1. Standard: MSS SP-110 for standard-port, two-piece ball valves.
2. Pressure Rating: 400-psig (2760-kPa) minimum CWP.
3. Size: NPS 3/4 (DN 20).
4. Body: Copper alloy.
5. Ball: Chrome-plated brass.
6. Seats and Seals: Replaceable.
7. Handle: Vinyl-covered steel.
8. Inlet: Threaded or solder joint.
9. Outlet: Threaded, short nipple with garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

2.12 TRAP-SEAL PRIMER DEVICE

A. Supply-Type, Trap-Seal Primer Device
1. Standard: ASSE 1018.
2. Pressure Rating: 125 psig (860 kPa) minimum.
3. Body: Bronze.
4. Inlet and Outlet Connections: NPS 1/2 (DN 15) threaded, union, or solder joint.
5. Gravity Drain Outlet Connection: NPS 1/2 (DN 15) threaded or solder joint.
6. Finish: Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.

B. Drainage-Type, Trap-Seal Primer Device
1. Standard: ASSE 1044, lavatory P-trap with NPS 3/8 (DN 10) minimum, trap makeup connection.
2. Size: NPS 1-1/4 (DN 32) minimum.
3. Material: Chrome-plated, cast brass.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Backflow Preventers: Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.

1. Locate backflow preventers in same room as connected equipment or system.

2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe-to-floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are unacceptable for this application.
3. Do not install bypass piping around backflow preventers.

B. Water Regulators: Install with inlet and outlet shutoff valves and bypass with memory-stop balancing valve. Install pressure gauges on inlet and outlet.

C. Balancing Valves: Install in locations where they can easily be adjusted.

D. Temperature-Actuated, Water Mixing Valves: Install with check stops or shutoff valves on inlets and with shutoff valve on outlet.

1. Install cabinet-type units recessed in or surface mounted on wall as specified.

E. Y-Pattern Strainers: For water, install on supply side of each control valve water pressure-reducing valve solenoid valve and pump.

F. Supply-Type, Trap-Seal Primer Device: Install with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow.

G. Drainage-Type, Trap-Seal Primer Device: Install as lavatory trap with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting.

3.2 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. When installing piping specialties adjacent to equipment and machines, allow space for service and maintenance.

C. Comply with requirements for grounding equipment in Section 260526 "Grounding and Bonding for Electrical Systems."

3.3 IDENTIFICATION

A. Plastic Labels for Equipment: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:

1. Pressure vacuum breakers.
2. Intermediate atmospheric-vent backflow preventers.
3. Reduced-pressure-principle backflow preventers.
4. Double-check, backflow-prevention assemblies.
5. Carbonated-beverage-machine backflow preventers.
6. Dual-check-valve backflow preventers.
7. Reduced-pressure-detector, fire-protection, backflow-preventer assemblies.

8. Double-check, detector-assembly backflow preventers.
9. Water pressure-reducing valves.
10. Automatic water shutoff valves.
11. Calibrated balancing valves.
12. Primary, thermostatic, water mixing valves.
13. Manifold, thermostatic, water mixing-valve assemblies.
14. Photographic-process, thermostatic, water mixing-valve assemblies.
15. Primary water tempering valves.
16. Outlet boxes.
17. Hose stations.
18. Supply-type, trap-seal primer valves.
19. Trap-seal primer systems.

B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Test each pressure vacuum breaker reduced-pressure-principle backflow preventer double-check, backflow-prevention assembly and double-check, detector-assembly backflow preventer according to authorities having jurisdiction and the device's reference standard.

B. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Set field-adjustable pressure set points of water pressure-reducing valves.

B. Set field-adjustable flow set points of balancing valves.

C. Set field-adjustable temperature set points of temperature-actuated, water mixing valves.

END OF SECTION 221119

SECTION 221123.13 - DOMESTIC-WATER PACKAGED BOOSTER PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Simplex, constant-speed booster pumps.
2. Multiplex, constant-speed booster pumps.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For booster pumps.

C. Delegated-Design Submittal: For domestic-water packaged booster pumps.

1. Include design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

1.3 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Drinking Water System Components - Health Effects and Drinking Water System Components - Lead Content Compliance: NSF 61 and NSF 372.

B. Seismic Performance: Booster pumps shall withstand the effects of earthquake motions determined according to ASCE/SEI 7

1. The term "withstand" means "the booster pump will remain in place without separation of any parts from the booster pump when subjected to the seismic forces specified and the booster pump will be fully operational after the seismic event."

2.2 SIMPLEX, CONSTANT-SPEED BOOSTER PUMPS

A. Description: Factory-assembled and -tested, fluid-handling system for domestic water, with pump, piping, valves, specialties, and controls, and mounted on base.

B. Pump:

1. Type: End suction as defined in HI 1.1-1.2 and HI 1.3 for end-suction, close-coupled, single-stage, overhung-impeller, centrifugal pump.
2. Casing: Radially split; bronze, cast iron or stainless steel as directed.
3. Impeller: Closed, ASTM B584 cast bronze or stainless steel as directed; statically and dynamically balanced and keyed to shaft.
4. Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve and deflector.
5. Seal: Mechanical.
6. Orientation: Mounted horizontally or vertically.

C. Motor: Single speed, with pre-greased, permanently shielded, ball-bearings, and directly mounted to pump casing. Select motor that will not overload through full range of pump performance curve.

D. Piping: Copper tube and copper fittings, Stainless-steel pipe and fittings, Stainless-steel pipe and fitting headers and copper tube and copper fittings between headers and pump or Galvanized-steel pipe and cast-iron fittings as directed.

E. Valves:

1. Shutoff Valves NPS 2 (DN 50) and Smaller: Gate valve or two-piece, full-port ball valve as directed, in pump suction and discharge piping.
2. Shutoff Valves NPS 2-1/2 (DN 65) and Larger: Gate valve or lug-type butterfly valve as directed, in pump suction and discharge piping.
3. Check Valve NPS 2 (DN 50) and Smaller: Silent or swing type in pump discharge piping as directed.
4. Check Valve NPS 2-1/2 (DN 65) and Larger: Silent type in pump discharge piping.
5. Control Valve: Adjustable, automatic, pilot-operated or direct-acting as directed, pressure-reducing type in pump discharge piping.
6. Control Valve: Combination adjustable, automatic, pilot-operated or direct-acting pressure-reducing-and-check type in pump discharge piping.
7. Thermal-Relief Valve: Temperature-and-pressure relief type in pump discharge piping.

F. Dielectric Fittings: With insulating material to isolate joined dissimilar metals.

G. Hydropneumatic Tank: Pre-charged, ASME-construction, diaphragm or bladder tank made of materials complying with NSF 61 and NSF 372.

H. Control Panel: Factory installed and connected as an integral part of booster pump; automatic for single-pump, constant-speed operation, with load control and protection functions.

1. Control Logic: Solid-state system with transducers, programmable microprocessor, and other devices in the controller.
2. Motor Controller: NEMA ICS 2, general-purpose, Class A, full-voltage, combination-magnetic type with undervoltage release feature, motor-circuit-protector-type disconnect, and short-circuit protective device.

    a. Control Voltage: 24 or 120 V ac as directed, with integral control-power transformer.

3. Motor Controller: NEMA ICS 2, solid-state, reduced-voltage type.

    a. Control Voltage: 24 or 120 V ac as directed, with integral control-power transformer.

4. Enclosure: NEMA 250, Type 1, Type 3R, Type 4 or Type 12 as directed.
5. Motor Overload Protection: Overload relay in each phase.
6. Starting Devices: Hand-off-automatic selector switch in cover of control panel, plus pilot device for automatic control.
7. Pump Operation: Current- or pressure-sensing method.

    a. Time Delay: Controls pump on-off operation; adjustable from 1 to 300 seconds.

8. Instrumentation: Suction and discharge pressure gauges.
9. Light: Running light for pump.
10. Thermal-bleed cutoff.
11. Low-suction-pressure and Water-storage-tank, low-level cutout.
12. High-suction-pressure cutout.
13. Low-discharge-pressure cutout.
14. High-discharge-pressure cutout.
15. Direct Digital Control (DDC) System for HVAC: Provide auxiliary contacts for interface to BACnet or LonWorks or as directed DDC system. DDC systems are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC." Include the following:

    a. On-off status of pump.
    b. Alarm status.

I. Base: Structural steel.

J. Capacities and Characteristics:

1. Minimum Pressure Rating: 125 (860) psig (kPa).
2. Booster-Pump Capacity: As directed.
3. Total Dynamic Head: As directed.
4. Speed: as directed.
5. Minimum Inlet Pressure: As directed.
6. Maximum Inlet Pressure: As directed
7. Discharge Pressure: As directed.
8. Low-Suction-Pressure Shutoff: As directed.
9. High-Suction-Pressure Shutoff: As directed.
10. Low-Discharge-Pressure Shutoff: As directed.
11. High-Discharge-Pressure Shutoff: As directed.
12. Inlet Size: As directed.
13. Outlet Size: As directed.
14. Control Valve:

    a. Minimum Size: As directed.
    b. Maximum Pressure Drop: As directed.

15. Electrical Characteristics:

a. Motor Horsepower: As directed.
b. Volts: As directed.
c. Phases: As directed.
d. Hertz: 60 Hz.
e. Full-Load Amperes: As directed.
f. Minimum Circuit Ampacity: As directed.
g. Maximum Overcurrent Protection: As directed.

16. Hydropneumatic Tank:

a. Minimum Water Volume Capacity: As directed.
b. Pressure Rating: 125 (860), 150 (1035) or 250 (1725) as directed.
c. Air Pre-charge: As directed.

2.3 MULTIPLEX, CONSTANT-SPEED BOOSTER PUMPS

A. Description: Factory-assembled and -tested, fluid-handling system for domestic water, with pumps, piping, valves, specialties, and controls, and mounted on base.

B. Pumps:

1. Type: End suction as defined in HI 1.1-1.2 and HI 1.3 for end-suction, close-coupled, single-stage, overhung-impeller, centrifugal pump.
2. Casing: Radially split; bronze, cast iron or stainless steel as directed.
3. Impeller: Closed, ASTM B584 cast bronze or stainless steel as directed; statically and dynamically balanced and keyed to shaft.
4. Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve and deflector.
5. Seal: Mechanical.
6. Orientation: Mounted horizontally or vertically.

C. Pumps:

1. Type: End suction as defined in HI 1.1-1.2 and HI 1.3 for end-suction, frame-mounted, separately coupled, single-stage, overhung-impeller, centrifugal pump.
2. Casing: Radially split; bronze, cast iron or stainless steel as directed.
3. Impeller: Closed, ASTM B584 cast bronze or stainless steel as directed; statically and dynamically balanced and keyed to shaft.
4. Shaft and Shaft Sleeve: Stainless-steel or steel shaft, with copper-alloy shaft sleeve and deflector.
5. Seal: Mechanical.
6. Bearing: pre-greased, permanently shielded ball type.
7. Coupling: Flexible, with metal guard.

D. Pumps:

1. Type: In line, single stage as defined in HI 1.1-1.2 and HI 1.3 for in-line, single-stage, close-coupled, overhung-impeller, centrifugal pump.
2. Casing: Radially split; bronze, cast iron or stainless steel as directed.
3. Impeller: Closed, ASTM B584 cast bronze or stainless steel as directed; statically and dynamically balanced and keyed to shaft.

4. Shaft and Shaft Sleeve: Stainless-steel or steel shaft, with copper-alloy shaft sleeve.
5. Seal: Mechanical.
6. Bearing: pre-greased, permanently shielded ball type.

E. Pumps:

1. Type: Vertical, multistage as defined in HI 1.1-1.2 and HI 1.3 for in-line, multistage, separately coupled, overhung-impeller, centrifugal pump.
2. Casing: Cast-iron or steel base and stainless-steel chamber.
3. Impeller: Closed, stainless steel; statically and dynamically balanced and keyed to shaft.
4. Shaft: Stainless steel.
5. Seal: Mechanical.
6. Bearing: Water-lubricated sleeve type.

F. Pumps:

1. Type: Vertical, can, as defined in HI 2.1-2.2 and HI 2.3 for in-line, barrel or can, lineshaft, vertical pump.
2. Impeller: Closed, stainless steel; statically and dynamically balanced and keyed to shaft.
3. Bowls: Epoxy-coated cast iron or as directed.
4. Shaft: Stainless steel.
5. Seals: Mechanical and stuffing-box types.
6. Bearings: Water-lubricated bushing type.

G. Motors: Single speed, with pre-greased, permanently shielded, ball-bearings. Select motors that will not overload through full range of pump performance curve.

H. Piping: Copper tube and copper fittings, Stainless-steel pipe and fittings, Stainless-steel pipe and fitting headers and copper tube and copper fittings between headers and pump or Galvanized-steel pipe and cast-iron fittings, as directed.

I. Valves:

1. Shutoff Valves NPS 2 (DN 50) and Smaller: Gate valve or two-piece, full-port ball valve, in each pump's suction and discharge piping.
2. Shutoff Valves NPS 2-1/2 (DN 65) and Larger: Gate valve or lug-type butterfly valve, in each pump's suction and discharge piping and in inlet and outlet headers as directed.
3. Check Valves NPS 2 (DN 50) and Smaller: Silent or swing type in each pump's discharge piping as directed.
4. Check Valves NPS 2-1/2 (DN 65) and Larger: Silent type in each pump's discharge piping.
5. Control Valves: Adjustable, automatic, pilot-operated or direct-acting as directed, pressure-reducing type in each pump's discharge piping.
6. Control Valves: Combination adjustable, automatic, pilot-operated or direct-acting pressure-reducing-and-check type in each pump's discharge piping as directed.
7. Thermal-Relief Valve: Temperature-and-pressure relief type in pump's discharge header piping.

J. Dielectric Fittings: With insulating material to isolate joined dissimilar metals.

K. Control Panel: Factory installed and connected as an integral part of booster pump; automatic for multiple-pump, constant-speed operation, with load control and protection functions.

1. Control Logic: Solid-state system with transducers, programmable microprocessor, and other devices in the controller.
2. Motor Controller: NEMA ICS 2, general-purpose, Class A, full-voltage, combination-magnetic type with undervoltage release feature, motor-circuit-protector-type disconnect, and short-circuit protective device.

    a. Control Voltage: 24 or 120 V ac, with integral control-power transformer.

3. Motor Controller: NEMA ICS 2, solid-state, reduced-voltage type.

    a. Control Voltage: 24 or 120 V ac, with integral control-power transformer.

4. Enclosure: NEMA 250, Type 1, Type 3R, Type 4 or Type 12 as directed.
5. Motor Overload Protection: Overload relay in each phase.
6. Starting Devices: Hand-off-automatic selector switch for each pump in cover of control panel, plus pilot device for automatic control.

    a. Duplex, Automatic, Alternating Starter: Switches lead pump to lag main pump and to two-pump operation.
    b. Triplex, Sequence (Lead-Lag-Lag) Starter: Switches lead pump to one lag main pump and to three-pump operation.

7. Pump Operation and Sequencing: Current- or pressure-sensing method.

    a. Time Delay: Controls pump on-off operation; adjustable from 1 to 300 seconds.

8. Instrumentation: Suction and discharge pressure gauges.
9. Lights: Running light for each pump.
10. Alarm Signal Device: Sounds alarm when backup pumps are operating.

    a. Time Delay: Controls alarm operation; adjustable from 1 to 300 seconds, with manual reset.

11. Thermal-bleed cutoff.
12. Low-suction-pressure and Water-storage-tank, low-level cutout as directed.
13. High-suction-pressure cutout.
14. Low-discharge-pressure cutout.
15. High-discharge-pressure cutout.
16. Direct Digital Control (DDC) System for HVAC: Provide auxiliary contacts for interface to DDC system as directed. DDC systems are specified in Section 230923 "Direct-Digital Control (DDC) System for HVAC." Include the following:

    a. On-off status of each pump.
    b. Alarm status.

L. Base: Structural steel.

M. Capacities and Characteristics:

1. Minimum Pressure Rating: 150 (1035) psig (kPa).
2. Booster-Pump Capacity: As directed.
3. Minimum Inlet Pressure: As directed.
4. Maximum Inlet Pressure: As directed.
5. Discharge Pressure: As directed
6. Low-Suction-Pressure Shutoff: As directed.
7. High-Suction-Pressure Shutoff: As directed.
8. Low-Discharge-Pressure Shutoff: As directed.
9. High-Discharge-Pressure Shutoff: As directed.
10. Header Size: As directed.
11. Lead Pump:

    a. Capacity: As directed.
    b. Total Dynamic Head: As directed.
    c. Speed: As directed.
    d. Control Valve:

        1) Minimum Size: As directed.
        2) Maximum Pressure Drop: As directed

    e. Electrical Characteristics:

        1) Motor Horsepower: As directed.
        2) Volts: As directed.
        3) Phases: As directed.
        4) Hertz: 60 Hz.

12. Each of Two Lag Pumps:

    a. Capacity: As directed.
    b. Total Dynamic Head: As directed.
    c. Speed: As directed.
    d. Control Valve:

        1) Minimum Size: As directed.
        2) Maximum Pressure Drop: As directed.

    e. Electrical Characteristics:

        1) Motor Horsepower: As directed.
        2) Volts: As directed.
        3) Phases: As directed.
        4) Hertz: 60 Hz.

13. Booster-Pump Electrical Characteristics:

    a. Full-Load Amperes: As directed.
    b. Minimum Circuit Ampacity: As directed.
    c. Maximum Overcurrent Protection: As directed.

2.4 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors.

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in NFPA 70.

2.5 SOURCE QUALITY CONTROL

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

B. ASME Compliance: Comply with ASME B31.9 for piping.

C. UL Compliance for Packaged Pumping Systems:

1. UL 508, "Industrial Control Equipment."
2. UL 508A, "Industrial Control Panels."
3. UL 778, "Motor-Operated Water Pumps."
4. UL 1995, "Heating and Cooling Equipment."

D. Booster pumps shall be listed and labeled as packaged pumping systems by testing agency acceptable to authorities having jurisdiction.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Booster-Pump Mounting:

1. Install booster pumps on cast-in-place concrete equipment base(s) as directed.
2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
3. Comply with requirements for vibration isolation devices as directed.

B. Support connected domestic-water piping so weight of piping is not supported by booster pumps.

C. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.2 PIPING CONNECTIONS

A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Booster-Pump Piping Connections: Connect domestic-water piping to booster pumps. Install suction and discharge pipe equal to or greater than size of system suction and discharge headers and/or piping as directed.

1. Install shutoff valves on piping connections to booster-pump suction and discharge headers and/or piping as directed. Install ball, butterfly, or gate valves same size as suction and discharge headers and/or piping as directed.
2. Install union, flanged, or grooved-joint connections on suction and discharge headers and/or piping as directed at connection to domestic-water piping.
3. Install valved bypass, same size as and between piping, at connections to booster-pump suction and discharge headers and/or piping as directed.
4. Install flexible connectors, same size as piping, on piping connections to booster-pump suction and discharge headers and/or piping as directed.
5. Where installing piping adjacent to booster pumps, allow space for service and maintenance.

3.3 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.5 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

B. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."

2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform tests and inspections.

1. Perform visual and mechanical inspection.
2. Leak Test: After installation, charge booster pump and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start booster pumps to confirm proper motor rotation and booster-pump operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Pumps and controls will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.7 ADJUSTING

A. Adjust booster pumps to function smoothly and lubricate as recommended by manufacturer.

B. Adjust pressure set points.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting booster pump to suit actual occupied conditions

3.8 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain booster pumps.

END OF SECTION 221123.13

SECTION 221123.21 - INLINE, DOMESTIC-WATER PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. In-line, seal less centrifugal pumps.
2. Horizontally mounted, in-line, close-coupled centrifugal pumps.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Detail pumps and adjacent equipment, drawn to scale and coordinated with each other, using input from installers of the items involved.

B. Seismic Qualification Data: Certificates, for inline, domestic-water pumps, accessories, and components, from manufacturer.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. UL Compliance: UL 778 for motor-operated water pumps.

C. Drinking Water System Components - Health Effects and Drinking Water System Components - Lead Content Compliance: NSF 61 and NSF 372.

D. Seismic Performance: Inline, domestic-water pumps shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: As directed 1.5 or 1.0.

2.2 IN-LINE, SEALLESS CENTRIFUGAL PUMPS

A. Description: Factory-assembled and -tested, in-line, close-coupled, canned-motor, sealless, overhung-impeller centrifugal pumps.

B. Capacities and Characteristics:

1. Capacity: As directed.
2. Total Dynamic Head: As directed.
3. Inlet and Outlet Size: As directed.
4. Pump Speed: As directed.
5. Pump Control: As directed Pressure switch, Thermostat or Timer.
6. Motor Horsepower: HP.
7. Electrical Characteristics:

    a. Volts: 120 V.
    b. Phase: Single phase.
    c. Hertz: 60 Hz.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed.
    f. Maximum Overcurrent Protection:

C. Pump Construction:

1. Pump and Motor Assembly: Hermetically sealed, replaceable-cartridge type with motor and impeller on common shaft and designed for installation with pump and motor shaft horizontal.
2. Minimum Working Pressure: 125 psig (860 kPa).
3. Maximum Continuous Operating Temperature: 220 deg F (104 deg C).
4. Casing: As directed Cast iron, Bronze or Stainless steel, with threaded or companion-flange connections.
5. Impeller: As directed Plastic, composite or stainless steel.
6. Motor: As directed Single or Three speed.

2.3 HORIZONTALLY MOUNTED, IN-LINE, CLOSE-COUPLED CENTRIFUGAL PUMPS

A. Description: Factory-assembled and -tested, in-line, single-stage, close-coupled, overhung-impeller centrifugal pumps designed for installation with pump and motor shaft mounted horizontal.

B. Capacities and Characteristics:

1. Capacity: As directed.
2. Total Dynamic Head: As directed.
3. Inlet and Outlet Size: As directed.
4. Pump Control: As directed Pressure switch, Thermostat or Timer.
5. Pump Speed: As directed.
6. Motor Horsepower: As directed.
7. Electrical Characteristics:

    a. Volts: As directed 120 or 240 V.
    b. Phases: As directed Single or Three phase.
    c. Hertz: 60 Hz.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed.
    f. Maximum Overcurrent Protection: As directed.

C. Pump Construction:

1. Casing:

    a. As directed, radially split bronze, brass or or cast iron with threaded companion-flange connections for pumps with NPS 2 (DN 50) pipe connections and flanged connections for pumps with NPS 2-1/2 (DN 65) pipe connections.
    b. Built to permit servicing of pump internals without disturbing the casing or the suction and discharge piping.
    c. Gauge port tappings at suction and discharge nozzles.

2. Impeller: Bronze or brass, statically and dynamically balanced, closed, and keyed to shaft.
3. Shaft and Shaft Sleeve: Steel shaft with deflector, with copper-alloy shaft sleeve. Include water slinger on shaft between motor and seal.
4. Shaft Coupling: Flexible, capable of absorbing torsional vibration and shaft misalignment.
5. Seal: Mechanical, with carbon-steel rotating ring, stainless-steel spring, ceramic seat, and rubber bellows and gasket.
6. Bearings: Grease-lubricated or permanently lubricated ball type.
7. Minimum Working Pressure: 175 psig (1200 kPa).
8. Continuous Operating Temperature: 225 deg F (107 deg C).

D. Motor: Single speed, with grease-lubricated ball bearings; resiliently or rigidly mounted to pump casing.

2.4 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 220513 "Common Motor Requirements for Plumbing Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2.5 CONTROLS

A. Thermostats: Electric; adjustable for control of hot-water circulation pump.

1. Type: Water-immersion temperature sensor, for installation in piping.
2. Range: As directed, 50 to 125 deg F (10 to 52 deg C), 65 to 200 deg F (18 to 93 deg C) or 100 to 240 deg F (38 to 116 deg C).
3. Enclosure: NEMA 250, Type 4X.
4. Operation of Pump: On or off.
5. Transformer: Provide if required.
6. Power Requirement: As directed, 24 V ac or 120 V ac.
7. Settings: As directed Start pump at 105 deg F (41 deg C), 110 deg F (43 deg C) or 115 deg F (46 deg C) and stop pump at 120 deg F (49 deg C) or 125 deg F (52 deg C).

B. Timers: Electric, for control of hot-water circulation pump.

1. Type: Programmable, seven-day clock with manual override on-off switch.
2. Enclosure: NEMA 250, Type 1, suitable for wall mounting.
3. Operation of Pump: On or off.
4. Transformer: Provide if required.
5. Power Requirement: As directed, 24 V ac or 120 V ac.
6. Programmable Sequence of Operation: Up to two on-off cycles each day for seven days.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with HI 1.4.

B. Mount pumps in orientation complying with manufacturer's written instructions.

C. Install continuous-thread hanger rods and vibration isolation of size required to support pump weight.

1. Comply with requirements for vibration isolation devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" or Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment" Fabricate brackets or supports as required.
2. Comply with requirements for hangers and supports specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

D. Install thermostats in hot-water return piping.

E. Install timers on wall in engineer's office.

F. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment" for identification of pumps.

G. As directed, engage a factory-authorized service representative to perform or Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Check piping connections for tightness.
3. Clean strainers on suction piping.
4. Set thermostats and timers for automatic starting and stopping operation of pumps.
5. Perform the following startup checks for each pump before starting:

    a. Verify bearing lubrication.
    b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
    c. Verify that pump is rotating in the correct direction.

6. Prime pump by opening suction valves and closing drains and prepare pump for operation.
7. Start motor.
8. Open discharge valve slowly.
9. Adjust temperature settings on thermostats.
10. Adjust timer settings.

3.2 PIPING CONNECTIONS

A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to inline, domestic-water pumps, allow space for service and maintenance.

C. Connect domestic-water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles.

1. Install flexible connectors adjacent to pumps in suction and discharge piping of the following pumps:

    a. Horizontally mounted, in-line, close-coupled centrifugal pumps.
    b. Comply with requirements for flexible connectors specified in Section 221116 "Domestic Water Piping."

D. Install shutoff valve and strainer on suction side of each pump, and check, shutoff, and throttling valves on discharge side of each pump. Install valves same size as connected piping. Comply with requirements for strainers specified in Section 221119 "Domestic Water Piping Specialties." Comply with requirements for valves specified in the following:

1. Section 220523.12 "Ball Valves for Plumbing Piping."
2. Section 220523.13 "Butterfly Valves for Plumbing Piping."
3. Section 220523.14 "Check Valves for Plumbing Piping."
4. Section 220523.15 "Gate Valves for Plumbing Piping."

5. Install pressure gauge and snubber at suction of each pump and pressure gauge and snubber at discharge of each pump. Install at integral pressure-gauge tappings where provided or install pressure-gauge connectors in suction and discharge piping around pumps. Comply with requirements for pressure gauges and snubbers specified in Section 220519 "Meters and Gages for Plumbing Piping."

3.3 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between temperature controllers and devices.

C. Interlock pump between water heater and hot-water storage tank with water heater burner and time-delay relay.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Inline, domestic-water pump will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust inline, domestic-water pumps to function smoothly, and lubricate as recommended by manufacturer.

B. Adjust initial temperature set points.

C. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

END OF SECTION 221123.21

SECTION 221216 - FACILITY ELEVATED, POTABLE-WATER STORAGE TANKS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes double-ellipsoidal, multiple-column, elevated, water-storage tanks for domestic and fire-suppression water.

B. Section includes double-cone, single-pedestal, elevated, water-storage tanks for domestic and fire-suppression water.

1.2 DEFINITIONS

A. Bottom Capacity Level (BCL): Water level above which the specified capacity is provided.

B. Capacity: Net volume, in gallons (liters), that may be removed from a tank filled to TCL and emptied to BCL.

C. Minimum Capacity within Operating Range: Capacity when water level is at BCL.

D. Range of Head: Vertical distance between TCL and BCL.

E. Top Capacity Level (TCL): Water level defined by the lip of the overflow elevation.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details for each facility elevated, potable-water storage tank, including the following:

1. Tank shell.
2. Riser and columns, for multiple-column, elevated, potable-water storage tanks.
3. Pedestal, for single-pedestal, elevated, potable-water storage tanks.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for elevated, potable-water storage tanks and components, from manufacturer.

B. Welding certificates.

C. Bacteriological test results.

D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."
3. AWS D1.4/D1.4M, "Structural Welding Code - Reinforcing Steel."

B. Pipe Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding, Brazing, and Fusing Qualifications."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1. Exception: Portions of composite, elevated, potable-water storage tanks that are not fabricated of welded steel.

B. Tanks for Potable-Water Storage and Fire-Suppression Water Supply: Comply with NFPA 22, "Water Tanks for Private Fire Protection."

C. Comply with NSF 61 and NSF 372.

D. Comply with 29 CFR 1910.

E. Structural Performance: Elevated, potable-water storage tank, including tank shell, structural reinforcement, supports, and foundations, shall withstand the effects of dead and live gravity loads and winds of 100 mph (161 km/h).

F. Seismic Performance: Elevated, potable-water storage tank, including tank shell, structural reinforcement, supports, and foundations, shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Important Factor: As directed 1.5 or 1.0.

G. Thermal Movements: Elevated, potable-water storage tank, including tank shell, structural reinforcement, supports, and foundations, shall allow for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures by preventing buckling, opening of joints, overstressing of components, failure of connections, and other detrimental effects. Base engineering calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.

1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.2 DOUBLE-ELLIPSOIDAL, MULTIPLE-COLUMN, ELEVATED WATER-STORAGE TANKS

A. Description: Ellipsoidal top and bottom and vertical sidewall, with welded-steel plates, bolts, rods, and reinforcing steel.

B. Standard: Tanks and accessories shall be designed and fabricated according to AWWA D100 and NFPA 22.

C. Shell Capacity: As directed, 20,000 gal. (75.7 cu. m) or 200,000 gal. (757 cu. m).

D. Minimum Capacity within Operating Range: As directed.

E. Tank Height: As directed, height in feet (m) from top of foundation to overflow level.

F. Range of Head: As directed, height in feet (m) from BCL to overflow level.

G. BCL: As directed, height of level above top of foundation.

H. Riser: Welded-steel pipe, with 12-by-18-inch- (300-by-450-mm-) minimum, reinforced-steel manhole with locking device; and steel safety grate with 18-by-18-inch- (450-by-450-mm-) minimum, hinged door over top of riser.

I. Pipe Connections: Match size of water-distribution pipe.

J. Overflow Piping: ASTM A53/A53M, Grade B, Schedule 40, welded-steel pipe with ASTM A234/A234M, Grade WPB, Schedule 40, carbon-steel butt-welded fittings.

K. Ladders:

1. Materials: As directed Galvanized steel or Steel.
2. Safety Devices: As required by 29 CFR 1910 (OSHA) safety and health regulations.
3. Exterior: Located outside tank on one column, shell sidewall, and roof.
4. Interior: Located inside tank and riser.
5. Size: Custom sized to tank.

L. Roof Opening Hatch at Ladder: Comply with AWWA D100. Steel, hinged cover, 24 by 24 inches (600 by 600 mm) minimum with 4-inch (100-mm) curb and 2-inch (50-mm) downward overlap with hasp and lock, located over interior ladder and adjacent to exterior ladder.

M. Roof Center Opening: Comply with AWWA D100. Steel, removable 30-inch (500-mm) minimum-diameter cover with 4-inch (100-mm) minimum, height curb and minimum 2-inch (50-mm) downward overlap with hasp and lock. Construct opening with capability of supporting ventilation fan.

N. Painter's Accessories: Removable 12-inch (300-mm) minimum-diameter cover on tank roof with 4-inch (100-mm) neck and 2-inch (50-mm) downward overlap with hasp and lock. As directed Include lugs, couplings or rail inside and outside the tank for painting.

O. Tank Vent: ASTM A53/A53M, Grade B, Schedule 40, welded-steel pipe with stainless-steel screen, constructed to prevent entrance of rain, insects, birds, and animals. Include pressure-vacuum screened vent or separate pressure-vacuum relief mechanism to maintain clear screen.

P. Balcony with Handrail: Steel, 24-inch (600-mm) minimum-width balcony with 42-inch (1060-mm) minimum-height handrail, according to 29 CFR 1910.

Q. Tower: Steel columns, struts, and windage rods according to AWWA D100 and NFPA 22.

R. Riser and Column Foundations: Reinforced concrete. See Section 033000 "Cast-in-Place Concrete."

S. Siphon System: Include valved connection to overflow pipe for 3/4-inch (19-mm) hose that will be used to siphon water that remains below riser pipe opening when shell is drained.

2.3 DOUBLE-CONE, SINGLE-PEDESTAL, ELEVATED WATER-STORAGE TANKS

A. Description: Inverted cone on upright cone with no sidewall steel shell, with welded-steel plates, bolts, rods, and reinforcing steel.

B. Standard: Tanks and accessories shall be designed and fabricated according to AWWA D100 and NFPA 22.

C. Shell Capacity: As directed 25,000 gal. (95 cu. m) or 200,000 gal. (757 cu. m).

D. Minimum Capacity within Operating Range: As directed.

E. Tank Height: As directed, height in feet (m) from top of foundation to overflow level.

F. Range of Head: As directed, height in feet (m) from lower capacity level to overflow level.

G. BCL: As directed, height of level above top of foundation.

H. Dry Well: Welded steel, located in tank.

I. Pipe Connection: Match size of water-distribution pipe.

J. Overflow Piping: ASTM A53/A53M, Grade B, Schedule 40, welded-steel pipe with ASTM A234/A234M, Grade WPB, Schedule 40, carbon-steel butt-welded fittings.

K. Ladders:

1. Materials: As directed, Galvanized steel or Steel.
2. Safety Devices: As required by 29 CFR 1910.
3. Size: Custom sized to tank.
4. Location: Inside tank dry well from pedestal to tank roof, inside tank from tank bottom to roof, and inside pedestal from pedestal base to tank.

L. Roof Opening Hatch at Ladder: Steel, hinged cover, 24 by 24 inches (600 by 600 mm) minimum or as required by OSHA, with 4-inch (100-mm) curb and 2-inch (50-mm) downward overlap with hasp and lock, located over interior ladder.

M. Roof Center Opening: Steel, removable 20-inch (500-mm) minimum-diameter cover with 4-inch (100-mm) minimum-height neck and minimum 2-inch (50-mm) downward overlap with hasp and lock. Construct opening with capability of supporting ventilation fan.

N. Painter's Accessories: Removable 12-inch (300-mm) minimum-diameter cover on tank roof with 4-inch (100-mm) neck and 2-inch (50-mm) downward overlap with hasp and lock. As directed Include lugs, couplings or rail inside and outside the tank for painting.

O. Tank Vent: ASTM A53/A53M, Grade B, Schedule 40, welded-steel pipe with stainless-steel screen, constructed to prevent entrance of rain, insects, birds, and animals. Include pressure-vacuum screened vent or separate pressure-vacuum relief mechanism to maintain clear screen.

P. Tank Handrail: As directed, Galvanized steel or Steel, 42-inch (1060-mm) minimum height, according to 29 CFR 1910.

Q. Pedestal:

1. Fabrication: Welded-steel, truncated cone base with cylindrical column.
2. Platform: 24-inch (600-mm) minimum width, inside at top.
3. Opening between Pedestal and Tank Dry Well: Same diameter as tank dry well.
4. Manway between Pedestal and Tank Bottom: Steel, waterproof-hinged door with locking device, 12 by 16 inches (300 by 400 mm) minimum.
5. Painter's Manway at Platform Level: Steel, 20-inch (500-mm) minimum door.
6. Pedestal Access Door: Steel, 30 by 60 inches (760 by 1520 mm) minimum with locking device.

R. Pedestal Foundation: Reinforced concrete. See Section 033000 "Cast-in-Place Concrete."

S. Painter's Rail: Locate inside and outside of pedestal top, and inside and outside of tank shell.

2.4 PAINT MATERIALS

A. Paint: Comply with AWWA D102.

B. Primer: Tank fabricator's epoxy-polyamide paint.

C. Tank Shell and Riser Interior Finish Paint: Tank fabricator's epoxy-polyamide paint complying with NSF 61 Annex G and compatible to prime coat.

D. Tank Shell and Steel Support Exterior Intermediate Paint: Tank fabricator's epoxy-polyamide paint compatible with prime and finish paint. Intermediate coat shall have a slight color contrast with finish coat.

E. Tank Shell and Steel Support Exterior Finish Paint: Tank fabricator's urethane paint.

1. Color: As selected by Owner from tank manufacturer's paint chart.

F. Tank Exterior Lettering and Logo: Tank fabricator's urethane paint.

1. Color: As selected by Owner from tank manufacturer's paint chart.

2.5 SHOP PAINTING

A. Shop Cleaning Interior Surfaces: After fabrication, blast clean according to SSPC-SP 10/NACE No. 2.

B. Shop Cleaning Exterior Surfaces: After fabrication, blast clean according to SSPC-SP 6/NACE No. 3.

C. After cleaning, remove dust or residue from cleaned surfaces.

D. If surface develops rust before prime coat is applied, repeat field surface preparation.

E. Apply prime coat to shop-cleaned, dry surfaces same day as surface preparation, to a dry film thickness of 3.0 to 5.0 mils (0.08 to 0.13 mm) for tank interior and to a dry film thickness of 2.0 to 3.0 mils (0.05 to 0.08 mm) for exterior tank and support surfaces.

2.6 ELEVATED WATER-STORAGE TANK APPURTENANCES

A. Water-Level Controls: Automatic controls for maintaining water level in tank, with valves, piping, and audible and visual alarms to indicate the following:

1. High- and low-water levels.
2. Tank overflowing or tank not filling.

B. Obstruction Lighting: Comply with requirements of authorities having jurisdiction.

C. Lightning Protection: Comply with requirements in Section 264113 "Lightning Protection for Structures."

D. Cathodic Protection: Comply with requirements in Section 134713 "Cathodic Protection" and with AWWA D104.

E. Tank Heaters: Comply with NFPA 22 and with capacity to maintain 42 deg F (6 deg C) water temperature inside elevated, potable-water storage tank.

PART 3 - EXECUTION

3.1 ELEVATED WATER-STORAGE TANK INSTALLATION

A. Erect water-storage tank according to AWWA D100.

B. Riser Manhole: Install bottom of manhole 36 inches (910 mm) above grade. Install safety grate at top of riser with hinged manhole.

C. Overflow Pipe: Penetrate tank shell at elevation indicated on Drawings, attach to tank shell exterior, attach to one tower column and extend down to 12 inches (300 mm) above grade, and terminate above concrete splash block.

D. Overflow Pipe: Penetrate wall of tank dry well at elevation indicated on Drawings, attach to exterior of tank dry well and to pedestal and extend down pedestal to 24 inches (600 mm) above grade. Turn with 90-degree elbow, penetrate pedestal wall, and terminate above concrete splash block.

3.2 FIELD PAINTING

A. Surface preparation is specified in Section 099113 "Exterior Painting" or Section 099600 "High-Performance Coatings" as directed.

B. Apply paint according to AWWA D102.

C. Prime-Coat Touchup: Apply primer to cleaned areas and where shop finish has been damaged during shipping, handling, and erection. Apply prime coat to a dry film thickness of 3.0 to 5.0 mils (0.08 to 0.13 mm) for tank interior and to a dry film thickness of 2.0 to 3.0 mils (0.05 to 0.08 mm) for exterior tank and support surfaces.

D. Tank Shell Interior Finish Coats: Apply two coats of interior finish paint above bottom ring to a dry film thickness of 4.0 to 5.0 mils (0.1 to 0.13 mm). Apply interior finish paint to surfaces below bottom ring to a dry film thickness of 8.0 to 10.0 mils (0.2 to 0.25 mm).

E. Tank Shell and Steel Support Exterior Coats: Apply intermediate paint to a dry film thickness of 2.0 to 3.0 mils (0.05 to 0.08 mm). Apply finish paint to a dry film thickness of 2.0 to 3.0 mils (0.05 to 0.08 mm).

F. Tank Exterior Lettering and Logo: Apply one coat or two coats of urethane paint to a dry film thickness of 2.0 to 3.0 mils (0.05 to 0.08 mm) for each application.

G. Overflow Pipe: Paint pipe exterior that is outside tank and structure as indicated for tank exterior.

H. Balcony and Exterior Ladders: Paint as indicated for tank exterior.

I. Do not paint if ambient temperature is less than 50 deg F (10 deg C) or is expected to drop below 40 deg F (5 deg C) in the next 18 hours. Do not paint if temperature of steel surface is higher than 125 deg F (52 deg C). Do not apply paint if surfaces are wet or damp, if precipitation is expected, or if relative humidity will exceed 85 percent. Do not spray paint

when wind velocity exceeds 15 mph (24 km/h). Maintain at least a 24-hour waiting period between coats. Provide adequate ventilation in tank during painting to maintain clear atmosphere and provide explosion-proof flood lighting and spot lighting.

J. Complete daily painting to allow time for paint to dry before condensation is expected.

3.3 ELEVATED WATER-STORAGE TANK APPURTENANCE INSTALLATION

A. Install and adjust water-level control valves, piping, and alarms.

B. Install obstruction lighting according to authorities having jurisdiction.

C. Install lightning protection according Section 264113 "Lightning Protection for Structures."

D. Install cathodic protection according to Section 134713 "Cathodic Protection" and AWWA D104.

E. Install tank heaters according to NFPA 22.

3.4 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

1. Connect tanks to water-distribution piping.
2. Connect drains to storm-drainage piping.

B. Install piping specialties furnished by manufacturer, but not factory mounted.

3.5 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.6 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Tank Weld Test: Use radiographic method according to AWWA D100. Repair failures and retest.
2. Leak Test: Comply with AWWA D100 and NFPA 22. Fill tanks with potable water and test for leaks after installation. Repair leaks and retest until no leaks exist.

    a. Water will be furnished by Owner.

D. Unit will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.8 CLEANING

A. Clean interior and exterior of elevated, potable-water storage tanks.

B. Disinfect elevated, potable-water storage tanks according to AWWA C652 or requirements of authorities having jurisdiction.

3.9 DEMONSTRATION

A. As directed Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain the following:

1. Obstruction lighting.
2. Water-level controls.
3. Tank heaters.

END OF SECTION 221216

SECTION 221219 - FACILITY GROUND-MOUNTED, POTABLE-WATER STORAGE TANKS

PART 1 - GENERAL

1.1 SUMMARY

A. As directed Section includes welded-steel reservoirs or standpipes for storage of domestic and fire-suppression water.

B. As directed, Section includes bolted-steel reservoirs or standpipes for storage of domestic and fire-suppression water.

C. Related Requirements:

1. Section 221216 "Facility Elevated, Potable-Water Storage Tanks" for multiple-column, elevated water-storage tanks and for single-pedestal, elevated water-storage tanks.

1.2 DEFINITIONS

A. Bottom Capacity Level (BCL): Water level above which the specified capacity is provided. In a ground-supported tank (reservoir or standpipe), the BCL is the water level in the tank shell when the tank is emptied through the specified discharge fittings, unless otherwise specified.

B. Capacity: Net volume, in gallons (liters), that may be removed from a tank filled to TCL and emptied to BCL.

C. CR: Chlorosulfonated polyethylene synthetic rubber.

D. Minimum Capacity within Operating Range: Capacity when water level is at BCL.

E. NR: Natural rubber.

F. Range of Head: Vertical distance between TCL and BCL.

G. Reservoir: Flat-bottomed, cylindrical, steel ground-mounted water-storage tank with shell height equal to or less than its diameter.

H. SDWA: Safe Drinking Water Act.

I. Standpipe: Flat-bottomed, cylindrical, ground-mounted water-storage tank with shell height greater than its diameter.

J. Top Capacity Level (TCL): Water level defined by the lip of the overflow elevation.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details for each facility ground-mounted, potable-water storage tank, including the following:

1. Tank, roof, and shell openings.
2. Safety railings and ladders.
3. Plans, elevations, sections, and attachment details.
4. Structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
5. Diagram power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for facility ground-mounted, potable-water storage tanks and components, from manufacturer.

B. Welding certificates.

C. Bacteriological test results.

D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."
3. AWS D1.4/D1.4M, "Structural Welding Code - Reinforcing Steel."

B. Pipe Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding, Brazing, and Fusing Qualifications."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Structural Performance: Ground-mounted, potable-water tank, including structural reinforcement and foundation, shall withstand the effects of dead and live gravity loads and winds of 100 mph (161 km/h).

B. Seismic Performance: Ground-mounted, potable-water storage tank, including structural reinforcement and foundation, shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: As directed 1.5 or 1.0.

C. Thermal Movements: Ground-mounted, potable-water tank, including structural reinforcement and foundation, shall allow for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures by preventing buckling, opening of joints, overstressing of components, failure of connections, and other detrimental effects. Base engineering calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.

1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Tanks for Potable-Water Storage and Fire-Suppression Water Supply: Comply with NFPA 22, "Water Tanks for Private Fire Protection,"

F. Comply with NSF 61 and NSF 372.

G. Comply with 29 CFR 1910.

2.2 WELDED-STEEL, GROUND-MOUNTED, POTABLE-WATER RESERVOIRS OR STANDPIPES AS DIRECTED

A. Description: Manufactured, welded-steel tank with welded-steel plates, bolts, rods, and reinforcing steel.

B. Standard: Designed and fabricated according to AWWA D100 and AWWA M42 or AWWA D100, AWWA M42, and NFPA 22.

C. Capacity: As directed, 50,000 gal. (189 cu. m) or 5,000,000 gal. (18 930 cu. m).

D. Minimum Capacity within Operating Range: As directed.

E. Shell Roof: As directed, Dome or Ellipsoidal welded steel and self-supporting.

F. Shell Roof: Conical with knuckle and column-rafter support.

G. Reservoir Shell Diameter: As directed.

H. Standpipe Shell Height: As directed, height in feet (m) from top of foundation to overflow level.

I. Standpipe Range of Head: As directed, height in feet (m) from BCL to overflow level.

J. BCL: As directed, height in feet (m) of level above foundation.

K. Pipe Connections: Comply with AWWA D100. Match size of water-distribution pipe.

L. Overflow Piping: ASTM A53/A53M, Grade B, Schedule 40, welded-steel pipe with ASTM A234/A234M, Grade WPB, Schedule 40, carbon-steel butt-weld fittings.

M. Roof Opening Hatch at Ladder: Comply with AWWA D100. Steel, hinged cover, 24 by 24 inches (600 by 600 mm) minimum or as required by OSHA, with 4-inch (100-mm) curb and 2-inch (50-mm) downward overlap with hasp and lock, located over interior ladder and adjacent to exterior ladder.

N. Roof Center Opening: Comply with AWWA D100. Steel, removable, 20-inch (500-mm) minimum-diameter cover with 4-inch (100-mm) minimum-height neck and minimum 2-inch (50-mm) downward overlap with hasp and lock. Construct opening with capability of supporting ventilation fan.

O. Shell Sidewall Manholes: Comply with AWWA D100. Provide two steel manholes. One circular, 30 inches (750 mm) minimum in diameter. The second, As directed circular, 24 inches (600 mm) in diameter, circular, 36 inches (900 mm) in diameter or elliptical, 18-by-22-inch (450-by-560-mm) minimum size.

P. Painter's Accessories: As directed include lugs, couplings or rail inside and outside tank for painting.

Q. Tank Vent: Steel pipe with stainless-steel screen, constructed to prevent entrance of rain, insects, birds, and animals. Include pressure-vacuum screened vent or separate pressure-vacuum relief mechanism to maintain clear screen.

R. Foundation: Reinforced concrete. See Section 033000 "Cast-in-Place Concrete."

2.3 BOLTED-STEEL, GROUND-MOUNTED, POTABLE-WATER RESERVOIRS OR STANDPIPES AS DIRECTED

A. Description: Manufactured tank with bolted-steel plates, bolts, rods, and reinforcing steel.

B. Standard: Designed and fabricated according to AWWA D103 and AWWA M42 or AWWA D103, AWWA M42, and NFPA 22 As directed.

C. Capacity: As directed, 4000 gal. (15 cu. m) or 160,000 gal. (605 cu. m).

D. Minimum Capacity within Operating Range: As directed.

E. Shell Roof: Comply with AWWA D103.

F. Reservoir Shell Diameter: As directed.

G. Standpipe Shell Height: As directed, height in feet (m) from top of foundation to overflow level.

H. Standpipe Range of Head: As directed, height in feet (m) from BCL to overflow level.

I. BCL: As directed, height in feet (m) of level above foundation.

J. Pipe Connection: Comply with AWWA D103. Match size of water-distribution pipe.

K. Overflow Piping: ASTM A53/A53M, Grade B, Schedule 40, welded-steel pipe with ASTM A234/A234M, Grade W.B., Schedule 40, carbon-steel butt-weld fittings.

L. Roof Opening Hatch above TCL: Comply with AWWA D103. Steel, hinged cover, 24 by 15 inches (600 by 600 mm) minimum or as required by OSHA, with 4-inch (100-mm) curb and 2-inch (50-mm) downward overlap with hasp and lock, located over interior ladder and adjacent to exterior ladder.

M. Roof Center Opening: Comply with AWWA D103. steel, removable, 20-inch- (500-mm-) minimum-diameter cover with 4-inch (100-mm) minimum-height neck and minimum 2-inch (50-mm) downward overlap with hasp and lock. Construct opening with capability of supporting ventilation fan.

N. Shell Sidewall Manholes: Comply with AWWA D103. Provide two steel manholes, circular, minimum 24 inches (600 mm) in diameter, square, minimum 24 by 24 inches (610 by 610 mm) in diameter, elliptical, minimum 18 by 22 inches (450 by 560 mm) or flush rectangular, minimum length 24 inch (610 mm) in shortest direction and maximum length 48 inches (1220 mm) in the longest direction.

O. Painter's Accessories: As directed, include lugs, couplings or rail inside and outside tank for painting.

P. Painting, Factory-Applied, Internal: Epoxy powder coating, NSF and FDA compliant.

Q. Painting, Factory-Applied, External: Polyester powder coating.

R. Tank Vent: Steel pipe with stainless-steel screen, constructed to prevent entrance of rain, insects, birds, and animals. Include pressure-vacuum screened vent or separate pressure-vacuum relief mechanism to maintain clear screen.

S. Foundation: Reinforced concrete. See Section 033000 "Cast-in-Place Concrete."

2.4 PAINT MATERIALS

A. Paint: Comply with AWWA D102.

B. Primer: Tank fabricator's epoxy-polyamide paint.

C. Tank Shell Interior Finish Paint: Tank fabricator's epoxy-polyamide paint complying with NSF 61 and NSF 372, and compatible with prime coat.

D. Tank Shell Exterior Intermediate Paint: Tank fabricator's epoxy-polyamide paint compatible with prime and finish paint. Intermediate coat shall have a slight color contrast with finish coat.

E. Tank Shell Exterior Finish Paint: Tank fabricator's urethane paint.

1. Color: As selected by Owner from tank manufacturer's paint chart.

2.5 SHOP PAINTING

A. Factory coating according to AWWA D103.

B. Tank Shell Interior Finish Coat: Comply with NSF 61 and NSF 372.

C. Tank Shell Exterior Finish Coat: Factory coating according to AWWA D103.

2.6 GROUND-MOUNTED, POTABLE-WATER STORAGE TANK APPURTENANCES

A. Water-Level Controls: Automatic controls for maintaining water level in tank, with valves, piping, and audible and visual alarms to indicate the following:

1. High- and low-water levels.
2. Tank overflowing or tank not filling.

B. Obstruction Lighting: Comply with requirements of authorities having jurisdiction.

C. Lightning Protection: Comply with requirements in Section 264113 "Lightning Protection for Structures."

D. Cathodic Protection: Comply with requirements in Section 134713 "Cathodic Protection" and with AWWA D104.

E. Tank Heaters: Comply with NFPA 22 and with capacity to maintain 42 deg F (6 deg C) water temperature inside surface water-storage tank.

F. Exterior Ladder: Spiral staircase.

1. Material: Galvanized steel.
2. Size: Custom sized to tank.
3. Accessories: Including step off platform.
4. Safety Devices: As required by 29 CFR 1910 (OSHA) safety and health regulations.
5. Standards: As directed Comply with AWWA D100, AWWA D103 or AWWA D110.

G. Exterior Ladder: Straight, vertical ladder rungs.

1. Material: As directed, powder-coated or galvanized or Stainless steel.
2. Size: Custom sized to tank.
3. Accessories: Including step off platform.

4. Safety Devices: As required by 29 CFR 1910 (OSHA) safety and health regulations.
5. Standards: As directed, comply with AWWA D100, AWWA D103 or AWWA D110.

H. Interior Ladder: Straight, vertical ladder rungs.

1. Material: As directed, powder-coated or galvanized or Stainless steel.
2. Size: Custom sized to tank.
3. Accessories: Including step off platform.
4. Safety Devices: As required by 29 CFR 1910 (OSHA) safety and health regulations.
5. Standards: As directed, comply with AWWA D100, AWWA D103 or AWWA D110.

PART 3 - EXECUTION

3.1 STEEL, GROUND-MOUNTED, POTABLE-WATER STORAGE TANK INSTALLATION

A. Welded-Steel Tanks:

1. Erect tank shell, accessories, and appurtenances according to AWWA D100 and AWWA M42.
2. Fabricate steel plate sections in the shop. Erect tank shell by welding plate sections in the field.

B. Bolted-Steel Tanks:

1. Erect tank shell, accessories, and appurtenances according to AWWA D103 and AWWA M42.
2. Fabricate tank sections and drill or punch bolt holes in the shop. Install bolts during field erection of tank.

C. Set top of reinforced-concrete foundation at least 6 inches (150 mm) above finish grade.

D. Install roof hatch near exterior and interior ladder(s).

E. Install roof center opening near center of roof.

F. Install tank vent at center of roof.

G. Install two manholes in tank wall near grade.

3.2 PIPING CONNECTIONS

A. Connect tanks to water-distribution piping.

B. Connect drains to storm-drainage piping.

3.3 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.5 SURFACE PREPARATION OF STEEL TANKS

A. Surface preparation is specified in Section 099113 "Exterior Painting" or Section 099600 "High-Performance Coatings", as directed.

B. Field Cleaning: After erecting tank shell, remove burrs, dirt, and construction debris and repair damaged finishes. Remove weld splatter, sharp edges on weld seams, and scabs and slivers by grinding. Remove weld flux, slag, fins, and laminations.

C. Field Surface Preparation: After field cleaning, prepare steel surfaces where shop prime coat has been damaged, according to the Specifications listed above for shop cleaning, and remove dust or residue from cleaned surfaces.

D. If surface develops rust before prime coat is applied, repeat field surface preparation.

3.6 FIELD PAINTING

A. Surface preparation is specified in Section 099113 "Exterior Painting" or Section 099600 "High-Performance Coatings", as directed.

B. Apply paint according to AWWA D102.

C. Prime-Coat Touchup: Apply primer to cleaned areas and where shop finish has been damaged during shipping, handling, and erection. Apply prime coat to a dry film thickness of 3.0 to 5.0

mils (0.08 to 0.13 mm) for tank interior and to a dry film thickness of 2.0 to 3.0 mils (0.05 to 0.08 mm) for exterior tank and support surfaces.

D. Tank Shell Interior Finish Coats: Apply two coats of interior finish paint above bottom ring to a dry film thickness of 4.0 to 5.0 mils (0.1 to 0.13 mm). Apply interior finish paint to surfaces below bottom ring to a dry film thickness of 8.0 to 10.0 mils (0.2 to 0.25 mm).

E. Tank Shell and Steel Support Exterior Coats: Apply intermediate paint to a dry film thickness of 2.0 to 3.0 mils (0.05 to 0.08 mm). Apply finish paint to a dry film thickness of 2.0 to 3.0 mils (0.05 to 0.08 mm).

F. Tank Exterior Lettering and Logo: As directed Apply one coat or two coats of urethane paint to a dry film thickness of 2.0 to 3.0 mils (0.05 to 0.08 mm) for each application.

G. Overflow Pipe: Paint pipe exterior that is outside tank and structure as indicated for tank exterior.

H. Exterior Ladders: Paint as indicated for tank shell exterior.

I. Do not paint if ambient temperature is less than 50 deg F (10 deg C) or is expected to drop below 40 deg F (5 deg C) in the next 18 hours. Do not paint if temperature of steel surface is higher than 125 deg F (52 deg C). Do not apply paint if surfaces are wet or damp, if precipitation is expected, or if relative humidity will exceed 85 percent. Do not spray paint when wind velocity exceeds 15 mph (24 km/h). Maintain at least a 24-hour waiting period between coats. Provide adequate ventilation in tank during painting to maintain clear atmosphere and provide explosion-proof flood lighting and spot lighting.

J. Complete daily painting to allow time for paint to dry before condensation is expected.

3.7 SURFACE WATER-STORAGE TANK APPURTENANCE INSTALLATION

A. Install and adjust water-level control valves, piping, and alarms.

B. Install obstruction lighting according to authorities having jurisdiction.

C. Install lightning protection according Section 264113 "Lightning Protection for Structures."

D. Install cathodic protection according to Section 134713 "Cathodic Protection" and AWWA D104.

E. Install tank heaters according to NFPA 22.

3.8 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Tank Weld Test: Use radiographic method according to AWWA D100. Repair failures and retest.
2. Leak Test: Comply with AWWA D100 and NFPA 22. Fill tanks with potable water and test for leaks after installation. Repair leaks and retest until no leaks exist.

    a. Water will be furnished by Owner.

3. Leak Test: Comply with AWWA D103 and NFPA 22. Fill tanks with potable water and test for leaks after installation. Repair leaks and retest until no leaks exist.

    a. Water will be furnished by Owner.

4. Leak Test: Comply with AWWA D110 or and NFPA 22. Fill tanks with potable water and test for leaks after installation. Repair leaks and retest until no leaks exist.

    a. Water will be furnished by Owner.

5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Unit will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.9 CLEANING

A. Clean interior and exterior of ground-mounted, potable-water storage tanks.

B. Disinfect surface water-storage tanks according to AWWA C652 or requirements of authorities having jurisdiction.

3.10 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or train Owner's maintenance personnel to adjust, operate, and maintain the following:

1. Obstruction lighting.
2. Water-level controls.
3. Tank heaters.

END OF SECTION 221219

SECTION 221223.11 - FACILITY INDOOR POTABLE-WATER STORAGE TANKS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Steel, pressure, potable-water storage tanks.
2. Steel, non-pressure, potable-water storage tanks.
3. Steel, pre-charged, potable-water storage tanks.
4. Insulated, steel, potable-water storage tanks.

1.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Steel water tanks shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For steel water storage tanks, accessories, and components, from manufacturer.

B. Product certificates.

C. Source quality-control reports.

D. Purging and disinfecting reports.

1.5 QUALITY ASSURANCE

A. ASME Compliance for Steel Tanks: Fabricate and label steel, ASME-code, potable-water storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

B. Comply with NSF 61 Annex G, "Drinking Water System Components - Health Effects," for potable-water storage tanks. Include appropriate NSF marking.

PART 2 - PRODUCTS

2.1 STEEL, PRESSURE, POTABLE-WATER STORAGE TANKS

A. Description: As directed Steel, horizontal or vertical, pressure-rated tank with cylindrical sidewalls.

B. Fabricate supports and attachments to tank with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure.

C. Construction: As directed ASME code, steel or Steel, constructed with nontoxic welded joints, for 125-psig (860-kPa) or 150-psig (1035-kPa) working pressure.

D. Manhole: Watertight, for tank more than 36 inches (915 mm) in diameter; same pressure rating as tank.

E. Tappings: Factory-fabricated stainless steel, welded to tank before testing and labeling.

1. NPS 2 (DN 50) and Smaller: ASME B1.20.1, with female thread.
2. NPS 2-1/2 (DN 65) and Larger: ASME B16.5, flanged.

F. Specialties and Accessories: Include tappings in tank and the following:

1. Pressure relief valve.
2. Pressure gage.
3. Thermometer.
4. Air-charging connection.
5. Gage glass, brass fittings, compression stops, and gage-glass guard.

G. Horizontal Tank Supports: Factory-fabricated steel saddles, welded to tank before testing and labeling.

H. Vertical Tank Supports: Factory-fabricated steel legs or steel skirt, welded to tank before testing and labeling.

I. Tank Interior Finish: Materials and thicknesses complying with NSF 61 Annex G barrier materials for potable-water tank linings. Extend finish into and through tank fittings and outlets.

1. Lining Material: As directed Cement or Copper.
2. Coating: As directed Epoxy resin, Galvanized, Glass or Nickel.

J. Exterior Coating: As directed Galvanized, Manufacturer's standard enamel paint or Primer paint.

2.2 STEEL, NONPRESSURE, POTABLE-WATER STORAGE TANKS

A. Description: As directed Steel, horizontal or vertical, non-pressure-rated tank with cylindrical sidewalls.

B. Fabricate supports and attachments to tank with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure.

C. Construction: Steel, constructed with nontoxic welded joints.

D. Manhole: Watertight, for tank more than 36 inches (915 mm) in diameter.

E. Cover for Open Tank: As directed Plastic or Steel, with lining same as or similar to tank lining and with shape that encloses top of tank.

F. Tappings: Factory-fabricated stainless steel, welded to tank.

1. NPS 2 (DN 50) and Smaller: ASME B1.20.1, with female thread.
2. NPS 2-1/2 (DN 65) and Larger: ASME B16.5, flanged.

G. Specialties and Accessories: Include tappings in the tank and the following:

1. Vacuum relief valve.
2. Free air vent with insect screen.
3. Thermometer.
4. Gage glass, brass fittings, compression stops, and gage-glass guard.

H. Horizontal Tank Supports: Factory-fabricated steel saddles, welded to tank before testing and labeling.

I. Vertical Tank Supports: Factory-fabricated steel legs or steel skirt, welded to tank before testing and labeling.

J. Tank Interior Finish: Materials and thicknesses complying with NSF 61 Annex G barrier materials for potable-water tank linings. Extend finish into and through tank fittings and outlets.

1. Lining Material: As directed Cement or Copper.
2. Coating: As directed Epoxy resin, Galvanized, Glass or Nickel.

K. Exterior Coating: As directed Galvanized, Manufacturer's standard enamel paint or Primer paint.

2.3 STEEL, PRECHARGED, POTABLE-WATER STORAGE TANKS

A. Steel, Precharged, Diaphragm, Water Storage Tanks:
1. Description: Steel, vertical, pressured-rated tank with cylindrical sidewalls and with air-charging valve and air precharge.
2. Fabricate supports and attachments to tank with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure.
3. Operation: Factory-installed, butyl-rubber diaphragm.

B. Construction: As directed ASME code, steel or Steel, constructed with nontoxic welded joints, for 125-psig (860-kPa) or 150-psig (1035-kPa) working pressure.

C. Tappings: Factory-fabricated stainless steel, welded to tank before testing and labeling.

1. NPS 2 (DN 50) and Smaller: ASME B1.20.1, with female thread.
2. NPS 2-1/2 (DN 65) and Larger: ASME B16.5, flanged.

D. Specialties and Accessories: Include tappings in tank and the following:

1. Pressure gage.

E. Vertical Tank Supports: Factory-fabricated steel legs or steel skirt, welded to tank before testing and labeling.

F. Tank Interior Finish: Materials and thicknesses complying with NSF 61 Annex G barrier materials for potable-water tank linings. Extend finish into and through tank fittings and outlets.

1. Lining Material: As directed Cement or Copper.
2. Coating: As directed Epoxy resin, Galvanized, Glass or Nickel.

G. Exterior Coating: As directed Galvanized, Manufacturer's standard enamel paint or Primer paint.

2.4 INSULATED, STEEL, POTABLE-WATER STORAGE TANKS

A. Description: Steel, vertical, pressure-rated tank with cylindrical sidewalls.

B. Fabricate supports and attachments to tank with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure.

C. Construction: As directed, ASME code, steel or Steel, constructed with nontoxic welded joints, for 125-psig (860-kPa) or 150-psig (1035-kPa) working pressure.

D. Manhole: Watertight, for tank more than 36 inches (915 mm) in diameter; same pressure rating as tank.

E. Tappings: Factory-fabricated stainless steel, welded to tank before testing and labeling.

1. NPS 2 (DN 50) and Smaller: ASME B1.20.1, with female thread.
2. NPS 2-1/2 (DN 65) and Larger: ASME B16.5, flanged.

F. Specialties and Accessories: Include tappings in tank and the following:

1. Pressure relief valve.
2. Pressure gage.
3. Thermometer.
4. Air-charging connection.
5. Gage glass, brass fittings, compression stops, and gage-glass guard.

G. Vertical Tank Supports: Factory-fabricated steel legs or steel skirt, welded to tank before testing and labeling.

H. Tank Interior Finish: Materials and thicknesses complying with NSF 61 Annex G barrier materials for potable-water tank linings. Extend finish into and through tank fittings and outlets.

1. Lining Material: As directed, Cement or Copper.
2. Coating: As directed Epoxy resin, Galvanized, Glass or Nickel.

I. Insulation: Factory-installed fiberglass or polyurethane foam; surrounding entire tank except connections and other openings; suitable for tank operating temperature; and complying with ASHRAE/IESNA 90.1.

J. Jacket: Steel, with manufacturer's standard finish unless otherwise indicated.

2.5 SOURCE QUALITY CONTROL

A. Test and inspect potable-water storage tanks according to the following tests and inspections and prepare test reports:

1. Pressure Testing for ASME-Code, Potable-Water Storage Tanks: Hydrostatically test to ensure structural integrity and freedom from leaks. Fill tanks with water, vent air, pressurize to 1-1/2 times tank pressure rating, disconnect test equipment, hold pressure for 30 minutes with no drop-in pressure, and check for leaks.
2. Pressure Testing for Non-ASME-Code, Pressure, Potable-Water Storage Tanks: Hydrostatically test to ensure structural integrity and freedom from leaks at pressure of 50 psig (345 kPa) above system operating pressure, but not less than 150 psig (1035 kPa). Fill tanks with water, vent air, pressurize tanks, disconnect test equipment, hold pressure for two hours with no drop-in pressure, and check for leaks.
3. Testing for Non-pressure, Potable-Water Storage Tanks: Fill tanks to water operating level to ensure structural integrity and freedom from leaks. Hold water level for two hours with no drop-in water level.

B. Repair or replace tanks that fail test with new tanks and repeat until test is satisfactory.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install water storage tanks on concrete bases, level and plumb, firmly anchored. Arrange so devices needing servicing are accessible.

1. As directed, install horizontal tanks on concrete piers and factory-fabricated or fabricated steel supports and saddles.

B. Anchor tank supports and tanks to substrate.

C. Install tank seismic restraints.

D. Install thermometers and pressure gages on water storage tanks and piping if indicated. Thermometers and pressure gages are specified in Section 220519 "Meters and Gages for Plumbing Piping."

E. Install the following devices on tanks where indicated:

1. Pressure relief valves.
2. Temperature and pressure relief valves.
3. Vacuum relief valves.
4. Tank vents on non-pressure tanks.
5. Connections to accessories.

F. After installing tanks with factory finish, inspect finishes and repair damages to finishes.

3.2 CONNECTIONS

A. Piping installation requirements are specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to potable-water storage tanks to allow service and maintenance.

C. Connect water piping to water storage tanks with unions or flanges and with shutoff valves. Connect tank drains with shutoff valves and discharge over closest floor drains.

1. General-duty valves are specified in Section 220523.12 "Ball Valves for Plumbing Piping," Section 220523.13 "Butterfly Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping" as directed.

   a. Valves NPS 2 (DN 50) and Smaller: Gate or ball.
   b. Valves NPS 2-1/2 (DN 65) and Larger: Gate or butterfly.
   c. Drain Valves: NPS 3/4 (DN 20) gate or ball valve. Include outlet with, or nipple in outlet with, ASME B1.20.7, 3/4-11.5NH thread for garden-hose service, threaded cap, and chain.

2. Water Piping Connections: Make connections to dissimilar metals with dielectric fittings. Dielectric fittings are specified in Section 221116 "Domestic Water Piping."
3. Connect air piping to hydropneumatic tanks with unions or flanges and gate or ball valves. Make connections to dissimilar metals with dielectric fittings, which are specified in Section 221513 "General-Service Compressed-Air Piping."

3.3 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

A. Perform the following final checks before filling:

1. Verify that air pre-charge in pre-charged tanks is correct.
2. Test operation of tank accessories and devices.
3. Verify that pressure relief valves have correct setting.

    a. Manually operate pressure relief valves.
    b. Adjust pressure settings.

4. Verify that vacuum relief valves are correct size.

    a. Manually operate vacuum relief valves.
    b. Adjust vacuum settings.

B. Filling Procedures: Follow manufacturer's written procedures. Fill tanks with water to operating level.

3.5 CLEANING

A. Clean and disinfect potable-water storage tanks.

B. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed, use procedure described in AWWA C652 or as described below:

1. Purge water storage tanks with potable water.
2. Disinfect tanks by one of the following methods:

    a. Fill tanks with water-chlorine solution containing at least 50 ppm (50 mg/L) of chlorine. Isolate tanks and allow to stand for 24 hours.
    b. Fill tanks with water-chlorine solution containing at least 200 ppm (200 mg/L) of chlorine. Isolate tanks and allow to stand for three hours.

3. Flush tanks, after required standing time, with clean, potable water until chlorine is not present in water coming from tank.
4. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedure if biological examination made by authorities having jurisdiction shows evidence of contamination.

C. Prepare written reports for purging and disinfecting activities.

END OF SECTION 221223.11

SECTION 221313 - FACILITY SANITARY SEWERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Hub-and-spigot, cast-iron soil pipe and fittings.
2. Hubless cast-iron soil pipe and fittings.
3. Nonpressure-type transition couplings.
4. Pressure-type pipe couplings.
5. Expansion joints and deflection fittings.
6. Backwater valves.
7. Cleanouts.
8. Encasement for piping.
9. Manholes.
10. Concrete.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For manholes. Include plans, elevations, sections, details, and frames and covers.

PART 2 - PRODUCTS

2.1 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A74, Service and Extra-Heavy classes.

B. Gaskets: ASTM C564, rubber.

C. Calking Materials: ASTM B29, pure lead and oakum or hemp fiber.

2.2 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A888 or CISPI 301.

B. CISPI-Trademark, Shielded Couplings:

1. Description: ASTM C1277 and CISPI 310, with stainless-steel corrugated shield; stainless-steel bands and tightening devices; and ASTM C564, rubber sleeve with integral, center pipe stop.

C. Heavy-Duty, Shielded Couplings:

1. Description: ASTM C1277 and ASTM C1540, with stainless-steel shield; stainless-steel bands and tightening devices; and ASTM C564, rubber sleeve with integral, center pipe stop.

2.3 PVC PIPE AND FITTINGS

A. PVC Corrugated Sewer Piping:

1. Pipe: ASTM F949, PVC corrugated pipe with bell-and-spigot ends for gasketed joints.
2. Fittings: ASTM F949, PVC molded or fabricated, socket type.
3. Gaskets: ASTM F477, elastomeric seals.

B. PVC Type PSM Sewer Piping:

1. Pipe: ASTM D3034, SDR 35, PVC Type PSM sewer pipe with bell-and-spigot ends for gasketed joints.
2. Fittings: ASTM D3034, PVC with bell ends.
3. Gaskets: ASTM F477, elastomeric seals.

2.4 NONPRESSURE-TYPE TRANSITION COUPLINGS

A. Comply with ASTM C1173, elastomeric, sleeve-type, reducing or transition coupling; for joining underground non-pressure piping. Include ends of same sizes as piping to be joined and include corrosion-resistant-metal tension band and tightening mechanism on each end.

B. Sleeve Materials:

1. For Cast-Iron Soil Pipes: ASTM C564, rubber.
2. For Plastic Pipes: ASTM F477, elastomeric seal or ASTM D5926, PVC.
3. For Dissimilar Pipes: ASTM D5926, PVC or other material compatible with pipe materials being joined.

C. Unshielded, Flexible Couplings:

1. Description: Elastomeric sleeve with stainless-steel shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.

D. Ring-Type, Flexible Couplings:

1. Description: Elastomeric compression seal with dimensions to fit inside bell of larger pipe and for spigot of smaller pipe to fit inside ring.

E. Non-pressure-Type, Rigid Couplings:

1. Description: ASTM C1461, sleeve-type, reducing- or transition-type mechanical coupling; molded from ASTM C1440, TPE material; with corrosion-resistant-metal tension band and tightening mechanism on each end.

2.5 BACKWATER VALVES

A. Cast-Iron Backwater Valves:

1. Description: ASME A112.14.1, gray-iron body and bolted cover, with bronze seat.

2. Horizontal type; with swing check valve and hub-and-spigot ends.
3. Combination horizontal and manual gate-valve type; with swing check valve, integral gate valve, and hub-and-spigot ends.
4. Terminal type; with bronze seat, swing check valve, and hub inlet.

B. PVC Backwater Valves:

1. Description: Horizontal type; with PVC body, PVC removable cover, and PVC swing check valve.

2.6 CLEANOUTS

A. Cast-Iron Cleanouts:

1. Description: ASME A112.36.2M, round, gray-iron housing with clamping device and round, secured, scoriated, gray-iron cover. Include gray-iron ferrule with inside calk or spigot connection and countersunk, tapered-thread, brass closure plug.

2. Top-Loading Classification(s): Light Duty, Medium Duty, Heavy Duty and Extra-Heavy Duty.
3. Sewer Pipe Fitting and Riser to Cleanout: ASTM A74, Service class, cast-iron soil pipe and fittings.

2.7 ENCASEMENT FOR PIPING

A. Standard: ASTM A674 or AWWA C105/A21.5.

B. Material: Linear low-density polyethylene film of 0.008-inch (0.20-mm) or high-density, cross-laminated polyethylene film of 0.004-inch (0.10-mm) minimum thickness as directed.

C. Form: Sheet or tube.

D. Color: Black or natural.

2.8 MANHOLES

A. Standard Precast Concrete Manholes:

1. Description: ASTM C478 (ASTM C478M), precast, reinforced concrete, of depth indicated, with provision for sealant joints.
2. Diameter: 48 inches (1200 mm) minimum unless otherwise indicated.
3. Ballast: Increase thickness of precast concrete sections or add concrete to base section, as required to prevent flotation.

4. Base Section: 6-inch (150-mm) minimum thickness for floor slab and 4-inch (100-mm) minimum thickness for walls and base riser section; with separate base slab or base section with integral floor.
5. Riser Sections: 4-inch (100-mm) minimum thickness, of length to provide depth indicated.
6. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated; with top of cone of size that matches grade rings.
7. Joint Sealant: ASTM C990 (ASTM C990M), bitumen or butyl rubber.
8. Resilient Pipe Connectors: ASTM C923 (ASTM C923M), cast or fitted into manhole walls, for each pipe connection.
9. Steps: Individual FRP steps, FRP ladder, or ASTM A615/A615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D4101, PP; wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of manhole to finished grade is less than 60 inches (1500 mm).
10. Adjusting Rings: Interlocking HDPE rings, with level or sloped edge in thickness and diameter matching manhole frame and cover, and with height as required to adjust manhole frame and cover to indicated elevation and slope. Include sealant recommended by ring manufacturer.
11. Grade Rings: Reinforced-concrete rings, 6- to 9-inch (150- to 225-mm) total thickness, with diameter matching manhole frame and cover, and with height as required to adjust manhole frame and cover to indicated elevation and slope.

B. Manhole Frames and Covers:

1. Description: Ferrous; 24-inch (610-mm) ID by 7- to 9-inch (175- to 225-mm) riser, with 4-inch (100-mm) minimum-width flange and 26-inch (660-mm) diameter cover. Include indented top design with lettering cast into cover, using wording equivalent to "SANITARY SEWER."
2. Material: ASTM A536, Grade 60-40-18 ductile or ASTM A48/A48M, Class 35 gray iron unless otherwise indicated.

2.9 CONCRETE

A. General: Cast-in-place concrete complying with ACI 318, ACI 350 (ACI 350M), and the following:

1. Cement: ASTM C150/C150M, Type II.
2. Fine Aggregate: ASTM C33/C33M, sand.
3. Coarse Aggregate: ASTM C33/C33M, crushed gravel.
4. Water: Potable.

B. Portland Cement Design Mix: 4000 psi (27.6 MPa) minimum, with 0.45 maximum water/cementitious materials ratio.

1. Reinforcing Fabric: ASTM A1064/A1064M, steel, welded wire fabric, plain.
2. Reinforcing Bars: ASTM A615/A615M, Grade 60 (420-MPa) deformed steel.

C. Manhole Channels and Benches: Factory or field formed from concrete. Portland cement design mix, 4000 psi (27.6 MPa) minimum, with 0.45 maximum water/cementitious materials ratio. Include channels and benches in manholes.

1. Channels: Concrete invert, formed to same width as connected piping, with height of vertical sides to three-fourths of pipe diameter. Form curved channels with smooth, uniform radius and slope.

a. Invert Slope: 2 percent through manhole.

2. Benches: Concrete, sloped to drain into channel.

a. Slope: 4 percent.

D. Ballast and Pipe Supports: Portland cement design mix, 3000 psi (20.7 MPa) minimum, with 0.58 maximum water/cementitious materials ratio.

1. Reinforcing Fabric: ASTM A1064/A1064M, steel, welded wire fabric, plain.
2. Reinforcing Bars: ASTM A615/A615M, Grade 60 (420-MPa) deformed steel.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavating, trenching, and backfilling are specified in Section 312000 "Earth Moving."

3.2 PIPING INSTALLATION

A. General Locations and Arrangements: Drawing plans and details to indicate general location and arrangement of underground sanitary sewer piping. Location and arrangement of piping layout take into account design considerations. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.

B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for using lubricants, cements, and other installation requirements.

C. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.

D. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.

E. When installing pipe under streets or other obstructions that cannot be disturbed, use pipe-jacking process of microtunneling.

F. Install gravity-flow, non-pressure, drainage piping according to the following:

1. Install piping pitched down in direction of flow, at minimum slope of 2 percent unless otherwise indicated.
2. Install piping NPS 6 (DN 150) and larger with restrained joints at tee fittings and at changes in direction. Use corrosion-resistant rods, pipe or fitting manufacturer's proprietary restraint system, or cast-in-place-concrete supports or anchors.
3. Install piping with 48-inch (1220-mm) minimum cover or as directed.
4. Install hub-and-spigot, cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook."
5. Install hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook."
6. Install PVC corrugated sewer piping according to ASTM D2321 and ASTM F1668.
7. Install PVC Type PSM sewer piping according to ASTM D2321 and ASTM F1668.

G. Install corrosion-protection piping encasement over the following underground metal piping according to ASTM A674 or AWWA C105/A21.5:

1. Hub-and-spigot, cast-iron soil pipe.
2. Hubless cast-iron soil pipe and fittings.
3. Expansion joints and deflection fittings.

H. Clear interior of piping and manholes of dirt and superfluous material as work progresses. Maintain swab or drag in piping and pull past each joint as it is completed. Place plug in end of incomplete piping at end of day and when work stops.

3.3 PIPE JOINT CONSTRUCTION

A. Join gravity-flow, non-pressure, drainage piping according to the following:

1. Join hub-and-spigot, cast-iron soil piping with gasket joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
2. Join hub-and-spigot, cast-iron soil piping with calked joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead and oakum calked joints.
3. Join hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.
4. Join PVC corrugated sewer piping according to ASTM D2321.
5. Join PVC Type PSM sewer piping according to ASTM D2321 and ASTM D3034 for elastomeric-seal joints or ASTM D3034 for elastomeric-gasket joints.
6. Join dissimilar pipe materials with non-pressure-type, flexible or rigid couplings as directed.

B. Pipe couplings, expansion joints, and deflection fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

1. Use non-pressure flexible couplings where required to join gravity-flow, non-pressure sewer piping unless otherwise indicated.

a. Unshielded flexible or rigid couplings for pipes of same or slightly different OD .
b. Unshielded, increaser/reducer-pattern, flexible or rigid couplings for pipes with different OD.

c. Ring-type flexible couplings for piping of different sizes where annular space between smaller piping's OD and larger piping's ID permits installation.

3.4 MANHOLE INSTALLATION

A. General: Install manholes complete with appurtenances and accessories indicated.

B. Install precast concrete manhole sections with sealants according to ASTM C891.

C. Form continuous concrete channels and benches between inlets and outlet.

D. Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops 3 inches (76 mm) above finished surface elsewhere unless otherwise indicated.

3.5 CONCRETE PLACEMENT

A. Place cast-in-place concrete according to ACI 318.

3.6 BACKWATER VALVE INSTALLATION

A. Install horizontal-type backwater valves in piping manholes or pits.

B. Install combination horizontal and manual gate-type valves in piping and in manholes.

C. Install terminal-type backwater valves on end of piping and in manholes. Secure units to sidewalls.

3.7 CLEANOUT INSTALLATION

A. Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts and use cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.

1. Use Light-Duty, top-loading classification cleanouts in earth or unpaved foot-traffic areas.
2. Use Medium-Duty, top-loading classification cleanouts in paved foot-traffic areas.
3. Use Heavy-Duty, top-loading classification cleanouts in vehicle-traffic service areas.
4. Use Extra-Heavy-Duty, top-loading classification cleanouts in roads.

B. Set cleanout frames and covers in earth in cast-in-place-concrete block, 18 by 18 by 12 inches (450 by 450 by 300 mm) deep. Set with tops 1 inch (25 mm) above surrounding grade.

C. Set cleanout frames and covers in concrete pavement and roads with tops flush with pavement surface.

3.8 CONNECTIONS

A. Connect non-pressure, gravity-flow drainage piping to building's sanitary building drains specified in Section 221316 "Sanitary Waste and Vent Piping."

B. Make connections to existing piping and underground manholes.

1. Use commercially manufactured wye fittings for piping branch connections. Remove section of existing pipe, install wye fitting into existing piping, and encase entire wye fitting plus 6-inch (150-mm) overlap with not less than 6 inches (150 mm) of concrete with 28-day compressive strength of 3000 psi (20.7 MPa).
2. Make branch connections from side into existing piping, NPS 4 to NPS 20 (DN 100 to DN 500). Remove section of existing pipe, install wye fitting into existing piping, and encase entire wye with not less than 6 inches (150 mm) of concrete with 28-day compressive strength of 3000 psi (20.7 MPa).
3. Make branch connections from side into existing piping, NPS 21 (DN 525) or larger, or to underground manholes by cutting opening into existing unit large enough to allow 3 inches (76 mm) of concrete to be packed around entering connection. Cut end of connection pipe passing through pipe or structure wall to conform to shape of, and be flush with, inside wall unless otherwise indicated. On outside of pipe or manhole wall, encase entering connection in 6 inches (150 mm) of concrete for minimum length of 12 inches (300 mm) to provide additional support of collar from connection to undisturbed ground.

    a. Use concrete that will attain a minimum 28-day compressive strength of 3000 psi (20.7 MPa) unless otherwise indicated.
    b. Use epoxy-bonding compound as interface between new and existing concrete and piping materials.

4. Protect existing piping and manholes to prevent concrete or debris from entering while making tap connections. Remove debris or other extraneous material that may accumulate.

C. Connect to grease, oil and sand interceptors as directed

3.9 CLOSING ABANDONED SANITARY SEWER SYSTEMS

A. Abandoned Piping: Close open ends of abandoned underground piping indicated to remain in place. Include closures strong enough to withstand hydrostatic and earth pressures that may result after ends of abandoned piping have been closed. Use either procedure below:

1. Close open ends of piping with at least 8-inch (203-mm) thick, brick masonry bulkheads.
2. Close open ends of piping with threaded metal caps, plastic plugs, or other acceptable methods suitable for size and type of material being closed. Do not use wood plugs.

B. Abandoned Manholes: Excavate around manhole as required and use either procedure below:

1. Remove manhole and close open ends of remaining piping.

2. Remove top of manhole down to at least 36 inches (915 mm) below final grade. Fill to within 12 inches (300 mm) of top with stone, rubble, gravel, or compacted dirt. Fill to top with concrete.

C. Backfill to grade according to Section 312000 "Earth Moving."

3.10 IDENTIFICATION

A. Comply with requirements in Section 312000 "Earth Moving" for underground utility identification devices. Arrange for installation of green warning tapes directly over piping and at outside edges of underground manholes.

1. Use warning tape or detectable warning tape over ferrous piping.
2. Use detectable warning tape over nonferrous piping and over edges of underground manholes.

3.11 FIELD QUALITY CONTROL

A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches (600 mm) of backfill is in place, and again at completion of Project.

1. Submit separate report for each system inspection.
2. Defects requiring correction include the following:

    a. Alignment: Less than full diameter of inside of pipe is visible between structures.
    b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
    c. Damage: Crushed, broken, cracked, or otherwise damaged piping.
    d. Infiltration: Water leakage into piping.
    e. Exfiltration: Water leakage from or around piping.

3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
4. Reinspect and repeat procedure until results are satisfactory.

B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.

1. Do not enclose, cover, or put into service before inspection and approval.
2. Test completed piping systems according to requirements of authorities having jurisdiction.
3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
4. Submit separate report for each test.
5. Hydrostatic Tests: Test sanitary sewerage according to requirements of authorities having jurisdiction and the following:

a. Fill sewer piping with water. Test with pressure of at least 10-foot (3-m) head of water and maintain such pressure without leakage for at least 15 minutes.
b. Close openings in system and fill with water.
c. Purge air and refill with water.
d. Disconnect water supply.
e. Test and inspect joints for leaks.

6. Manholes: Perform hydraulic test according to ASTM C969 (ASTM C969M).

C. Leaks and loss in test pressure constitute defects that must be repaired.

D. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

END OF SECTION 221313

SECTION 221316 - SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Hub-and-spigot, cast-iron soil pipe and fittings.
2. Copper tube and fittings.
3. ABS pipe and fittings.
4. PVC pipe and fittings.
5. Specialty pipe fittings.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 WARRANTY

A. Listed manufacturers to provide labelling and warranty of their respective products.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:

1. Soil, Waste, and Vent Piping: 10-foot head of water (30 kPa).

B. Seismic Performance: Soil, waste, and vent piping and support and installation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

2.2 PIPING MATERIALS

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.3 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A74, Service class.

B. Gaskets: ASTM C564, rubber.

C. Calking Materials: ASTM B29, pure lead and oakum or hemp fiber.

2.4 COPPER TUBE AND FITTINGS

A. Copper Type DWV Tube: ASTM B306, drainage tube, drawn temper.

B. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.

C. Copper Pressure Fittings:

1. Copper Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
2. Copper Unions: MSS SP-123, copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

D. Copper Flanges: ASME B16.24, Class 150, cast copper with solder-joint end.

1. Flange Gasket Materials: ASME B16.21, full-face, flat, nonmetallic, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.
2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

E. Solder: ASTM B32, lead free with ASTM B813, water-flushable flux.

2.5 ABS PIPE AND FITTINGS

A. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-dwv" for plastic drain, waste, and vent piping and "NSF-sewer" for plastic sewer piping.

B. Solid-Wall ABS Pipe: ASTM D2661, Schedule 40.

C. Cellular-Core ABS Pipe: ASTM F628, Schedule 40.

D. ABS Socket Fittings: ASTM D2661, made to ASTM D3311, drain, waste, and vent patterns.

E. Solvent Cement: ASTM D2235.

2.6 PVC PIPE AND FITTINGS

A. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-dwv" for plastic drain, waste, and vent piping and "NSF-sewer" for plastic sewer piping.

B. Solid-Wall PVC Pipe: ASTM D2665, drain, waste, and vent.

C. Cellular-Core PVC Pipe: ASTM F891, Schedule 40.

D. PVC Socket Fittings: ASTM D2665, made to ASTM D3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.

E. Adhesive Primer: ASTM F656.

F. Solvent Cement: ASTM D2564.

2.7 SPECIALTY PIPE FITTINGS

A. Transition Couplings:

1. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
2. Unshielded, Non-pressure Transition Couplings:
   a. Standard: ASTM C1173.
   b. Description: Elastomeric, sleeve-type, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
   c. End Connections: Same size as and compatible with pipes to be joined.
   d. Sleeve Materials:

      1) For Cast-Iron Soil Pipes: ASTM C564, rubber.
      2) For Plastic Pipes: ASTM F477, elastomeric seal or ASTM D5926, PVC.
      3) For Dissimilar Pipes: ASTM D5926, PVC or other material compatible with pipe materials being joined.

3. Shielded, Non-pressure Transition Couplings:
   a. Standard: ASTM C1460.
   b. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
   c. End Connections: Same size as and compatible with pipes to be joined.

PART 3 - EXECUTION

3.1 EARTH MOVING

A. Comply with requirements for excavating, trenching, and backfilling specified in Section 312000 "Earth Moving."

3.2 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems.

1. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations.
2. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

K. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends.

1. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical.
2. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back to back or side by side with common drain pipe.

    a. Straight tees, elbows, and crosses may be used on vent lines.

3. Do not change direction of flow more than 90 degrees.
4. Use proper size of standard increasers and reducers if pipes of different sizes are connected.

    a. Reducing size of waste piping in direction of flow is prohibited.

L. Lay buried building waste piping beginning at low point of each system.

1. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream.
2. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
3. Maintain swab in piping and pull past each joint as completed.

M. Install soil and waste and vent piping at the following minimum slopes unless otherwise indicated:

1. Building Sanitary Waste: 2 percent downward in direction of flow for piping NPS 3 (DN 80) and smaller; 2 percent downward in direction of flow for piping NPS 4 (DN 100) and larger.
2. Horizontal Sanitary Waste Piping: 2 percent downward in direction of flow.
3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.

N. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

O. Install aboveground copper tubing according to CDA's "Copper Tube Handbook."

P. Install aboveground ABS piping according to ASTM D2661.

Q. Install aboveground PVC piping according to ASTM D2665.

R. Install underground ABS and PVC piping according to ASTM D2321.

S. Plumbing Specialties:

1. Install backwater valves in sanitary waster gravity-flow piping.

    a. Comply with requirements for backwater valves specified in Section 221319 "Sanitary Waste Piping Specialties."

2. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary waste gravity-flow piping.

    a. Comply with requirements for cleanouts specified in Section 221319 "Sanitary Waste Piping Specialties."

3. Install drains in sanitary waste gravity-flow piping.

    a. Comply with requirements for drains specified in Section 221319 "Sanitary Waste Piping Specialties."

T. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

U. Install sleeves for piping penetrations of walls, ceilings, and floors.

1. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

V. Install sleeve seals for piping penetrations of concrete walls and slabs.

1. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

W. Install escutcheons for piping penetrations of walls, ceilings, and floors.

1. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

A. Join hub-and-spigot, cast-iron soil piping with gasket joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.

B. Join copper tube and fittings with soldered joints according to ASTM B828. Use ASTM B813, water-flushable, lead-free flux and ASTM B32, lead-free-alloy solder.

C. Grooved Joints: Cut groove ends of pipe according to AWWA C606. Lubricate and install gasket over ends of pipes or pipe and fitting. Install coupling housing sections, over gasket, with keys seated in piping grooves. Install and tighten housing bolts.

D. Plastic, Non-pressure-Piping, Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements.
2. ABS Piping: Join according to ASTM D2235 and ASTM D2661 appendixes.
3. PVC Piping: Join according to ASTM D2855 and ASTM D2665 appendixes.

3.4 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:

1. Install transition couplings at joints of piping with small differences in ODs.
2. In Waste Drainage Piping: Unshielded or Shielded, non-pressure transition couplings as directed.

3.5 VALVE INSTALLATION

A. Comply with requirements in Section 220523.12 "Ball Valves for Plumbing Piping," Section 220523.13 "Butterfly Valves for Plumbing Piping," Section 220523.14 "Check Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping" for general-duty valve installation requirements.

B. Shutoff Valves:

1. Install shutoff valve on each sewage pump discharge.
2. Install gate or full-port ball valve for piping NPS 2 (DN 50) and smaller.
3. Install gate valve for piping NPS 2-1/2 (DN 65) and larger.

C. Check Valves: Install swing check valve, between pump and shutoff valve, on each sewage pump discharge.

D. Backwater Valves: Install backwater valves in piping subject to backflow.

1. Horizontal Piping: Horizontal backwater valves. Use normally closed type unless otherwise indicated.
2. Floor Drains: Drain outlet backwater valves unless drain has integral backwater valve.
3. Install backwater valves in accessible locations.
4. Comply with requirements for backwater valve specified in Section 221319 "Sanitary Waste Piping Specialties."

3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for pipe hanger and support devices as directed.

1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
2. Install stainless-steel or fiberglass pipe hangers for horizontal piping in corrosive environments.
3. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
4. Install stainless-steel pipe support clamps for vertical piping in corrosive environments.
5. Vertical Piping: MSS Type 8 or Type 42, clamps.
6. Install individual, straight, horizontal piping runs:

    a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
    b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
    c. Longer Than 100 Feet (30 m) if Indicated: MSS Type 49, spring cushion rolls.

7. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
8. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Support horizontal piping and tubing within 12 inches (300 mm) of each fitting, valve, and coupling.

D. Support vertical piping and tubing at base and at each floor.

E. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
2. NPS 3 (DN 80): 60 inches (1500 mm) with 1/2-inch (13-mm) rod.
3. NPS 4 and NPS 5 (DN 100 and DN 125): 60 inches (1500 mm) with 5/8-inch (16-mm) rod.
4. NPS 6 and NPS 8 (DN 150 and DN 200): 60 inches (1500 mm) with 3/4-inch (19-mm) rod.
5. NPS 10 and NPS 12 (DN 250 and DN 300): 60 inches (1500 mm) with 7/8-inch (22-mm) rod.

6. Spacing for 10-foot (3-m) lengths may be increased to 10 feet (3 m). Spacing for fittings is limited to 60 inches (1500 mm).

G. Install supports for vertical cast-iron soil piping every 15 feet (4.5 m).

H. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4 (DN 32): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
2. NPS 1-1/2 (DN 40): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
3. NPS 2 (DN 50): 10 feet (3 m) with 3/8-inch (10-mm) rod.
4. NPS 2-1/2 (DN 65): 11 feet (3.4 m) with 1/2-inch (13-mm) rod.
5. NPS 3 (DN 80): 12 feet (3.7 m) with 1/2-inch (13-mm) rod.
6. NPS 4 and NPS 5 (DN 100 and DN 125): 12 feet (3.7 m) with 5/8-inch (16-mm) rod.
7. NPS 6 and NPS 8 (DN 150 and DN 200): 12 feet (3.7 m) with 3/4-inch (19-mm) rod.
8. NPS 10 and NPS 12 (DN 250 and DN 300): 12 feet (3.7 m) with 7/8-inch (22-mm) rod.

I. Install supports for vertical steel piping every 15 feet (4.5 m).

J. Install hangers for stainless-steel piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 2 (DN 50): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
2. NPS 3 (DN 80): 96 inches (2400 mm) with 1/2-inch (13-mm) rod.
3. NPS 4 (DN 100): 108 inches (2700 mm) with 1/2-inch (13-mm) rod.
4. NPS 6 (DN 150): 10 feet (3 m) with 5/8-inch (16-mm) rod.

K. Install supports for vertical stainless-steel piping every 10 feet (3 m).

L. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4 (DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
2. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
3. NPS 2-1/2 (DN 65): 108 inches (2700 mm) with 1/2-inch (13-mm) rod.
4. NPS 3 and NPS 5 (DN 80 and DN 125): 10 feet (3 m) with 1/2-inch (13-mm) rod.
5. NPS 6 (DN 150): 10 feet (3 m) with 5/8-inch (16-mm) rod.
6. NPS 8 (DN 200): 10 feet (3 m) with 3/4-inch (19-mm) rod.

M. Install supports for vertical copper tubing every 10 feet (3 m).

N. Install hangers for ABS and PVC piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 48 inches (1200 mm) with 3/8-inch (10-mm) rod.
2. NPS 3 (DN 80): 48 inches (1200 mm) with 1/2-inch (13-mm) rod.
3. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1200 mm) with 5/8-inch (16-mm) rod.

4. NPS 6 and NPS 8 (DN 150 and DN 200): 48 inches (1200 mm) with 3/4-inch (19-mm) rod.
5. NPS 10 and NPS 12 (DN 250 and DN 300): 48 inches (1200 mm) with 7/8-inch (22-mm) rod.

O. Install supports for vertical ABS and PVC piping every 48 inches (1200 mm).

P. Support piping and tubing not listed above according to MSS SP-58 and manufacturer's written instructions.

3.7 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

C. Connect waste and vent piping to the following:

1. Plumbing Fixtures: Connect waste piping in sizes indicated, but not smaller than required by plumbing code.
2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
3. Plumbing Specialties: Connect waste and vent piping in sizes indicated, but not smaller than required by plumbing code.
4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
5. Install horizontal backwater valves with cleanout cover flush with floor.
6. Comply with requirements for backwater valves, cleanouts and drains as directed
7. Equipment: Connect waste piping as indicated.

    a. Provide shutoff valve if indicated and union for each connection.
    b. Use flanges instead of unions for connections NPS 2-1/2 (DN 65) and larger.

D. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

E. Make connections according to the following unless otherwise indicated:

1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.8 IDENTIFICATION

A. Identify exposed sanitary waste and vent piping.

B. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.9 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary waste and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired.

    a. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.

2. Leave uncovered and unconcealed new, altered, extended, or replaced waste and vent piping until it has been tested and approved.

    a. Expose work that was covered or concealed before it was tested.

3. Roughing-in Plumbing Test Procedure: Test waste and vent piping except outside leaders on completion of roughing-in.

    a. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water (30 kPa).
    b. From 15 minutes before inspection starts to completion of inspection, water level must not drop.
    c. Inspect joints for leaks.

4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight.

    a. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg (250 Pa).
    b. Use U-tube or manometer inserted in trap of water closet to measure this pressure.
    c. Air pressure must remain constant without introducing additional air throughout period of inspection.
    d. Inspect plumbing fixture connections for gas and water leaks.

5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.

6. Prepare reports for tests and required corrective action.

3.10 CLEANING AND PROTECTION

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect sanitary waste and vent piping during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

D. Exposed ABS and PVC Piping: Protect plumbing vents exposed to sunlight with two coats of water-based latex paint.

E. Repair damage to adjacent materials caused by waste and vent piping installation.

3.11 PIPING SCHEDULE

A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.

B. Aboveground, soil and waste piping NPS 4 (DN 100) and smaller shall be any of the following:

1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Copper Type DWV tube, copper drainage fittings, and soldered joints.
3. Solid-wall or Cellular-core ABS pipe, ABS socket fittings, and solvent-cemented joints.
4. Solid-wall or Cellular-core PVC pipe, PVC socket fittings, and solvent-cemented joints.
5. Dissimilar Pipe-Material Couplings: Unshielded or Shielded, non-pressure transition couplings as directed.

C. Aboveground, soil and waste piping NPS 5 (DN 125) and larger shall be any of the following:

1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Solid-wall or Cellular-core PVC pipe, PVC socket fittings, and solvent-cemented joints.
3. Dissimilar Pipe-Material Couplings: Unshielded or Shielded, non-pressure transition couplings as directed.

D. Aboveground, vent piping NPS 4 (DN 100) and smaller shall be any of the following:

1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Copper Type DWV tube, copper drainage fittings, and soldered joints.

    a. Option for Vent Piping, NPS 2-1/2 and NPS 3-1/2 (DN 65 and DN 90): Hard copper tube, Type M (Type C); copper pressure fittings; and soldered joints.

3. Solid-wall or Cellular-core ABS pipe, ABS socket fittings, and solvent-cemented joints.
4. Solid-wall or Cellular-core PVC pipe, PVC socket fittings, and solvent-cemented joints.
5. Dissimilar Pipe-Material Couplings: Unshielded or Shielded, non-pressure transition couplings as directed.

E. Aboveground, vent piping NPS 5 (DN 125) and larger shall be any of the following:

1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Dissimilar Pipe-Material Couplings: Unshielded or Shielded, non-pressure transition couplings as directed.

F. Underground, soil, waste, and vent piping NPS 4 (DN 100) and smaller shall be any of the following:

1. Service class, cast-iron soil piping; gaskets; and gasketed joints.
2. Solid wall or Cellular-core ABS pipe, ABS socket fittings, and solvent-cemented joints.
3. Solid wall or Cellular-core PVC pipe, PVC socket fittings, and solvent-cemented joints.
4. Dissimilar Pipe-Material Couplings: Unshielded or Shielded, non-pressure transition couplings as directed.

G. Underground, soil and waste piping NPS 5 (DN 125) and larger shall be any of the following:

1. Service class, cast-iron soil piping; gaskets; and gasketed joints.
2. Solid-wall or Cellular-core PVC pipe; PVC socket fittings; and solvent-cemented joints.
3. Dissimilar Pipe-Material Couplings: Unshielded or Shielded, non-pressure transition couplings as directed.

END OF SECTION 221316

SECTION 221319 - SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Backwater valves.
2. Cleanouts.
3. Roof flashing assemblies.
4. Miscellaneous sanitary drainage piping specialties.

1.2 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene.

B. PVC: Polyvinyl chloride.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTIONS

A. Sanitary waste piping specialties shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF 14 for plastic sanitary waste piping specialty components.

2.2 BACKWATER VALVES

A. Horizontal, Cast-Iron Backwater Valves
1. Standard: ASME A112.14.1.
2. Size: Same as connected piping.
3. Body: Cast iron.
4. Cover: Cast iron with bolted or threaded access check valve.

5. End Connections: Hub and spigot or hubless, as directed.
6. Type Check Valve: Removable, bronze, swing check, factory assembled or field modified to hang closed or open for airflow unless subject to backflow condition as directed.
7. Extension: ASTM A74, Service class; full-size, cast-iron, soil-pipe extension to field-installed cleanout at floor; replaces backwater valve cover.

B. Horizontal, Plastic Backwater
1. Size: Same as connected piping.
2. Body: ABS or PVC, as directed.
3. Cover: Same material as body with threaded access to check valve.
4. Check Valve: Removable swing check.
5. End Connections: Socket type.

2.3 CLEANOUTS

A. Cast-Iron Exposed Cleanouts
1. Standard: ASME A112.36.2M for cast iron for cleanout test tee.
2. Size: Same as connected drainage piping
3. Body Material: Hub-and-spigot, cast-iron soil pipe T-branch or Hubless, cast-iron soil pipe test tee as required to match connected piping.
4. Closure: Countersunk or raised-head plug.
5. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
6. Closure: Stainless-steel plug with seal.

B. Cast-Iron Exposed Floor Cleanouts Retain first 12 subparagraphs below for cast-iron or stainless-steel cleanouts complying with ASME A112.36.2M.
1. Standard: ASME A112.36.2M for adjustable housing, cast-iron soil pipe with cast-iron ferrule, heavy-duty, adjustable housing or threaded, adjustable housing cleanout as directed.
2. Size: Same as connected branch.
3. Type: Adjustable housing, Cast-iron soil pipe with cast-iron ferrule, Heavy-duty, adjustable housing or Threaded, adjustable housing as directed.
4. Body or Ferrule: Cast iron.
5. Clamping Device: Required as directed.
6. Outlet Connection: Inside calk, Spigot or Threaded as directed.
7. Closure: Brass plug with straight threads and gasket or Brass plug with tapered threads, as directed.
8. Adjustable Housing Material: Cast iron or Plastic with threads or setscrews or other devices, as directed.
9. Frame and Cover Material and Finish: as directed.
10. Frame and Cover Shape: Round or Square as directed.
11. Top Loading Classification: As directed.
12. Riser: ASTM A74, Extra-Heavy or Service class as directed, cast-iron drainage pipe fitting and riser to cleanout.

C. Cast-Iron Wall Cleanouts
1. Standard: ASME A112.36.2M. Include wall access.
2. Size: Same as connected drainage piping.

3. Body: Hub-and-spigot, cast-iron soil pipe T-branch or Hubless, cast-iron soil pipe test tee as required to match connected piping.
4. Closure Plug:

    a. Brass or Cast iron, as directed.
    b. Countersunk or raised head, as directed.
    c. Drilled and threaded for cover attachment screw.
    d. Size: Same as or not more than one size smaller than cleanout size.

5. Wall Access: Round, deep, chrome-plated bronze or flat, chrome-plated brass or stainless-steel cover plate with screw, as directed.
6. Wall Access: Round or Square, nickel-bronze, copper-alloy, or stainless-steel wall-installation frame and cover, as directed.

D. Plastic Floor
1. Size: Same as connected branch.
2. Body: PVC.
3. Closure Plug: PVC.
4. Riser: Drainage pipe fitting and riser to cleanout of same material as drainage piping.

2.4 ROOF FLASHING ASSEMBLIES

A. Roof Flashing Assemblies
1. Description: Manufactured assembly made of 4.0-lb/sq. ft. (20-kg/sq. m), 0.0625-inch (1.6-mm) or 6.0-lb/sq. ft. (30-kg/sq. m), 0.0938-inch (2.4-mm) thick, lead flashing collar and skirt extending at least 6 inches (150 mm) from pipe, with galvanized-steel boot reinforcement and counterflashing fitting, as directed.

    a. Open-Top Vent Cap: Without cap.
    b. Low-Silhouette Vent Cap: With vandal-proof vent cap.
    c. Extended Vent Cap: With field-installed, vandal-proof vent cap.

2.5 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Open Drains

1. Description: Shop or field fabricate from ASTM A74, Service class, hub-and-spigot, cast-iron soil-pipe fittings. Include P-trap, hub-and-spigot riser section; and where required, increaser fitting joined with ASTM C564 rubber gaskets.
2. Size: Same as connected waste piping with increaser fitting of size indicated.

B. Deep-Seal Traps

1. Description: Cast-iron or bronze casting, with inlet and outlet matching connected piping and cleanout trap-seal primer valve connection.
2. Size: Same as connected waste piping.

    a. NPS 2 (DN 50): 4-inch (100-mm) minimum water seal.
    b. NPS 2-1/2 (DN 65) and Larger: 5-inch (125-mm) minimum water seal.

C. Floor-Drain, Trap-Seal Primer Fittings

1. Description: Cast iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
2. Size: Same as floor drain outlet with NPS 1/2 (DN 15) side inlet.

D. Air-Gap Fittings

1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.
2. Body: Bronze or cast iron.
3. Inlet: Opening in top of body.
4. Outlet: Larger than inlet.
5. Size: Same as connected waste piping and with inlet large enough for associated indirect waste piping.

E. Sleeve Flashing Device

1. Description: Manufactured, cast-iron fitting, with clamping device that forms sleeve for pipe floor penetrations of floor membrane. Include galvanized-steel pipe extension in top of fitting that will extend 1 inch (25 mm) or 2 inches (51 mm) above finished floor and galvanized-steel pipe extension in bottom of fitting that will extend through floor slab.
2. Size: As required for close fit to riser or stack piping as directed.

F. Stack Flashing Fittings

1. Description: Counterflashing-type, cast-iron fitting, with bottom recess for terminating roof membrane, and with threaded or hub top for extending vent pipe.
2. Size: Same as connected stack vent or vent stack.

G. Vent Caps

1. Description: Cast-iron body with threaded or hub inlet and vandal-proof design. Include vented hood and setscrews to secure to vent pipe.
2. Size: Same as connected stack vent or vent stack.

H. Expansion Joints

1. Standard: ASME A112.6.4.
2. Body: Cast iron with bronze sleeve, packing, and gland.
3. End Connections: Matching connected piping.
4. Size: Same as connected soil, waste, or vent piping.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install backwater valves in building drain piping.

1. For interior installation, provide cleanout deck plate flush with floor and centered over backwater valve cover, and of adequate size to remove valve cover for servicing.

B. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:

1. Size same as drainage piping up to NPS 4 (DN 100). Use NPS 4 (DN 100) for larger drainage piping unless larger cleanout is indicated.
2. Locate at each change in direction of piping greater than 45 degrees.
3. Locate at minimum intervals of 50 feet (15 m) for piping NPS 4 (DN 100) and smaller and 100 feet (30 m) for larger piping.
4. Locate at base of each vertical soil and waste stack.

C. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

E. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof. Comply with requirements in Section 076200, Sheet Metal Flashing and Trim.

F. Install flashing fittings on sanitary stack vents and vent stacks that extend through roof. Comply with requirements in Section 076200, Sheet Metal Flashing and Trim.

G. Assemble open drain fittings and install with top of hub 1 inch (25 mm) or 2 inches (51 mm) above floor as directed.

H. Install deep-seal traps on floor drains and other waste outlets, if indicated.

I. Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.

1. Exception: Fitting may be omitted if trap has trap-seal primer connection.
2. Size: Same as floor drain inlet.

J. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.

K. Install sleeve and sleeve seals with each riser and stack passing through floors with waterproof membrane.

L. Install vent caps on each vent pipe passing through roof.

M. Install expansion joints on vertical stacks and conductors. Position expansion joints for easy access and maintenance.

N. Install wood-blocking reinforcement for wall-mounting-type specialties.

O. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

3.2 CONNECTIONS

A. Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FLASHING INSTALLATION

A. Comply with requirements in Section 076200 "Sheet Metal Flashing and Trim."

B. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required.

C. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.

1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches (250 mm), and skirt or flange extending at least 8 inches (200 mm) around pipe.
2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches (200 mm) around sleeve.
3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches (200 mm) around specialty.

D. Set flashing on floors and roofs in solid coating of bituminous cement.

E. Secure flashing into sleeve and specialty clamping ring or device.

F. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings, according to Section 076200 "Sheet Metal Flashing and Trim."

G. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.

3.4 LABELING AND IDENTIFYING

A. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit.

1. Nameplates and signs are specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.5 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 221319

SECTION 221319.13 - SANITARY DRAINS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Floor drains.
2. Floor sinks.
3. Trench drains.

1.2 DEFINITIONS

A. ABS: Acrylonitrile-butadiene styrene.

B. FRP: Fiberglass-reinforced plastic.

C. HDPE: High-density polyethylene.

D. PE: Polyethylene.

E. PP: Polypropylene.

F. PVC: Polyvinyl chloride.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 DRAIN ASSEMBLIES

A. Sanitary drains shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF 14 for plastic sanitary piping specialty components.

2.2 FLOOR DRAINS

A. Cast-Iron Floor Drains
1. Standard: ASME A112.6.3 with backwater valve.
2. Pattern: Area, Floor, Funnel floor or Sanitary drain.
3. Body Material: Gray iron.

4. Seepage Flange: Required.
5. Anchor Flange: Required.
6. Clamping Device: Required.
7. Outlet: Bottom or Side as directed.
8. Backwater Valve: Drain-outlet type or Integral, ASME A112.14.1, swing-check type as directed.
9. Coating on Interior and Exposed Exterior Surfaces: Acid-resistant enamel as directed.
10. Sediment Bucket: As directed.
11. Top or Strainer Material: Bronze, Gray iron, Nickel bronze or Stainless steel as directed.
12. Top of Body and Strainer Finish: Nickel bronze, Polished bronze, Rough bronze or Stainless steel, as directed.
13. Top Shape: Round or Square, as directed.
14. Dimensions of Top or Strainer: As directed
15. Top Loading Classification: Heavy Duty or Medium Duty As directed.
16. Funnel: Required As directed.
17. Inlet Fitting: Gray iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection, as directed.
18. Trap Material: Bronze, Cast iron or Copper, as directed.
19. Trap Pattern: Standard P-trap, as directed.
20. Trap Features: As directed.

B. Plastic Floor Drains
1. Standard: ASME A112.6.3.
2. Material: ABS or PVC, as directed.
3. Seepage Flange: As directed.
4. Clamping Device: As directed
5. Outlet: Bottom or Side, as directed.
6. Sediment Bucket: As directed.
7. Top or Strainer Material: Bronze, Plastic or Stainless steel, as directed.
8. Top of Body and Strainer Finish: As directed.
9. Top Shape: Round or Square As directed.
10. Dimensions of Top or Strainer: As directed.
11. Trap Material: As directed.
12. Trap Pattern: As directed.

2.3 FLOOR SINKS

A. Cast-Iron Floor Sinks
1. Standard: ASME A112.6.7.
2. Pattern: Floor or Funnel floor drain, as directed.
3. Body Material: Cast iron.
4. Anchor Flange: As directed.
5. Clamping Device: As directed
6. Outlet: Bottom, no-hub, connection.
7. Coating on Interior Surfaces: Acid-resistant enamel as directed.
8. Sediment Bucket: As directed.
9. Internal Strainer: Dome or Flat, as directed.
10. Internal Strainer Material: Aluminum.
11. Top Grate Material: Cast iron.
12. Top of Body and Grate Finish: Nickel bronze or Acid-resistant enamel as directed.

13. Top Shape: As directed.
14. Dimensions of Top Grate: As directed.
15. Top Loading Classification: As directed.
16. Funnel: As directed.

B. Plastic Floor Sinks
1. Standard: ASME A112.6.7.
2. Pattern: As directed.
3. Body Material: PVC.
4. Outlet: Bottom, PVC primer and solvent cement, connection.
5. Sediment Bucket: As directed.
6. Internal Strainer: As directed.
7. Internal Strainer Material: PVC.
8. Top Grate Material: PVC.
9. Top Shape: Round or Square, as directed.
10. Dimensions of Top Grate: As directed
11. Top Loading Classification: As directed
12. Funnel: As directed.

2.4 TRENCH DRAINS

A. Trench Drains
1. Standard: ASME A112.6.3 for trench drains.
2. Material: Ductile or gray iron.
3. Flange: Anchor or as directed.
4. Clamping Device: as directed.
5. Outlet: As directed.
6. Grate Material: Ductile iron or Ductile iron or gray iron as directed.
7. Grate Finish: As directed.
8. Dimensions of Frame and Grate: As directed.
9. Top Loading Classification: As directed.
10. Trap Material: As directed.
11. Trap Pattern: As directed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.

1. Position floor drains for easy access and maintenance.
2. Set floor drains below elevation of surrounding finished floor to allow floor drainage.
3. Set with grates depressed according to the following drainage area radii:

a. Radius, 30 Inches (750 mm) or Less: Equivalent to 1 percent slope, but not less than 1/4-inch (6.35-mm) total depression.
b. Radius, 30 to 60 Inches (750 to 1500 mm): Equivalent to 1 percent slope.

c. Radius, 60 Inches (1500 mm) or Larger: Equivalent to 1 percent slope, but not greater than 1-inch (25-mm) total depression.

4. Install floor-drain flashing collar or flange, so no leakage occurs between drain and adjoining flooring.

a. Maintain integrity of waterproof membranes where penetrated.

5. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

B. Install trench drains at low points of surface areas to be drained.

1. Set grates of drains flush with finished surface, unless otherwise indicated.
2. Install on support devices, so that top will be flush with adjacent surface.

C. Install open drain fittings with top of hub 1 inch (25 mm) above floor.

3.2 CONNECTIONS

A. Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Comply with requirements in Section 221319 "Sanitary Waste Piping Specialties" for backwater valves, air admittance devices and miscellaneous sanitary drainage piping specialties.

C. Comply with requirements in Section 221323 "Sanitary Waste Interceptors" for grease interceptors, grease-removal devices, oil interceptors, sand interceptors, and solid interceptors.

D. Install piping adjacent to equipment to allow service and maintenance.

E. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

F. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 LABELING AND IDENTIFYING

A. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 221319.13

SECTION 221323 - SANITARY WASTE INTERCEPTORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Grease interceptors.
2. Grease removal devices.
3. Oil interceptors.
4. Solids interceptors.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of interceptor.

B. Shop Drawings: For each type and size of precast concrete interceptor indicated.

1. Include materials of construction, dimensions, rated capacities, retention capacities, location and size of each pipe connection, furnished specialties, and accessories.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Interceptors, drawn to scale, and coordinated with each other, using input from installers of the items involved:

1. Piping connections. Include size, location, and elevation of each.
2. Interface with underground structures and utility services.

PART 2 - PRODUCTS

2.1 GREASE INTERCEPTORS

A. Precast Concrete Grease Interceptors: Comply with ASTM C913.

1. Include rubber-gasketed joints, vent connections, manholes, compartments or baffles, and piping or openings to retain grease and to permit wastewater flow.
2. Structural Design Loads:

a. Light-Traffic Load: Comply with ASTM C890, A-8.
b. Medium-Traffic Load: Comply with ASTM C890, A-12.
c. Heavy-Traffic Load: Comply with ASTM C890, A-16.
d. Walkway Load: Comply with ASTM C890, A-03.

3. Resilient Pipe Connectors: ASTM C923 (ASTM C923M), cast or fitted into interceptor walls, for each pipe connection.
4. Steps: As directed Individual FRP steps or FRP ladder, Individual FRP steps, FRP ladder, or ASTM A615/A615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D4101, PP or ASTM A615/A615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D4101, PP, wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of interceptor to finished grade is less than 60 inches (1500 mm).
5. Grade Rings: Reinforced-concrete rings, 6- to 9-inch (150- to 225-mm) total thickness, to match diameter of manhole frame and cover.
6. Manhole Frames and Covers: Ferrous; 24-inch (610-mm) ID by 7- to 9-inch (175- to 225-mm) riser with 4-inch (100-mm) minimum width flange and 26-inch (660-mm) diameter cover.

    a. Ductile Iron: ASTM A536, Grade 60-40-18, unless otherwise indicated.
    b. Gray Iron: ASTM A48/A48M, Class 35, unless otherwise indicated.
    c. Include indented top design with lettering cast into cover, using wording equivalent to "INTERCEPTOR, GREASE INTERCEPTOR or SANITARY SEWER" As directed.

B. Cast-Iron or Steel Grease Interceptors:
1. Standard: ASME A112.14.3 and PDI-G101, for intercepting and retaining fats, oils, and greases from food-preparation or -processing wastewater.
2. Plumbing and Drainage Institute Seal: As directed Not required or Required.
3. Body Material: Cast iron or steel.
4. Interior Lining: As directed, Corrosion-resistant enamel or Not required.
5. Exterior Coating: As directed, Corrosion-resistant enamel or Not required.
6. Body Dimensions: As directed.
7. Body Extension: As directed, Not required or Required.

C. Plastic Grease Interceptors:
1. Standard: ASME A112.14.3 and PDI-G101, for intercepting and retaining fats, oils, and greases from food-preparation or -processing wastewater.
2. Plumbing and Drainage Institute Seal: As directed, Not required or Required.
3. Body Material: Plastic.
4. Body Dimensions: As directed.
5. Body Extension: As directed, Not required or Required.

D. Capacities and Characteristics:

1. Length by Width by Depth: As directed.
2. Number of Compartments: As directed, One or Two.
3. Flow Rate: As directed.
4. Retention Capacity: As directed.
5. Inlet and Outlet Pipe Size: As directed.

    a. Centerline of Inlet to Floor: As directed.
    b. Centerline of Outlet to Floor: As directed.

6. End Connections: As directed, Flanged, Hub or Threaded.

7. Cleanout: Integral or field installed on outlet.
8. Trapped Outlet Required: As directed, Integral, No or Yes
9. Vent Pipe Size: Not required.
10. Mounting: As directed, above floor, recessed in acid-resistant, coated steel frame and cradle or Recessed, flush with floor.
11. Flow-Control Fitting: As directed, Not required or Required.
12. Operation: As directed, Automatic recovery, Manual cleaning or Semiautomatic, manual drawoff.

2.2 GREASE REMOVAL DEVICES

A. Grease Removal Devices:
1. Standard: ASME A112.14.4 and with PDI-G101 for flow tests, for automatic intercepting and removal of fats, oils, and greases from food-preparation or -processing wastewater.
2. Body Material: As directed Stainless steel or Steel.
3. Interior Separation Device: As directed Baffles or Screens.
4. Heater: As directed Not required or Required.
5. Interior Lining: Not required.
6. Exterior Coating: Not required.
7. Unit Dimensions: As directed.
8. Flow Rate: As directed.
9. Basket Material: Stainless steel.
10. Inlet and Outlet Size: As directed.
11. End Connections: As directed Flanged, Hub or Threaded.
12. Cleanout: Integral or field installed on outlet.
13. Mounting: Above floor.
14. Flow-Control Fitting: Not required or Required.
15. Operation: Automatic recovery.
16. Power Requirement: 120-V ac.
17. Full-Load Amperes: As directed.
18. Minimum Circuit Ampacity: As directed.
19. Maximum Overcurrent Protection: As directed.
20. Waste Grease Receptacle: Furnished by Owner.

2.3 OIL INTERCEPTORS

A. Cast-Iron or Steel Oil Interceptors: Factory-fabricated; with removable sediment bucket or strainer, baffles, vents, and flow-control fitting on inlet.
1. Inlet, Outlet, Vent, and Waste-Oil Outlet Piping Connections: Hub, hubless, or threaded, unless otherwise indicated.
2. Extension: Cast-iron or steel shroud, full size of interceptor, extending from top of interceptor to grade.
3. Cover: Cast iron or steel, with steel reinforcement to provide ASTM C890, A-03, walkway load.
4. Comply with requirements in Section 231113 "Facility Fuel-Oil Piping" for waste-oil storage tank and piping.

B. Capacities and Characteristics:

1. Capacity: Not applicable.
2. Overall Dimensions: As directed.
3. Flow Rate: As directed.
4. Inlet and Outlet Pipe Size: As directed.

    a. Centerline of Inlet to Floor: As directed.
    b. Centerline of Outlet to Floor: As directed.

5. End Connections: As directed Flanged, Hub or Threaded.
6. Waste-Oil-Outlet Pipe Size: As directed.

    a. Centerline of Outlet to Floor: As directed.

7. Trapped Outlet Required: As directed, Integral, No or Yes.
8. Cleanout: Integral or field installed on outlet.
9. Vent Pipe Size: As directed.
10. Mounting: As directed, above floor, recessed in acid-resistant, coated steel frame and cradle or Recessed, flush with floor.
11. Flow-Control Fitting: As directed, not required or Required.

2.4 SOLIDS INTERCEPTORS

A. Cast-Iron or Steel Solids Interceptors:
1. Type: Factory-fabricated interceptor made for removing and retaining lint or sediment from wastewater as directed.
2. Body Material: Cast iron or steel.
3. Interior Separation Device: As directed Baffles or Screens.
4. Interior Lining: As directed Corrosion-resistant enamel or Not required.
5. Exterior Coating: As directed Corrosion-resistant enamel or Not required.
6. Body Dimensions: As directed.
7. Flow Rate: Not required.
8. Inlet and Outlet Size: As directed.
9. End Connections: Threaded.
10. Mounting: As directed Above floor or Inline.

B. Plastic Solids Interceptors:
1. Type: Factory-fabricated interceptor made for removing and retaining lint or sediment from wastewater as directed.
2. Body Material: Plastic.
3. Interior Separation Device: As directed, baffles or screens.
4. Body Dimensions: As directed.
5. Flow Rate: Not required.
6. Inlet and Outlet Size: As directed.
7. End Connections: Threaded.
8. Mounting: As directed, above floor or inline.

2.5 PRECAST CONCRETE MANHOLE RISERS

A. Precast Concrete Manhole Risers: As directed ASTM C478 (ASTM C478M) or ASTM C913, with rubber-gasket joints.

1. Structural Design Loads:

    a. Light-Traffic Load: Comply with ASTM C890, A-8.
    b. Medium-Traffic Load: Comply with ASTM C890, A-12.
    c. Heavy-Traffic Load: Comply with ASTM C890, A-16.
    d. Walkway Load: Comply with ASTM C890, A-03.

2. Length: From top of underground concrete structure to grade.
3. Riser Sections: 3-inch (75-mm) minimum thickness and 36-inch (915-mm) diameter.
4. Top Section: Eccentric cone, unless otherwise indicated. Include top of cone to match grade ring size.
5. Gaskets: ASTM C443 (ASTM C443M), rubber.
6. Steps: As directed, individual FRP steps or FRP ladder, individual FRP steps, FRP ladder, or ASTM A615/A615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D4101, PP or ASTM A615/A615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D4101, PP, wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals.

B. Grade Rings: Reinforced-concrete rings, 6- to 9-inch (150- to 225-mm) total thickness, diameter matching manhole frame and cover, and height as required to adjust the manhole frame and cover to indicated elevation and slope.

C. Manhole Frames and Covers: Ferrous; 24-inch (610-mm) ID by 7- to 9-inch (175- to 225-mm) riser with 4-inch- (100-mm-) minimum width flange and 26-inch- (660-mm-) diameter cover.

1. Ductile Iron: ASTM A536, Grade 60-40-18, unless otherwise indicated.
2. Gray Iron: ASTM A48/A48M, Class 35, unless otherwise indicated.
3. Include indented top design with lettering cast into cover, using wording equivalent to the following:

    a. Grease Interceptors in Sanitary Sewerage System: "INTERCEPTOR, GREASE INTERCEPTOR or SANITARY SEWER” As directed.
    b. Oil Interceptors in Sanitary Sewerage System: "INTERCEPTOR, OIL INTERCEPTOR or SANITARY SEWER" As directed.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavating, trenching, and backfilling are specified in Section 312000 "Earth Moving."

3.2 INSTALLATION

A. Equipment Mounting:

1. As directed, install grease interceptors, grease removal devices and solids interceptors on cast-in-place concrete equipment base(s).
2. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" As directed.

B. Install precast concrete interceptors according to ASTM C891.

C. Set interceptors level and plumb.

D. Install manhole risers from top of underground concrete interceptors to manholes and gratings at finished grade.

E. Set tops of manhole frames and covers flush with finished surface in pavements.

1. Set tops 3 inches (75 mm) above finish surface elsewhere unless otherwise indicated.

F. Set tops of grating frames and grates flush with finished surface.

G. Set metal and plastic interceptors level and plumb.

H. Set tops of metal interceptor covers flush with finished surface in pavements.

1. Set tops 3 inches (75 mm) above finish surface elsewhere unless otherwise indicated.

I. Install piping and oil storage tanks according to Section 231113 "Facility Fuel-Oil Piping."

J. Install grease interceptors, including trapping, venting, and flow-control fitting, according to authorities having jurisdiction and with clear space for servicing.

1. Above-Floor Installation: Set unit with bottom resting on floor unless otherwise indicated.
2. Flush with Floor Installation: Set unit and extension, if required, with cover flush with finished floor.
3. Recessed Floor Installation: Set unit in receiver housing having bottom or cradle supports, with receiver housing cover flush with finished floor.
4. Install cleanout immediately downstream from interceptors not having integral cleanout on outlet.

K. Install grease removal devices on floor. Install trap, vent, and flow-control fitting according to authorities having jurisdiction.

1. Install control panel adjacent to unit unless otherwise indicated.

L. Install oil interceptors, including trapping, venting, and flow-control fitting, according to authorities having jurisdiction and with clear space for servicing.

1. Coordinate oil-interceptor storage tank and gravity drain with Section 231113 "Facility Fuel-Oil Piping."

M. Install solids interceptors with cleanout immediately downstream from interceptors that do not have integral cleanout on outlet.

1. Install trap on interceptors that do not have integral trap and are connected to sanitary drainage and vent systems.

3.3 CONNECTIONS

A. Piping installation requirements are specified in Section 221316 "Sanitary Waste and Vent Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Make piping connections between interceptors and piping systems.

3.4 IDENTIFICATION

A. Identification materials and installation are specified in Section 312000 "Earth Moving."

1. Arrange for installation of green warning tapes directly over piping and at outside edges of underground interceptors.
2. Use warning tapes or detectable warning tape over ferrous piping.
3. Use detectable warning tape over nonferrous piping and over edges of underground structures.

B. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:

1. Grease interceptors.
2. Grease removal devices.
3. Oil interceptors.
4. Solids interceptors.

END OF SECTION 221323

SECTION 221329 - SANITARY SEWERAGE PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Submersible sewage pumps.
2. Wet-pit-volute sewage pumps.
3. Sewage-pump basins and basin covers.

B. Related Requirements:

1. Section 221343 "Facility Packaged Sewage Pumping Stations" for applications in site-construction sewage pumping.
2. Section 221429 "Sump Pumps" for applications in storm-drainage systems.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting or attachment details as directed.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
4. Include diagrams for power, signal, and control wiring.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. UL Compliance: Comply with UL 778 for motor-operated water pumps.

2.2 SUBMERSIBLE SEWAGE PUMPS

A. Submersible, Fixed-Position, Single-Seal Sewage Pumps:
   1. Description: Factory-assembled and -tested sewage-pump unit.
   2. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sewage pump as defined in HI 1.1-1.2 and HI 1.3.
   3. Pump Casing: Cast iron, with open inlet, legs that elevate pump to permit flow into impeller, and vertical discharge for piping connection.
   4. Impeller: As directed, Statically and dynamically balanced, ASTM A48/A48M, Class No. 25 A cast iron, ASTM A532/A532M, abrasion-resistant cast iron, ASTM B584, cast bronze and or stainless steel, nonclog, open, or semiopen design for solids handling, and keyed and secured to shaft.
   5. Pump and Motor Shaft: Stainless steel or steel, with factory-sealed, grease-lubricated ball bearings.
   6. Seal: Mechanical.
   7. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.

      a. Motor Housing Fluid: As directed Air or Oil.

   8. Controls:

      a. Enclosure: As directed, NEMA 250, Type 1 or Type 4X.
      b. Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
      c. Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
      d. Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches (1500 mm).
      e. High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120 V ac, with transformer and contacts for remote alarm bell.

   9. Controls:

      a. Enclosure: As directed, NEMA 250, Type 1 or Type 4X; pedestal or wall mounted.
      b. Switch Type: As directed, Mechanical-float, Mercury-float or Pressure type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
      c. Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
      d. High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120 V ac, with transformer and contacts for remote alarm bell.

   10. Control-Interface Features:

      a. Remote Alarm Contacts: For remote alarm interface.
      b. Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:

         1) On-off status of pump.
         2) Alarm status.

B. Submersible, Quick-Disconnect, Single-Seal Sewage Pumps:

1. Description: Factory-assembled and -tested sewage-pump unit with guide-rail supports.
2. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sewage pump as defined in HI 1.1-1.2 and HI 1.3.
3. Pump Casing: Cast iron, with open inlet, and discharge fittings for connection to guide-rail support.
4. Impeller: As directed, Statically and dynamically balanced, ASTM A48/A48M, Class No. 25 A cast iron, ASTM A532/A532M, abrasion-resistant cast iron or ASTM B584, cast bronze and stainless steel, non-clog, open, or semi-open design for solids handling, and keyed and secured to shaft.
5. Pump and Motor Shaft: Stainless steel or steel, with factory-sealed, grease-lubricated ball bearings.
6. Seal: Mechanical.
7. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.

    a. Motor Housing Fluid: As directed Air or Oil.

8. Controls:

    a. Enclosure: As directed, NEMA 250, Type 1 or Type 4X.
    b. Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
    c. Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
    d. Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches (1500 mm).
    e. High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120 V ac, with transformer and contacts for remote alarm bell.

9. Controls:

    a. Enclosure: As directed, NEMA 250, Type 1 or Type 4X; pedestal or wall mounted.
    b. Switch Type: As directed, Mechanical-float, Mercury-float or Pressure type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
    c. Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
    d. High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120 V ac, with transformer and contacts for remote alarm bell.

10. Control-Interface Features:

    a. Remote Alarm Contacts: For remote alarm interface.
    b. Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:

        1) On-off status of pump.
        2) Alarm status.

11. Guide-Rail Supports:

    a. Standard: SWPA's "Submersible Sewage Pumping Systems (SWPA) Handbook."
    b. Guide Rails: Vertical pipes or structural members, made of galvanized steel or other corrosion-resistant metal, attached to baseplate and basin sidewall or cover.
    c. Baseplate: Corrosion-resistant metal plate, attached to basin floor, supporting guide rails and stationary elbow.
    d. Pump Yoke: Motor- or casing-mounted yokes or other attachments for aligning pump during connection of flanges.
    e. Movable Elbow: Pump discharge-elbow fitting with flange, seal, and positioning device.
    f. Stationary Elbow: Fixed discharge-elbow fitting with flange that mates to movable-elbow flange and support attached to baseplate.
    g. Lifting Cable: Stainless steel; attached to pump and cover at manhole.

C. Capacities and Characteristics:

1. Unit Capacity: As directed gpm (L/min).
2. Number of Pumps: As directed One or Two.
3. Each Pump:

    a. Capacity: As directed, gpm (L/min).
    b. Solids Handling Capability: Not applicable, 2 inches (50 mm) minimum, 2-1/2 inches (65 mm) minimum or 3 inches (75 mm) minimum, as directed.
    c. Total Dynamic Head: As directed, feet (kPa).
    d. Speed: As directed.
    e. Discharge Pipe Size: As directed, NPS (DN).
    f. Motor Horsepower: As directed, hp.
    g. Electrical Characteristics:

        1) Volts: As directed, 120, 240, 277 or 480 V ac.
        2) Phases: As directed, Single or Three.
        3) Hertz: 60.

4. Unit Electrical Characteristics:

    a. Full-Load Amperes: As directed.
    b. Minimum Circuit Ampacity: As directed.
    c. Maximum Overcurrent Protection: As directed.

2.3 WET-PIT-VOLUTE SEWAGE PUMPS

A. Description: Factory-assembled and -tested sewage-pump unit.

B. Pump Type: Wet-pit-volute, single-stage, separately coupled, overhung-impeller, centrifugal sewage pump as defined in HI 1.1-1.2 and HI 1.3.

C. Pump Casing: Cast iron, with open inlet and threaded or flanged connection for discharge piping.

D. Pump Shaft: As directed Stainless steel and steel.

E. Impeller: Statically and dynamically balanced, as directed ASTM A48/A48M, Class No. 25 A cast iron, ASTM A532/A532M, abrasion-resistant cast iron and ASTM B584, cast bronze, non-clog, open, or semi-open design for solids handling, and keyed and secured to shaft.

F. Sleeve Bearings: Bronze. Include oil-lubricated, intermediate sleeve bearings at 48-inch (1200-mm) maximum intervals if basin depth is more than 48 inches (1200 mm), and grease-lubricated, ball-type thrust bearings.

G. Pump and Motor Shaft Coupling: Flexible, capable of absorbing torsional vibration and shaft misalignment.

H. Pump Discharge Piping: Factory or field fabricated, galvanized, ASTM A53/A53M, Schedule 40, steel pipe with ASME B16.1, Class 125, cast-iron flanges and flanged fittings or ASME B16.4, Class 125, gray-iron threaded fittings.

I. Support Plate: Cast iron or coated steel; strong enough to support pumps, motors, and controls. See "Sewage-Pump Basins and Basin Covers" Article for requirements.

J. Shaft Seal: Stuffing box, with graphite-impregnated braided-yarn rings and bronze packing gland.

K. Motor: Single speed; grease-lubricated ball bearings and mounted on vertical, cast-iron pedestal.

L. Controls:

1. Enclosure: As directed, NEMA 250, Type 1 or Type 4X.
2. Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
3. Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
4. Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches (1500 mm).
5. High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120 V ac, with transformer and contacts for remote alarm bell.

M. Controls:

1. Enclosure: As directed, NEMA 250, Type 1 or Type 4X; pedestal or wall mounted.
2. Switch Type: As directed, Mechanical-float, Mercury-float or Pressure type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
3. Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
4. High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120 V ac, with transformer and contacts for remote alarm bell.

N. Control-Interface Features:

1. Remote Alarm Contacts: For remote alarm interface.
2. Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:

    a. On-off status of pump.
    b. Alarm status.

O. Capacities and Characteristics:

1. Unit Capacity: As directed, gpm (L/min).
2. Number of Pumps: As directed, One or Two As directed.
3. Each Pump:

    a. Capacity: As directed, gpm (L/min).
    b. Solids Handling Capability: As directed, 2 inches (50 mm), 2-1/2 inches (65 mm) or 3 inches (75 mm) minimum.
    c. Total Dynamic Head: As directed, feet (kPa).
    d. Speed: As directed.
    e. Discharge Pipe Size: As directed, NPS (DN).
    f. Motor Horsepower: As directed, hp.
    g. Electrical Characteristics:

        1) Volts: As directed, 120, 240, 277 or 480 V ac.
        2) Phases: As directed, Single or Three.
        3) Hertz: 60.

4. Unit Electrical Characteristics:

    a. Full-Load Amperes: As directed.
    b. Minimum Circuit Ampacity: As directed.
    c. Maximum Overcurrent Protection: As directed.

2.4 SEWAGE-PUMP BASINS AND BASIN COVERS

A. Basins: Factory-fabricated, watertight, cylindrical, basin sump with top flange and sidewall openings for pipe connections.

1. Material: As directed, Cast iron, Fiberglass or Polyethylene.
2. Reinforcement: Mounting plates for pumps, fittings, guide-rail supports if used, and accessories.
3. Anchor Flange: Same material as or compatible with basin sump, cast in or attached to sump, in location and of size required to anchor basin in concrete slab.

B. Basin Covers: Fabricate metal cover with openings having gaskets, seals, and bushings; for access to pumps, pump shafts, control rods, discharge piping, vent connections, and power cables.

1. Reinforcement: Steel or cast iron, capable of supporting foot traffic for basins installed in foot-traffic areas.

C. Capacities and Characteristics:

1. Capacity: As directed, gal. (L).
2. Diameter: As directed, inches (mm).
3. Depth: As directed, inches (mm).
4. Inlet No. 1:

    a. Drainage Pipe Size: As directed, NPS (DN).
    b. Bottom of Sump to Centerline: As directed, inches (mm).
    c. Type: As directed, Flanged, Hubbed or Threaded outside.

5. Inlet No. 2:

    a. Drainage Pipe Size: As directed, NPS (DN).
    b. Bottom of Sump to Centerline: As directed, inches (mm).
    c. Type: As directed Flanged, Hubbed or Threaded outside.

6. Inlet No. 3:

    a. Drainage Pipe Size: As directed, NPS (DN).
    b. Bottom of Sump to Centerline: As directed, inches (mm).
    c. Type: As directed Flanged, Hubbed or Threaded outside.

7. Sidewall Outlet:

    a. Discharge Pipe Size: As directed, NPS (DN).
    b. Bottom of Sump to Centerline: As directed, inches (mm).
    c. Type: As directed, Hubbed inside or Hubbed outside.

8. Cover Material: As directed, Cast iron, Steel with bituminous coating or Cast iron or steel with bituminous coating.
9. Cover Diameter: As directed, Inches (mm), but not less than outside diameter of basin top flange.
10. Manhole Required in Cover: As directed Yes or No.
11. Vent Size: As directed NPS (DN).

2.5 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 220513 "Common Motor Requirements for Plumbing Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

B. Motors for submersible pumps shall be hermetically sealed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Pump Installation Standards:

1. Comply with HI 1.4 for installation of centrifugal pumps.
2. Comply with HI 3.1-3.5 for installation of progressing-cavity sewage pumps.

B. Equipment Mounting:

1. Install progressing-cavity sewage pumps on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" As directed
2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
3. Comply with requirements for vibration isolation devices specified in Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."

C. Wiring Method: Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.2 CONNECTIONS

A. Comply with requirements for piping specified in Section 221316 "Sanitary Waste and Vent Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to equipment, allow space for service and maintenance.

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Perform each visual and mechanical inspection.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Pumps and controls will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 221329

SECTION 221343 - FACILITY PACKAGED SEWAGE PUMPING STATIONS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes wet-well, packaged pumping stations with submersible or submersible grinder sewage pumps.

1.2 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Show fabrication and installation details for each packaged sewage pumping station. Detail equipment assemblies and indicate dimensions; shipping, installed, and operating weights; loads; required clearances; method of field assembly; components; electrical characteristics; and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control test reports.

B. Warranty: Special warranty specified in this Section.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with HI 1.1-1.2, "Centrifugal Pumps for Nomenclature and Definitions"; HI 1.3, "Centrifugal Pumps for Design and Application"; and HI 1.4, "Centrifugal Pumps for Installation, Operation and Maintenance," for sewage and sump pumps.

C. Comply with UL 778, "Motor-Operated Water Pumps," for sewage and sump pumps.

1.6 PROJECT CONDITIONS

A. Interruption of Existing Sanitary Sewer Service: Do not interrupt sanitary sewer service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary sanitary sewer service according to requirements indicated:

1. As directed, Notify Architect, Construction Manager or Owner no fewer than two days in advance of proposed interruption of sanitary sewer service.
2. As directed, do not proceed with interruption of sanitary sewer service without Architect's, Construction Manager's or Owner's written permission.

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of packaged sewage pumping stations that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

   a. Structural failures including shell.
   b. Faulty operation of sewage pumps, controls, or accessories.
   c. Deterioration of metals, metal finishes, and other materials beyond normal use.

2. Warranty Period for Shells: As directed, number years from date of Substantial Completion.
3. Warranty Period for Sewage Pumps and Controls: As directed, number years from date of Substantial Completion.
4. Warranty Period for Accessories: As directed, number years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 WET-WELL, PACKAGED SEWAGE PUMPING STATIONS

A. Wet-Well, Packaged Sewage Pumping Stations with Submersible Sewage Pumps:
1. Description: Factory fabricated, assembled, and tested with wet well for sewage pumps and collection of sanitary sewage and with sewage pumps and dry equipment chamber for controls and accessories.

   a. Orientation: As directed, Shell underground with dry equipment chamber underground with top flush with grade, partially recessed underground, above grade or underground with entrance tube to grade.
   b. Shell: Factory fabricated from fiberglass.
   c. Entrance Tube: From dry compartment to entrance at grade, and of size required to replace largest piece of equipment, but not smaller than 36 inches (914 mm) in diameter.

d. Sewage Pumps: As directed, Two or Three submersible-type sewage pumps, with guide rail, quick-disconnect system, controls, and piping. Include ASTM A48/A48M, Class 25, nonclog, cast-iron impeller capable of passing solids of 3-inch (76-mm) minimum diameter; and hermetically sealed motor with moisture-sensing probe, mechanical seals, and waterproof power cable.

2. Capacities and Characteristics:

a. Diameter or Dimensions of Shell: As directed.
b. Height of Shell Base Section: As directed.
c. Pumping Station, Inlet Pipe Size: As directed.
d. Pumping Station, Discharge Pipe Size: As directed.
e. Sewage Pumps: As directed, Two or Three required.
f. Each Sewage Pump:

1) Capacity: As directed.
2) Total Dynamic Head: As directed.
3) Speed: As directed.
4) Impeller:

a) Type: As directed.
b) Diameter: As directed.
c) Solids Size Design: As directed.

5) Inlet Size: As directed.
6) Discharge Size: As directed.
7) Motor Size: As directed hp.
8) Electrical Characteristics:

a) Volts: As directed, 240, 277 or 480 V.
b) Phases: As directed, Single or Three.
c) Hertz: 60.

g. Sump Pump:

1) Capacity: As directed.
2) Total Dynamic Head: As directed.
3) Speed: As directed.
4) Discharge Size: As directed.
5) Motor Size: As directed hp.
6) Electrical Characteristics:

a) Volts: As directed, 120, 240, 277 or 480 V.
b) Phases: As directed, Single or Three.
c) Hertz: 60.

h. Pumping Station Electrical Characteristics:

1) Full-Load Amperes: As directed.
2) Minimum Circuit Ampacity: As directed.
3) Maximum Overcurrent Protection: As directed.

B. Wet-Well, Packaged Sewage Pumping Stations with Submersible Grinder Sewage Pumps:

1. Description: Factory fabricated, assembled, and tested with wet well for sewage pumps and collection of sanitary sewage and with dry equipment chamber for controls and accessories.

   a. Orientation: As directed, Shell underground with dry equipment chamber underground with top flush with grade, partially recessed underground, above grade or underground with entrance tube to grade.
   b. Shell: Factory fabricated from fiberglass.
   c. Entrance Tube: From dry compartment to entrance at grade, and of size required to replace largest piece of equipment, but not smaller than 36 inches (914 mm) in diameter.
   d. Sewage Pumps: As directed, Two or Three submersible grinder-type sewage pumps, with guide rail, quick-disconnect system, controls, and piping. Include stainless-steel grinder impeller and hermetically sealed motor with moisture-sensing probe, mechanical seals, and waterproof power cable.

2. Capacities and Characteristics:

   a. Diameter or Dimensions of Shell: As directed.
   b. Height of Shell Base Section: As directed.
   c. Pumping Station, Inlet Pipe Size: As directed.
   d. Pumping Station, Discharge Pipe Size: As directed.
   e. Sewage Pumps: As directed, Two or Three required.
   f. Each Sewage Pump:

      1) Capacity: As directed.
      2) Total Dynamic Head: As directed.
      3) Speed: As directed.
      4) Impeller: As directed, Cutter, Cutter or grinder or Grinder type.
      5) Inlet Size: As directed.
      6) Discharge Size: As directed.
      7) Motor Size: As directed hp.
      8) Electrical Characteristics:

         a) Volts: As directed, 240, 277 or 480V.
         b) Phases: As directed, Single or Three.
         c) Hertz: 60.

   g. Sump Pump:

      1) Capacity: As directed.
      2) Total Dynamic Head: As directed.
      3) Speed: As directed.
      4) Discharge Size: As directed.
      5) Motor Size: As directed hp.
      6) Electrical Characteristics:

         a) Volts: As directed, 120, 240, 277 or 480 V.
         b) Phases: As directed, Single or Three.

c) Hertz: 60.

h. Pumping Station Electrical Characteristics:

1) Full-Load Amperes: As directed.
2) Minimum Circuit Ampacity: As directed.
3) Maximum Overcurrent Protection: As directed.

2.2 CONTROLS

A. Control Sequence of Operation: Cycle each sewage pump on and off automatically to maintain wet-well sewage level. Automatic control operates both pumps in parallel if wet-well level rises above starting point of low-level pump, until shutoff level is reached. Automatic alternator, with manual disconnect switch, changes sequence of lead-lag sewage pumps at completion of each pumping cycle.

B. As directed Electrode, Float-Switch, Pressure-Switch or Ultrasonic System: Senses variations of sewage level in wet well. Include high and low adjustments capable of operating on 6-inch (150-mm) minimum differential of liquid level.

C. Motor Controllers: Magnetic, full voltage, non-reversing. Include undervoltage release, thermal-overload heaters in each phase, manual reset buttons, and hand-automatic selector switches. Include circuit breakers to provide branch-circuit protection for each controller.

D. 120-V accessory controls with 15-A, single-phase circuit breakers or fuses for each item.

E. Control Panel: Enclosure complying with UL 508A and with UL 508A, Supplement SB with separate compartments and covers for controllers, circuit breakers, transformers, alternators, and single-phase controls. Include 20-A duplex receptacle in NEMA WD 1, Configuration 5-20R mounted on exterior of control panel.

1. Mounting: As directed, inside, on dry-chamber wall or outside, on pedestal, at grade.
2. Enclosure: As directed, NEMA 250, Type 1, 4 or 4X.

F. Install labels on panel face to identify switches and controls.

G. Wiring: Tin-copper wiring.

H. Connection for Portable Generator: Nonautomatic (manual) transfer switch with receptacle matching generator electrical power requirements. Nonautomatic transfer switches are specified in Section 263600 "Transfer Switches" and receptacles are specified in Section 262726 "Wiring Devices."

2.3 ACCESSORIES

A. Lighting: Minimum of 2, UL 1571, heavy-duty, cast-metal, wet-location-type fixtures with 100-W bulbs and guards in service area. Locate switches, with pilot lights, at chamber entrance.

B. Submersible Sump Pump:

1. Discharge Size: NPS 1-1/4 (DN 32) minimum.
2. Pump End Bell and Motor Shell: Cast iron.
3. Motor: 1/3 hp, 1750-rpm, hermetically sealed, capacitor-start, with built-in overload protection.
4. Impeller: ASTM B584, cast bronze or ASTM B36/B36M, brass.
5. Shaft: Stainless steel.
6. Bearings: Grease-lubricated, factory-sealed ball bearings.
7. Seals: Mechanical.
8. Accessories: Inlet strainer.
9. Controls: Float switch.

C. Dehumidifier: Electric refrigeration system, adjustable humidistat, reverse-acting thermostat for low-temperature cutoff controls, and condensate pump with drain piping to sump.

1. Dehumidification system capacity adequate to remove at least 15 pints (7 L) of water per day from service area air that is 80 deg F (27 deg C) with a relative humidity of 60 percent.

D. Ventilation: Electrically powered ventilation system. Include centrifugal blower with 4-inch-(100-mm-) round exhaust vent designed to keep out rain, insects, and other foreign matter; limit switch to start blower if entrance door or lid is opened; 0- to 15-minute timer; and separate manual switch.

1. Ventilating system capacity to change air in dry equipment chamber every two minutes.

E. Heater: Electric, 1.5 kW minimum, with fan and thermostat control.

F. High-Water Audio Alarm: Horn for audio indication of station high-water level, energized by separate level-detecting device. Include alarm silencer switch and relay in station.

G. Remote Alarm Circuit: Include contacts for connection to remote alarm panel.

2.4 MOTORS

A. General requirements for motors are specified in Section 220513 "Common Motor Requirements for Plumbing Equipment."

2.5 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A6/A6M, W or HP shapes, or ASTM A36/A36M, plates or beams.

B. Grout: ASTM C1107, Grade B, non-shrink cement grout.

1. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

C. Concrete: Concrete is specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" As directed.

2.6 PACKAGED SEWAGE PUMPING STATION FABRICATION

A. Fabricate shell from fiberglass with structural-steel reinforcement.

1. Attach structural-steel reinforcement to top and bottom heads.
2. Fabricate shell with continuous joints to make watertight and gastight construction.
3. Attach air vent to pump chamber and entrance tube.
4. Ladder: As directed Steel or Fiberglass.

B. Install sump, 18 inches (450 mm) in diameter by 10 inches (254 mm) deep in dry-chamber floor. Slope floor toward sump and fasten rubber mat to floor walkway with cement.

C. Entrance tube may be furnished separately for field installation.

D. Entrance Cover: Waterproof and corrosion resistant, with lock. Include way to open cover from inside tube if cover is locked.

E. Air Vent: Duct fabricated from corrosion-resistant material, extended to above grade, outlet turned down, and with insect screen in outlet.

F. Factory fabricate piping between unit components.

1. Use galvanized-steel pipe and cast-iron fittings or ductile-iron pipe and fittings.
2. Use fittings for changes in direction and branch connections.
3. Flanged and union joints may be used instead of joints specified.
4. Use dielectric fittings for connections between ferrous- and copper-alloy piping.

G. Piping Connections: Unless otherwise indicated, make the following piping connections:

1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment having NPS 2 (DN 50) or smaller threaded pipe connection.
2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment having flanged pipe connection.

H. Valves: Ferrous alloy.

1. Sewage Pump Piping: Include gate valve on each pump inlet and gate and check valves on each discharge pipe.
2. Sump Pump Piping: Include ball or gate and check valves on discharge pipe.

I. Wiring: Tin-coated copper.

2.7 SOURCE QUALITY CONTROL

A. Test and inspect sewage and sump pumps according to HI 1.6, "Centrifugal Pump Tests." Include test recordings that substantiate correct performance of pumps at design head, capacity, suction lift, speed, and horsepower.

B. Test accessories and controls through complete cycle. Include test recordings that substantiate correct performance.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Excavation, trenching, and backfilling are specified in Section 312000 "Earth Moving."

B. Install packaged sewage pumping station components where indicated, according to specific equipment and piping arrangement indicated.

C. Shell Base Supports: Form from structural-steel beams, of number and lengths required to support bottom of shell and to anchor beams to concrete foundation.

1. Use elevator blocks attached to bottom of shell to slope station floor 1 inch in 10 feet (25.4 mm in 3 m) down toward sump.

D. Grout under and around shell. Ensure that there are no voids between foundation slab and underslab of pumping station.

E. Fill voids between shell sidewalls, sleeves, and piping and make watertight seal with grout.

F. Sanitary sewer piping installation requirements are specified in Section 221313 "Facility Sanitary Sewers." Drawings indicate general arrangement of piping.

G. Install piping adjacent to machine to allow service and maintenance.

H. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

I. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

J. Install identifying labels permanently attached to equipment.

K. Install operating instruction signs permanently attached to equipment or on pumping station wall near equipment.

L. Arrange for installing green detectable warning tape over outside edges of underground packaged sewage pumping stations. Tape materials and their installation are specified in Section 312000 "Earth Moving."

M. Prepare and paint ferrous piping in wet wells, structural-steel supports, and anchor devices with coal-tar epoxy-polyamide paint according to SSPC-Paint 16.

N. Paint field-welded areas to match factory coating.

3.2 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. After installing packaged sewage pumping stations and after electrical circuitry has been energized, test for compliance with requirements. Furnish water required for pump tests.
2. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace packaged sewage pumping stations that do not pass tests and inspections and retest as specified above.

3.3 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Adjust pump, accessory, and control settings, and safety and alarm devices.

END OF SECTION 221343

SECTION 221353 - FACILITY SEPTIC TANKS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Septic tanks.
2. Distribution boxes.
3. Pipe and fittings.
4. Absorption systems.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1. Include construction details, material descriptions, dimensions of individual components, and profiles.
2. Include manhole openings, covers, and pipe connections.

B. Shop Drawings: As directed for trench absorption systems or bed absorption systems.

1. Include manhole openings, covers, pipe connections, and accessories.
2. Include piping with sizes and invert elevations.
3. Include underground structures.
4. Include other utilities.

PART 2 - PRODUCTS

2.1 CONCRETE SEPTIC TANKS

A. Description: ASTM C1227, precast, reinforced-concrete tank and covers; As directed single chamber, single chamber with internal baffle or two chambers.

B. Design: For A-8 (H10-44), A-12 (HS15-44) or A-16 (HS20-44) traffic loading according to ASTM C890, as directed.

C. Manholes: As directed 20-inch (508-mm), 22-inch (559-mm) or 24-inch (610-mm) minimum diameter opening with reinforced-concrete risers to grade and access lid with steel lift rings. Include manhole in center of each septic tank compartment top.

D. Filter Access: Reinforced-concrete access hole, large enough to remove filter, over filter position.

E. Inlet and Outlet Access: 12-inch (305-mm) minimum diameter, reinforced-concrete access lids with steel lift rings. Include access centered over inlet and outlet.

F. Resilient Connectors: ASTM C923 (ASTM C923M), of size required for piping, fitted into inlet and outlet openings.

G. Capacity and Characteristics:

1. Capacity: As directed.
2. Inlet and Outlet Size: As directed.

2.2 POLYETHYLENE SEPTIC TANKS

A. Description: Molded, HDPE or PE construction; fabricated for septic tank application; single chamber, single chamber with baffle and at least one access riser and manhole or two chambers each with an access riser and manhole as directed.

B. Manholes: As directed, 18-inch (457-mm), 20-inch (508-mm) or 22-inch (559-mm) minimum diameter opening with HDPE or PE access risers to grade and cover.

C. Filter Access: Include access hole, large enough to remove filter, over filter position.

D. Resilient Connectors: ASTM C923 (ASTM C923M) or other watertight seal, of size required for piping, fitted into inlet and outlet openings.

E. Capacity and Characteristics:

1. Capacity: As directed.
2. Inlet and Outlet Size: As directed.

2.3 FILTERS

A. Description: Removable, septic-tank-outlet filter that restricts discharge solids to 1/8 inch (3.2 mm).

B. Housing: HDPE or PVC.

C. Outlet Size: As directed, NPS 4 (DN 100) or NPS 6 (DN 150).

2.4 CONCRETE DISTRIBUTION BOXES

A. Description: Precast concrete, single-chamber box and cover.

B. Design: As directed, made according to ASTM C913, and for A-8 (H10-44), A-12 (HS15-44) or A-16 (HS20-44 traffic loading according to ASTM C890. Include baffle opposite inlet.

C. Manholes: As directed, 20-inch (508-mm), 22-inch (559-mm) or 24-inch (610-mm) minimum diameter opening with reinforced-concrete risers to grade and cover with steel lift rings in center of distribution box cover.

D. Resilient Connectors: ASTM C923 (ASTM C923M), of size required for piping, fitted into inlet and outlet openings. Include watertight plugs in outlets not required.

E. Capacity and Characteristics:

1. Inlet Size: As directed.
2. Number of Outlets: As directed Two, Three or Four.
3. Outlet Size: As directed.

2.5 PE DISTRIBUTION PIPE AND FITTINGS

A. Tube and Fittings: ASTM F405, perforated corrugated tube with solid-wall fittings.

B. Couplings: PE band, matching tube and fitting dimensions.

2.6 NONPRESSURE PIPE COUPLINGS

A. Description: Comply with ASTM C1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground non-pressure piping. Include ends of same sizes as piping to be joined, with corrosion-resistant-metal tension band and tightening mechanism on each end.

1. Sleeve Materials for Plastic Pipes: ASTM F477, elastomeric seal or ASTM D5926, PVC.
2. Sleeve Materials for Dissimilar Pipes: ASTM D5926, PVC or other material compatible with pipe materials being joined.

2.7 TRENCH OR BED ABSORPTION-SYSTEM MATERIALS

A. Filter Material: ASTM D448, Size No. 24, 3/4 to 2-1/2 inches (19 to 63 mm), washed, crushed stone or gravel; or broken, hard-burned clay brick.

B. Filter Mat: As directed, Geotextile woven or spun filter fabric, in one or more layers, for minimum total unit weight of 3 oz./sq. yd. (101 g/sq. m) or Untreated building paper or similar porous material.

C. Cover for Distribution Pipe: Geotextile woven filter fabric, in one or more layers, for minimum total unit weight of 3 oz./sq. yd. (101 g/sq. m).

D. Fill Material: Soil removed from trench.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavating, trenching, and backfilling for piping is specified in Section 312000 "Earth Moving."

1. Stockpile topsoil for reuse in finish grading without intermixing with other excavated material. Stockpile materials away from edge of excavation and do not store within drip line of remaining trees.
2. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.

B. Excavating and Backfilling for Septic Tanks:

1. Excavate sufficient width and length for tanks to depth determined by tank inlet elevation. Provide level bottom.
2. Backfill with excavated soil, mounding soil above original grade without compacting.

C. Excavating and Backfilling for Trench Absorption Systems:

1. Excavate for trench absorption systems 30 inches (762 mm) wide and 24 inches (610 mm) deep, minimum.
2. Backfill with excavated soil, mounding soil above original grade without compacting.

D. Excavating and Backfilling for Bed Absorption Systems:

1. Excavate for bed absorption systems of width indicated and 24 inches (610 mm) deep, minimum.
2. Backfill with excavated soil, mounding soil above original grade without compacting.

3.2 SEPTIC TANK INSTALLATION

A. Install precast concrete septic tanks according to ASTM C891.

B. Install septic tanks level.

C. Connect septic tank to concrete ballast pad.

D. Install filter in septic tank outlet. Secure filter to septic tank wall. Make direct connections to distribution piping.

E. Install insulation on exterior sides and top of septic tank. Comply with requirements for insulation specified in Section 220716 "Plumbing Equipment Insulation."

F. Fill septic tank with water.

3.3 DISTRIBUTION BOX INSTALLATION

A. Install precast-concrete distribution boxes according to ASTM C891 and at invert elevations indicated. Set level and plumb.

3.4 PIPING INSTALLATION

A. Comply with requirements for sewer pipe installation specified in Section 221313 "Facility Sanitary Sewers."

B. Install distribution piping according to the following:

1. As directed, use perforated pipe and fittings for trench or bed absorption systems with perforations at bottom.
2. PE Tube and Fittings: ASTM F481.

3.5 PIPE JOINT CONSTRUCTION

A. Join distribution piping with or according to the following:

1. As directed, install pipe and fittings for trench or bed absorption systems with closed joints unless otherwise indicated.
2. PE Tube and Fittings: With PE band couplings.

B. Join dissimilar pipe materials according to ASTM D5926, with couplings and gaskets compatible with pipe materials being joined.

3.6 CLEANOUT INSTALLATION

A. Install cleanouts according to the following:

1. Inlet and Outlet of Septic Tanks: Cast-iron cleanouts.
2. Inlet and Outlet of Dosing Tanks: Cast-iron cleanouts.
3. Inlet and Outlet of Distribution Boxes: As directed Cast-iron or PVC cleanouts.
4. At Each Change in Direction of Sewer Piping: As directed Cast-iron or PVC cleanouts.
5. At Ends of Each Row and at Each Change in Direction of Distribution Piping: As directed Cast-iron or PVC cleanouts.

B. Comply with requirements for cleanouts specified in Section 221313 "Facility Sanitary Sewers."

C. Cast-Iron Cleanouts: Install with PVC riser from sewer and distribution piping to cast-iron cleanout housing at grade. Use NPS 4 (DN 100) PVC sewer pipe and fittings with solvent-cemented joints for risers. Attach riser to cleanout housing with rubber gasket or coupling.

D. PVC Cleanouts: Install with PVC riser from sewer and distribution piping to PVC cleanout at grade. Use NPS 4 (DN 100) PVC sewer pipe and fittings with solvent-cemented joints for risers and cleanout fitting.

E. Cleanout Support: Set cleanouts in concrete blocks 18-by-18-by-12-inches (457-by-457-by-305-mm) deep unless location is in concrete pavement. Formwork, reinforcement, and concrete are specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" As directed.

F. As directed, Set top of cleanout 1 inch (25 mm) or 2 inches (51 mm) above surrounding rough grade or set flush with grade if installed in pavement.

3.7 TRENCH OR BED ABSORPTION-SYSTEM INSTALLATION

A. Filter Material: As directed Place supporting layer of filter material over the compacted trench or bed base to a compacted depth not less than 6 inches (152 mm) below bottom of pipe.

B. As directed Install sewer piping at minimum slope of 1 percent and maximum slope of 2 percent or at no slope.

C. Install distribution piping solidly bedded in filter material, with full bearing for each pipe section throughout its length. Maintain pipe alignment with no slope.

1. Install perforated pipe with perforations down and joints tightly closed. Install couplings as required.
2. Install elbow fittings with tight joints.
3. Install absorption-system materials as follows from surface of excavation to grade:

    a. Trench Size: As directed, 12 inches (305 mm) or 36 inches (914 mm) wide by long.
    b. Bed Size: As directed, specific Value wide with distribution piping 36 inches (914 mm) minimum apart by long.
    c. Bottom Filter Material Layer: As directed, 6 inches (152 mm) or 8 inches (203 mm) thick below distribution piping.
    d. Intermediate Filter Material Layer: OD of distribution piping.
    e. Top Filter Material Layer: As directed, 6-inch (152-mm) or 8-inch (203-mm) minimum thickness above distribution piping.
    f. Filter Mat: Above final filter-material layer.
    g. Fill: Above filter mat to final grade.

D. Install filter mat over filter material before backfilling.

3.8 IDENTIFICATION

A. Identification materials and their installation are specified in Section 312000 "Earth Moving." Arrange for installation of green, detectable warning tape directly over piping, at outside edges of underground structures, and at outside edges of absorption systems.

3.9 FIELD QUALITY CONTROL

A. System Tests: Perform testing of completed septic tank system piping and structures according to authorities having jurisdiction.

B. Additional Tests: Fill underground structures with water and let stand overnight. If water level recedes, locate and repair leaks and retest. Repeat tests and repairs until no leaks exist.

3.10 CLEANING

A. Clear interior of piping and structures of dirt and other superfluous material as work progresses.

B. Maintain swab or drag in piping and pull past each joint as it is completed. Place plugs in ends of uncompleted pipe at end of workday or when work stops.

END OF SECTION 221353

SECTION 221363 - FACILITY GRAY-WATER STORAGE TANKS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Steel, non-pressure, water storage tanks.
2. Plastic, non-pressure, water storage tanks.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting or attachment details as directed.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly as directed.
4. Include diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal: For facility gray-water storage tanks.

1. Include design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For gray-water storage tanks, accessories, and components, from manufacturer.

B. Welding certificates.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."

2. AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."
3. AWS D1.4/D1.4M, "Structural Welding Code - Reinforced Steel."

B. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design facility gray-water storage tanks.

B. Structural Performance: Surface water-storage tank, including structural reinforcement and foundation, shall be capable of withstanding the effects of dead and live gravity loads and winds of 100 mph (161 km/h).

C. Seismic Performance: Surface water-storage tank, including structural reinforcement and foundation, withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: As directed 1.5 or 1.0.

D. Thermal Movements: Surface water-storage tank, including structural reinforcement and foundation, shall allow for thermal movements from ambient and surface temperature changes by preventing buckling, opening of joints, overstressing of components, failure of connections, and other detrimental effects. Base engineering calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.

1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

E. Comply with AWWA D100, "Welded Steel Tanks for Water Storage," and with AWWA M42, "Steel Water-Storage Tanks."

F. Comply with AWWA D110, "Wire- and Strand-Wound, Circular, Prestressed Concrete Water Tanks."

G. Comply with AWWA D110, "Wire- and Strand-Wound, Circular, Prestressed Concrete Water Tanks."

H. Comply with AWWA D115, "Tendon-Prestressed Concrete Water Tanks."

I. Comply with AWWA D120, "Thermosetting Fiberglass-Reinforced Plastic Tanks."

2.2 STEEL, NONPRESSURE, WATER STORAGE TANKS

A. Description: As directed, Steel, horizontal or vertical, non-pressure-rated tank with cylindrical sidewalls.

B. Fabricate supports and attachments to tank with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure.

C. Construction: Steel, constructed with nontoxic welded joints.

D. Manhole: Watertight, for tank more than 36 inches (915 mm) in diameter.

E. Cover for Open Tank: As directed Plastic or Steel, with lining same as or similar to tank lining and with shape that encloses top of tank.

F. Tappings: Factory-fabricated stainless steel, welded to tank.

1. NPS 2 (DN 50) and Smaller: ASME B1.20.1, with female thread.
2. NPS 2-1/2 (DN 65) and Larger: ASME B16.5, flanged.

G. Specialties and Accessories: Include tappings in tank and the following:

1. Vacuum relief valve.
2. Free air vent with insect screen.
3. Thermometer.
4. Gage glass, brass fittings, compression stops, and gage-glass guard.

H. Horizontal Tank Supports: Factory-fabricated steel saddles, welded to tank before testing.

I. Vertical Tank Supports: Factory-fabricated steel legs or steel skirt, welded to tank before testing.

J. Exterior Coating: As directed Galvanized, Manufacturer's standard enamel paint or Primer paint.

2.3 PLASTIC, NONPRESSURE, WATER STORAGE TANKS

A. FRP Water Storage Tanks:
1. Description: FRP, vertical, non-pressure-rated water tank.
2. Construction: ASTM D3299, filament-wound or ASTM D4097, contact-molded FRP.
3. Tappings: Factory-fabricated, FRP flanged-end nozzle.

a. NPS 2 (DN 50) and Smaller: Include plastic-to-steel transition fitting from tank nozzle flange to ASME B1.20.1, female thread.

1) Exception: Tappings may be threaded FRP coupling integral with nozzle for connections for plastic piping.

b. NPS 2-1/2 (DN 65) and Larger: Flanged.

4. Vertical Tank Support: Separate factory-fabricated steel stand capable of supporting tank.

B. PE Water Storage Tanks:
   1. Description: PE, vertical, flat-bottom, non-pressure-rated water tank.
   2. Construction: ASTM D1998, molded PE.
   3. Tappings: Factory-fabricated bulkhead fittings attached to tank.
      a. NPS 2 (DN 50) and Smaller: With female thread.
      b. NPS 2-1/2 (DN 65) and Larger: Flanged.
   4. Vertical Tank Support: Separate factory-fabricated steel stand capable of supporting entire bottom of tank.

C. Manhole: Watertight, for tank more than 36 inches (915 mm) in diameter.

D. Cover for Open Tank: Plastic, same as or similar to tank material and with shape that encloses top of tank.

E. Specialties and Accessories: Include tappings in tank and the following:
   1. Vacuum relief valve.
   2. Free air vent with insect screen.
   3. Thermometer.
   4. Gage glass, brass fittings, compression stops, and gage-glass guard.

2.4 PAINT MATERIALS

A. Paint: Comply with AWWA D102.

B. Primer: Tank fabricator's standard epoxy-polyamide paint.

C. Tank Shell Exterior Intermediate Paint: Tank fabricator's standard, two-component epoxy paint compatible with prime and finish paint. Intermediate coat shall have a slight color contrast with finish coat.

D. Tank Shell Exterior Finish Paint: Tank fabricator's standard urethane paint.
   1. Color: As selected by Owner from tank manufacturer's paint chart.

2.5 SHOP PAINTING

A. Tank Shell Exterior Finish Coat: Factory coating according to AWWA D103.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install water storage tanks on concrete bases, level and plumb, firmly anchored. Arrange so devices needing servicing are accessible.

1. As directed Install horizontal tanks on concrete piers and factory-fabricated or fabricated steel supports and saddles.

B. Vertical Water Storage Tanks:

1. Install on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" As directed.
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

C. Anchor tank supports and tanks to substrate.

1. Use steel or FRP straps over or around plastic tanks.

D. Install tank seismic restraints.

E. Install thermometers and pressure gages on water storage tanks and piping if indicated. Thermometers and pressure gages are specified in Section 220519 "Meters and Gages for Plumbing Piping."

F. Install the following devices on tanks:

1. Pressure relief valves.
2. Temperature and pressure relief valves.
3. Vacuum relief valves.
4. Tank vents on non-pressure tanks.
5. Connections to accessories.

G. After installing tanks with factory finish, inspect finishes and repair damages to finishes.

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Tank Weld Test: Use radiographic method according to AWWA D100. Repair failures and retest.
2. Leak Test: Comply with AWWA D100 and NFPA 22. Fill tanks with water and test for leaks after installation. Repair leaks and retest until no leaks exist.

    a. Water will be furnished by Owner.

3. Leak Test: As directed Comply with AWWA D110, AWWA D115 or and NFPA 22. Fill tanks with water and test for leaks after installation. Repair leaks and retest until no leaks exist.

    a. Water will be furnished by Owner.

4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Water storage tanks will be considered defective if they do not pass test and inspections.

C. Prepare test and inspection reports.

END OF SECTION 221363

SECTION 221413 - FACILITY STORM DRAINAGE PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Hub-and-spigot, cast-iron soil pipe and fittings.
2. Hubless, cast-iron soil pipe and fittings.
3. ABS pipe and fittings.
4. PVC pipe and fittings.
5. Specialty pipe and fittings.

B. Related Requirements:

1. Section 334400 "Stormwater Utility Equipment" for storm drainage piping outside the building.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: As directed for controlled-flow or siphonic roof drainage system. Include calculations, plans, and details.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Detail storm drainage piping. Show support locations, type of support, weight on each support, required clearances, and other details, drawn to scale, and coordinated with each other, using input from installers of the items involved.

B. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:

1. Storm Drainage Piping: 10-foot head of water (30 kPa).

2.2 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings:

1. Marked with CISPI collective trademark and NSF certification mark.
2. Class: ASTM A74, Service class.

B. Gaskets: ASTM C564, rubber.

2.3 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings:

1. Marked with CISPI collective trademark and NSF certification mark.
2. Standard: ASTM A888 or CISPI 301.

B. CISPI, Hubless-Piping Couplings:
1. Couplings shall bear CISPI collective trademark and NSF certification mark.
2. Standards: ASTM C1277 and CISPI 310.
3. Description: Stainless-steel corrugated shield with stainless-steel bands and tightening devices; and ASTM C564, rubber sleeve with integral, center pipe stop.

C. Heavy-Duty, Hubless-Piping Couplings:
1. Standard: ASTM C1540.
2. Description: Stainless-steel shield with stainless-steel bands and tightening devices; and ASTM C564, rubber sleeve with integral, center pipe stop.

D. Cast-Iron, Hubless-Piping Couplings:
1. Standard: ASTM C1277.
2. Description: Two-piece ASTM A48/A48M, cast-iron housing; stainless-steel bolts and nuts; and ASTM C564, rubber sleeve with integral, center pipe stop.

2.4 ABS PIPE AND FITTINGS

A. NSF Marking: Comply with NSF 14, "Plastics Piping System Components and Related Materials," for plastic piping components. Include marking with "NSF-drain" for plastic storm drain and "NSF-sewer" for plastic storm sewer piping.

B. Solid-Wall ABS Pipe: ASTM D2661, Schedule 40.

C. Cellular-Core ABS Pipe: ASTM F628, Schedule 40.

D. ABS Socket Fittings: ASTM D2661, made to ASTM D3311, drain, waste, and vent patterns.

E. Solvent Cement: ASTM D2235.

2.5 PVC PIPE AND FITTINGS

A. NSF Marking: Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-drain" for plastic storm drain and "NSF-sewer" for plastic storm sewer piping.

B. Solid-Wall PVC Pipe: ASTM D2665; drain, waste, and vent.

C. Cellular-Core PVC Pipe: ASTM F891, Schedule 40.

D. PVC Socket Fittings: ASTM D2665, made to ASTM D3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.

E. Adhesive Primer: ASTM F656.

F. Solvent Cement: ASTM D2564.

2.6 SPECIALTY PIPE FITTINGS

A. Transition Couplings:

1. General Requirements: Fitting or device for joining piping with small differences in ODs or of different materials. Include end connections same size as and compatible with pipes to be joined.
2. Fitting-Type Transition Couplings: Manufactured piping coupling or specified-piping-system fitting.
3. Unshielded, Non-pressure Transition Couplings:
    a. Standard: ASTM C1173.
    b. Description: Elastomeric sleeve, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
    c. Sleeve Materials:
        1) For Cast-Iron Soil Pipes: ASTM C564, rubber.
        2) For Plastic Pipes: ASTM F477, elastomeric seal or ASTM D5926, PVC.
        3) For Dissimilar Pipes: ASTM D5926, PVC or other material compatible with pipe materials being joined.
4. Shielded, Non-pressure Transition Couplings:
    a. Standard: ASTM C1460.
    b. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
    c. End Connections: Same size as and compatible with pipes to be joined.

PART 3 - EXECUTION

3.1 EARTH MOVING

A. Comply with requirements for excavating, trenching, and backfilling specified in Section 312000 "Earth Moving."

3.2 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems.

1. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations.
2. Install piping as indicated unless deviations from layout are approved on coordination drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

K. Make changes in direction for piping using appropriate branches, bends, and long-sweep bends.

1. Do not change direction of flow more than 90 degrees.
2. Use proper size of standard increasers and reducers if pipes of different sizes are connected.

a. Reducing size of drainage piping in direction of flow is prohibited.

L. Lay buried building piping beginning at low point of each system.

1. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream.
2. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
3. Maintain swab in piping and pull past each joint as completed.

M. Install piping at the following minimum slopes unless otherwise indicated:

1. Building Storm Drain: 2 percent downward in direction of flow for piping NPS 3 (DN 80) and smaller; As directed 1 or 2 percent downward in direction of flow for piping NPS 4 (DN 100) and larger.
2. Horizontal Storm Drainage Piping: 2 percent downward in direction of flow.

N. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

O. Install aboveground ABS piping according to ASTM D2661.

P. Install aboveground PVC piping according to ASTM D2665.

Q. Install underground ABS and PVC piping according to ASTM D2321.

R. As directed, Install engineered controlled-flow or siphonic drain specialties and storm drainage piping in locations indicated.

S. Plumbing Specialties:

1. Install backwater valves in storm drainage gravity-flow piping.

    a. Comply with requirements for backwater valves specified in Section 221423 "Storm Drainage Piping Specialties."

2. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers in storm drainage gravity-flow piping.

    a. Comply with requirements for cleanouts specified in Section 221423 "Storm Drainage Piping Specialties."

3. Install drains in storm drainage gravity-flow piping.

    a. Comply with requirements for drains specified in Section 221423 "Storm Drainage Piping Specialties."

T. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

U. Install sleeves for piping penetrations of walls, ceilings, and floors.

1. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

V. Install sleeve seals for piping penetrations of concrete walls and slabs.

1. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

W. Install escutcheons for piping penetrations of walls, ceilings, and floors.

1. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

A. Hub-and-Spigot, Cast-Iron Soil Piping Gasketed Joints: Join according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.

B. Hubless, Cast-Iron Soil Piping Coupled Joints:

1. Join according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.

C. ABS and PVC, Nonpressure-Piping, Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements.
2. ABS Piping: Join according to ASTM D2235 and ASTM D2661 appendices.
3. PVC Piping: Join according to ASTM D2855 and ASTM D2665 appendices.

D. Joint Restraints and Sway Bracing:

1. Provide joint restraints and sway bracing for storm drainage piping joints to comply with the following conditions:

a. Provide axial restraint for pipe and fittings 5 inches (125 mm) and larger, upstream and downstream of all changes in direction, branches, and changes in diameter greater than two pipe sizes.
b. Provide rigid sway bracing for pipe and fittings 4 inches (100 mm) and larger, upstream and downstream of all changes in direction 45 degrees and greater.
c. Provide rigid sway bracing for pipe and fittings 5 inches (125 mm) and larger, upstream and downstream of all changes in direction and branch openings.

3.4 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:

1. Install transition couplings at joints of piping with small differences in ODs.
2. In Drainage Piping: As directed Unshielded or Shielded, nonpressure transition couplings.

3.5 VALVE INSTALLATION

A. General valve installation requirements for general-duty valve installations are specified in the following Sections:

1. Section 220523.12 "Ball Valves for Plumbing Piping."
2. Section 220523.13 "Butterfly Valves for Plumbing Piping."
3. Section 220523.14 "Check Valves for Plumbing Piping."
4. Section 220523.15 "Gate Valves for Plumbing Piping."

B. Shutoff Valves:

1. Install shutoff valve on each sump pump discharge.
2. Install gate for piping NS 2 (DN 50) and smaller.
3. Install gate valve for piping NPS 2-1/2 (DN 65) and larger.

C. Check Valves: Install swing-check valve, between pump and shutoff valve, on each sump pump discharge.

D. Backwater Valves: Install backwater valves in piping subject to backflow.

1. Horizontal Piping: Horizontal backwater valves. Use normally closed type unless otherwise indicated.
2. Install backwater valves in accessible locations.
3. Comply with requirements for backwater valves specified in Section 221423 "Storm Drainage Piping Specialties."

3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for pipe hanger and support devices and installation specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
2. As directed Install stainless-steel or fiberglass pipe hangers for horizontal piping in corrosive environments.
3. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
4. Install stainless-steel pipe support clamps for vertical piping in corrosive environments.
5. Vertical Piping: MSS Type 8 or Type 42, clamps.
6. Install individual, straight, horizontal piping runs:

    a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
    b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
    c. Longer Than 100 Feet (30 m) if Indicated: MSS Type 49, spring cushion rolls.

7. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
8. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Support horizontal piping and tubing within 12 inches (300 mm) of each fitting, valve, and coupling.

D. Support vertical piping and tubing at base and at each floor.

E. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
2. NPS 3 (DN 80): 60 inches (1500 mm) with 1/2-inch (13-mm) rod.
3. NPS 4 and NPS 5 (DN 100 and DN 125): 60 inches (1500 mm) with 5/8-inch (16-mm) rod.
4. NPS 6 and NPS 8 (DN 150 and DN 200): 60 inches (1500 mm) with 3/4-inch (19-mm) rod.
5. NPS 10 and NPS 12 (DN 250 and DN 300): 60 inches (1500 mm) with 7/8-inch (22-mm) rod.
6. Spacing for 10-foot (3-m) pipe lengths may be increased to 10 feet (3 m). Spacing for fittings is limited to 60 inches (1500 mm).

G. Install supports for vertical cast-iron soil piping every 15 feet (4.5 m).

H. Install hangers for ABS and PVC piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 48 inches (1200 mm) with 3/8-inch (10-mm) rod.
2. NPS 3 (DN 80): 48 inches (1200 mm) with 1/2-inch (13-mm) rod.
3. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1200 mm) with 5/8-inch (16-mm) rod.
4. NPS 6 and NPS 8 (DN 150 and DN 200): 48 inches (1200 mm) with 3/4-inch (19-mm) rod.
5. NPS 10 and NPS 12 (DN 250 and DN 300): 48 inches (1200 mm) with 7/8-inch (22-mm) rod.

I. Install supports for vertical ABS and PVC piping every 48 inches (1200 mm).

J. Support piping and tubing not listed above according to MSS SP-58 and manufacturer's written instructions.

3.7 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.

C. Connect storm drainage piping to roof drains and storm drainage specialties.

1. Install test tees (wall cleanouts) in conductors near floor, and floor cleanouts with cover flush with floor.
2. As directed Install horizontal backwater valves with cleanout cover flush with floor or in pit with pit cover flush with floor.
3. As directed Comply with requirements for backwater valves, cleanouts and drains specified in Section 221423 "Storm Drainage Piping Specialties."

D. Where installing piping adjacent to equipment, allow space for service and maintenance.

E. Make connections according to the following unless otherwise indicated:

1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.8 IDENTIFICATION

A. Identify exposed storm drainage piping.

B. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.9 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.
2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Test storm drainage piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired.

    a. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.

2. Leave uncovered and unconcealed new, altered, extended, or replaced storm drainage piping until it has been tested and approved.

    a. Expose work that was covered or concealed before it was tested.

3. Test Procedure:

a. Test storm drainage piping, except outside leaders, on completion of roughing-in.
b. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water (30 kPa). From 15 minutes before inspection starts until completion of inspection, water level must not drop. Inspect joints for leaks.

4. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
5. Prepare reports for tests and required corrective action.

C. Piping will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.10 CLEANING AND PROTECTION

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

3.11 PIPING SCHEDULE

A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.

B. Aboveground storm drainage piping NPS 6 (DN 150) and smaller shall be any of the following:

1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings; As directed CISPI, or heavy-duty, hubless-piping couplings; and coupled joints.
3. As directed Solid-wall or Cellular-core ABS pipe, ABS socket fittings, and solvent-cemented joints.
4. As directed Solid-wall or Cellular-core PVC pipe, PVC socket fittings, and solvent-cemented joints.
5. Dissimilar Pipe-Material Couplings: As directed Unshielded or Shielded, nonpressure transition couplings.

C. Aboveground, storm drainage piping NPS 8 (DN 200) and larger shall be any of the following:

1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings; CISPI, heavy-duty, hubless-piping couplings; and coupled joints.
3. As directed Solid-wall or Cellular-core PVC pipe, PVC socket fittings, and solvent-cemented joints.
4. Dissimilar Pipe-Material Couplings: As directed Unshielded or Shielded, nonpressure transition couplings.

D. Underground storm drainage piping NPS 6 (DN 150) and smaller shall be any of the following:

1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings; As directed CISPI, heavy-duty, cast-iron, hubless-piping couplings; and coupled joints.
3. As directed Solid-wall or Cellular-core ABS pipe, ABS socket fittings, and solvent-cemented joints.
4. As directed Solid-wall or Cellular-core PVC pipe, PVC socket fittings, and solvent-cemented joints.
5. Dissimilar Pipe-Material Couplings: As directed Unshielded or Shielded, nonpressure transition couplings.

E. Underground, storm drainage piping NPS 8 (DN 200) and larger shall be any of the following:

1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings; As directed CISPI, heavy-duty, cast-iron, hubless-piping couplings; and coupled joints.
3. As directed Solid-wall or Cellular-core PVC pipe, PVC socket fittings, and solvent-cemented joints.
4. Cellular-core, sewer and drain series, PVC pipe; PVC socket fittings; and solvent-cemented joints.
5. Dissimilar Pipe-Material Couplings: As directed Unshielded or Shielded, nonpressure transition couplings.

END OF SECTION 221413

SECTION 221423 - STORM DRAINAGE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal roof drains.
2. Miscellaneous storm drainage piping specialties.
3. Cleanouts.
4. Backwater valves.
5. Trench drains.

B. Related Requirements:

1. Section 076200 "Sheet Metal Flashing and Trim" for penetrations of roofs.
2. Section 078413 "Penetration Firestopping" for firestopping roof penetrations.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 QUALITY ASSURANCE

A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

PART 2 - PRODUCTS

2.1 METAL ROOF DRAINS

A. Cast-Iron, Large-Sump, General-Purpose Roof Drains:
1. Standard: ASME A112.6.4.
2. Body Material: Cast iron.
3. Dimension of Body: Nominal 14-to 16-inch (357- to 406-mm) diameter.
4. Combination Flashing Ring and Gravel Stop: As directed Not required or Required.
5. Flow-Control Weirs: As directed, Not required or Required.
6. Outlet: As directed Bottom or Side.
7. Outlet Type: As directed No hub, inside caulk or Threaded.
8. Extension Collars: As directed, Not required or Required.
9. Underdeck Clamp: As directed, Not required or Required.
10. Expansion Joint: As directed, Not required or Required.
11. Sump Receiver Plate: As directed, Not required or Required.
12. Dome Material: As directed, Aluminum, Cast iron or PE or Bronze.

13. Perforated Gravel Guard: As directed, Stainless steel or Not required.
14. Vandal-Proof Dome: As directed, Not required or Required.
15. Water Dam: As directed, not required or 2 inches (50 mm) high.

B. Cast-Iron, Medium-Sump, General-Purpose Roof Drains:
1. Standard: ASME A112.6.4.
2. Body Material: Cast iron.
3. Dimension of Body: 8- to 12-inch (203- to 305-mm) diameter.
4. Combination Flashing Ring and Gravel Stop: As directed Not required or Required.
5. Flow-Control Weirs: As directed, Not required or Required.
6. Outlet: As directed Bottom or Side.
7. Outlet Type: As directed, no hub, inside caulk or Threaded.
8. Extension Collars: As directed, Not required or Required.
9. Underdeck Clamp: As directed, Not required or Required.
10. Expansion Joint: As directed, Not required or Required.
11. Sump Receiver Plate: As directed, Not required or Required.
12. Dome Material: As directed, Aluminum, Cast iron, PE or Bronze.
13. Wire Mesh: As directed, Stainless steel or brass over dome or Not required.
14. Perforated Gravel Guard: As directed, Stainless steel or Not required.
15. Vandal-Proof Dome: As directed, Not required or Required.
16. Water Dam: As directed, Not required or 2 inches (50 mm) high.

C. Cast-Iron, Small-Sump, General-Purpose Roof Drains:
1. Standard: ASME A112.6.4.
2. Body Material: Cast iron.
3. Dimension of Body: Nominal 8-inch (203-mm) diameter.
4. Combination Flashing Ring and Gravel Stop: As directed Not required or Required.
5. Outlet: As directed Bottom or Side.
6. Outlet Type: As directed, no hub, inside caulk or Threaded.
7. Extension Collars: As directed, Not required or Required.
8. Underdeck Clamp: As directed, Not required or Required.
9. Expansion Joint: As directed, Not required or Required.
10. Sump Receiver Plate: As directed, Not required or Required.
11. Dome Material: As directed, Cast iron.
12. Wire Mesh: As directed, Stainless steel or brass over dome or Not required.
13. Vandal-Proof Dome: As directed, Not required or Required.

D. Metal, Cornice and Gutter Roof Drains:
1. Standard: ASME A112.6.4.
2. Body Material: Cast iron.
3. Dimension of Body: Nominal 6-inch (152-mm) diameter.
4. Outlet: As directed Bottom or Side.
5. Outlet Type: Threaded.
6. Dome Material: Bronze.
7. Wire Mesh: As directed, Stainless steel or brass over dome or Not required.
8. Vandal-Proof Dome: As directed, Not required or Required.

E. Metal, Parapet Roof Drains:
1. Standard: ASME A112.6.4.
2. Body Material: As directed, Cast iron.
3. Outlet: As directed, Back or Angle.

4. Outlet Type: Threaded.
5. Grate Material: As directed, Bronze, Cast iron or Nickel-bronze alloy.
6. Wire Mesh: As directed, Stainless steel or brass over grate or Not required.
7. Vandal-Proof Grate: As directed Not required or Required.

F. Metal, Large-Sump, Promenade Roof Drains:
1. Standard: ASME A112.6.4.
2. Body Material: Cast iron.
3. Dimension of Body: Nominal 12- to 14-inch (305- to 357-mm) diameter.
4. Dimension of Frame and Grate: Nominal 12 to 14 inches (305 to 357 mm) square.
5. Outlet: Bottom or Side.
6. Outlet Type: As directed, no hub, inside caulk or Threaded.
7. Grate Material: As directed, Bronze, Cast iron or Nickel-bronze alloy.
8. Vandal-Proof Grate: As directed, Not required or Required.
9. Extension Collars: As directed, Not required or Required.
10. Underdeck Clamp: As directed, Not required or Required.
11. Expansion Joint: As directed, Not required or Required.
12. Sump Receiver Plate: As directed, Not required or Required.

G. Metal, Medium-Sump, Promenade Roof Drains:
1. Standard: ASME A112.6.4.
2. Body Material: Cast iron.
3. Dimension of Body: 11- to 12-inch (280- to 305-mm) diameter.
4. Dimension of Frame and Grate: Nominal 12 inches (305 mm) square.
5. Outlet: As directed Bottom or Side.
6. Outlet Type: As directed, no hub, inside caulk or Threaded.
7. Grate Material: As directed, Bronze, Cast iron or Nickel-bronze alloy.
8. Vandal-Proof Grate: As directed, Not required or Required.
9. Extension Collars: As directed, Not required or Required.
10. Underdeck Clamp: As directed, Not required or Required.
11. Expansion Joint: As directed, Not required or Required.
12. Sump Receiver Plate: As directed, Not required or Required.

H. Metal, Small-Sump, Promenade Roof Drains:
1. Standard: ASME A112.6.4.
2. Body Material: Cast iron.
3. Dimension of Body: Nominal 8-inch (203-mm) diameter.
4. Dimension of Frame and Grate: Nominal 8 inches (203 mm) square.
5. Outlet: Bottom.
6. Outlet Type: As directed No hub, inside caulk or Threaded.
7. Grate Material: As directed Bronze, Cast iron or Nickel-bronze alloy.
8. Vandal-Proof Grate: As directed Not required or Required.
9. Extension Collars: As directed Not required or Required.
10. Underdeck Clamp: As directed Not required or Required.
11. Expansion Joint: As directed Not required or Required.
12. Sump Receiver Plate: As directed Not required or Required.

I. Metal, Medium-Sump, Deck Roof Drains:
1. Standard: ASME A112.6.4.
2. Body Material: Cast iron.
3. Flange: As directed Anchor, Anchor with weep holes or Not required.

4. Clamping Device: As directed, Not required or Required.
5. Integral Backwater Valve: As directed, Not required or Required.
6. Outlet: As directed Bottom or Side.
7. Outlet Type: As directed, no hub, inside caulk or Threaded.
8. Grate Material: Cast or ductile iron.
9. Grate Finish: Not required.
10. Overall Dimension of Frame and Grate: As directed Nominal 12 to 14 inches (305 to 357 mm), round or square.
11. Top-Loading Classification: Heavy Duty.
12. Vandal-Proof Frame and Grate: As directed, Not required or Required.

J. Metal, Small-Sump, Deck Roof Drains:
1. Standard: ASME A112.6.4.
2. Body Material: Metal.
3. Flange: As directed Anchor, Anchor with weep holes or Not required.
4. Clamping Device: As directed, Not required or Required.
5. Integral Backwater Valve: As directed, Not required or Required.
6. Outlet: As directed Bottom or Side.
7. Outlet Type: As directed No hub, inside caulk or Threaded.
8. Grate Material: Cast or ductile iron.
9. Grate Finish: Not required.
10. Overall Dimension of Frame and Grate: As directed, Nominal 8 inches (203 mm), round or square.
11. Top-Loading Classification: As directed.
12. Vandal-Proof Frame and Grate: As directed, Not required or Required.

2.2 MISCELLANEOUS STORM DRAINAGE PIPING SPECIALTIES

A. Downspout Adaptors:

1. Description: Manufactured, gray-iron casting, for attaching to horizontal-outlet, parapet roof drain and to exterior, sheet metal downspout.
2. Size: Inlet size to match parapet drain outlet.

B. Downspout Boots:

1. Description: Manufactured, ASTM A48/A48M, gray-iron casting, with strap or ears for attaching to building; NPS 4 (DN 100) outlet; and shop-applied bituminous coating.
2. Size: Inlet size to match downspout and NPS 4 (DN 100) outlet.

C. Conductor Nozzles:

1. Description: Bronze body with threaded inlet and bronze wall flange with mounting holes.
2. Size: Same as connected conductor.

2.3 CLEANOUTS

A. Cast-Iron Exposed Cleanouts:

1. Standard: ASME A112.36.2M.
2. Size: Same as connected branch.
3. Body Material: As directed, Hub-and-spigot, cast-iron soil pipe T-branch or No-hub, cast-iron soil pipe test tee as required to match connected piping.
4. Closure: As directed, Countersunk, Countersunk or raised-head, raised head, brass, cast-iron or plastic plug.
5. Closure Plug Size: Same as, or not more than, one size smaller than cleanout size.

B. Cast-Iron Exposed Floor Cleanouts:
1. Standard: ASME A112.36.2M.
2. Size: Same as connected branch.
3. Type: As directed, Adjustable housing, Cast-iron soil pipe with cast-iron ferrule, Heavy-duty, adjustable housing or Threaded, adjustable housing.
4. Body or Ferrule: Cast iron.
5. Clamping Device: As directed, Not required or Required.
6. Outlet Connection: As directed, no hub, Hub with inside caulk, Hub with gasket or Threaded.
7. Closure: As directed, Brass plug with straight threads and gasket, Brass plug with tapered threads, Cast-iron plug or Plastic plug.
8. Adjustable Housing Material: As directed, Cast iron or Plastic with threads or setscrews or other devices.
9. Frame and Cover Material and Finish: As directed Nickel-bronze, copper alloy, Painted cast iron, Polished bronze or Rough bronze.
10. Frame and Cover Shape: As directed, Round or Square.
11. Top Loading Classification: As directed, Extra-Heavy, Heavy, Light or Medium Duty.
12. Riser: As directed, ASTM A74, Extra-Heavy or Service class, cast-iron drainage pipe fitting and riser to cleanout.

C. Cast-Iron Wall Cleanouts:
1. Standard: ASME A112.36.2M. Include wall access.
2. Size: Same as connected drainage piping.
3. Body: Hub-and-spigot, cast-iron soil pipe T-branch or No-hub, cast-iron soil pipe test tee as required to match connected piping.
4. Closure Plug:

    a. As directed, Brass or Cast iron.
    b. Countersunk or raised head.
    c. Drilled and threaded for cover attachment screw.
    d. Size: Same as, or not more than, one size smaller than cleanout size.

5. Wall Access: As directed, Round, deep, chrome-plated bronze, flat, chrome-plated brass or stainless-steel cover plate with screw.
6. Wall Access: As directed, Round, Square, nickel-bronze, copper-alloy, or stainless-steel wall-installation frame and cover.

D. Test Tees:
1. Standard: ASME A112.36.2M and ASTM A74, ASTM A888, or CISPI 301.
2. Size: Same as connected drainage piping.
3. Body Material: Hub-and-spigot, cast-iron soil-pipe T-branch or no-hub, cast-iron soil-pipe test tee as required to match connected piping.
4. Closure Plug: Countersunk or raised head, brass.

5. Closure Plug Size: Same as, or not more than, one size smaller than cleanout size.

2.4 BACKWATER VALVES

A. Cast-Iron, Horizontal Backwater Valves:
   1. Standard: ASME A112.14.1.
   2. Size: Same as connected piping.
   3. Body Material: Cast iron.
   4. Cover: Cast iron with bolted or threaded access check valve.
   5. End Connections: Hub and spigot or no hub.
   6. Check Valve: As directed Removable, bronze, swing check, factory assembled or field modified to hang closed or open for airflow unless subject to backflow condition.
   7. Extension: ASTM A74, Service class; full-size, cast-iron soil-pipe extension to field-installed cleanout at floor; replaces backwater valve cover.
   8. Size: Same as connected piping.

2.5 TRENCH DRAINS

A. Trench Drains:
   1. Standard: ASME A112.6.3.
   2. Body Material: Cast iron.
   3. Flange: As directed Anchor, Seepage or Not required.
   4. Clamping Device: As directed, Not required or Required.
   5. Outlet: As directed Bottom, End or Side.
   6. Outlet Type: Inside caulk.
   7. Grate Material: As directed, Ductile iron, cast iron or stainless steel.
   8. Grate Finish: As directed, Painted or Not required.
   9. Dimensions of Frame and Grate: As directed.
   10. Top-Loading Classification: As directed, Extra-Heavy, Heavy, Light or Medium Duty.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions.

   1. Install flashing collar or flange of roof drain to prevent leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
   2. Install expansion joints, if indicated, in roof drain outlets.
   3. Position roof drains for easy access and maintenance.

B. Install downspout adapters on outlet of back-outlet parapet roof drains and connect to sheet metal downspouts.

C. As directed, Install downspout boots at grade with top 6 inches (152 mm), 12 inches (305 mm) or 18 inches (457 mm) above grade. Secure to building wall.

D. Install conductor nozzles at exposed bottom of conductors where they spill onto grade.

E. Install cleanouts in aboveground piping and building drain piping according to the following instructions unless otherwise indicated:

1. Use cleanouts the same size as drainage piping up to NPS 4 (DN 100). Use NPS 4 (DN 100) for larger drainage piping unless larger cleanout is indicated.
2. Locate cleanouts at each change in direction of piping greater than 45 degrees.
3. Locate cleanouts at minimum intervals of 50 feet (15 m) for piping NPS 4 (DN 100) and smaller and 100 feet (30 m) for larger piping.
4. Locate cleanouts at base of each vertical storm piping conductor.

F. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

G. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

H. Install horizontal backwater valves in floor with cover flush with floor.

I. Install test tees in vertical conductors and near floor.

J. Install wall cleanouts in vertical conductors. Install access door in wall if indicated.

K. Install trench drains at low points of surface areas to be drained. Set grates of drains flush with finished surface unless otherwise indicated.

L. Install through-penetration firestop assemblies for penetrations of fire- and smoke-rated assemblies.

1. Comply with requirements in Section 078413 "Penetration Firestopping".

M. Comply with requirements for piping specified in Section 221413 "Facility Storm Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

3.2 FLASHING INSTALLATION

A. Fabricate flashing from single piece of metal unless large pans, sumps, or other drainage shapes are required.

B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.

C. Set flashing on floors and roofs in solid coating of bituminous cement.

D. Secure flashing into sleeve and specialty clamping ring or device.

3.3 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 221423

SECTION 221429 - SUMP PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Submersible sump pumps.
2. Wet-pit-volute sump pumps.
3. Sump-pump basins and basin covers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting or attachment details as directed.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
4. Include diagrams for power, signal, and control wiring.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. UL Compliance: Comply with UL 778 for motor-operated water pumps.

2.2 SUBMERSIBLE SUMP PUMPS

A. Submersible, Fixed-Position, Single-Seal Sump Pumps:
1. Description: Factory-assembled and -tested sump-pump unit.

2. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sump pump as defined in HI 1.1-1.2 and HI 1.3.
3. Pump Casing: Cast iron, with strainer inlet, legs that elevate pump to permit flow into impeller, and vertical discharge for piping connection.
4. Impeller: As directed Statically and dynamically balanced, ASTM A48/A48M, Class No. 25 A cast iron, ASTM A532/A532M, abrasion-resistant cast iron and ASTM B584, cast bronze, semi-open design for clear wastewater handling, and keyed and secured to shaft.
5. Pump and Motor Shaft: Stainless steel or steel, with factory-sealed, grease-lubricated ball bearings.
6. Seal: Mechanical.
7. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.

    a. Motor Housing Fluid: As directed Air or Oil.

8. Controls:

    a. Enclosure: NEMA 250, As directed Type 1 or Type 4X.
    b. Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
    c. Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
    d. Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches (1500 mm).
    e. High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120 V ac, with transformer and contacts for remote alarm bell.

9. Controls:

    a. Enclosure: As directed, NEMA 250, Type 1 or Type 4X; pedestal or wall mounted.
    b. Switch Type: As directed Mechanical-float, Mercury-float or Pressure type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
    c. Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
    d. High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120 V ac, with transformer and contacts for remote alarm bell.

10. Control-Interface Features:

    a. Remote Alarm Contacts: For remote alarm interface.
    b. Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:

        1) On-off status of pump.
        2) Alarm status.

2.3 WET-PIT-VOLUTE SUMP PUMPS

A. Description: Factory-assembled and -tested sump-pump unit.

B. Pump Type: Wet-pit-volute, single-stage, separately coupled, overhung-impeller, centrifugal sump pump as defined in HI 1.1-1.2 and HI 1.3.

C. Pump Casing: Cast iron, with strainer inlet and threaded connection for NPS 2 (DN 50) and smaller and flanged connection for NPS 2-1/2 (DN 65) and larger discharge piping.

D. Impeller: As directed Statically and dynamically balanced, ASTM A48/A48M, Class No. 25 A cast iron, ASTM A532/A532M, abrasion-resistant cast iron and ASTM B584, cast bronze, semi-open design for clear wastewater handling, and keyed and secured to shaft.

E. Sleeve Bearings: Bronze. Include oil-lubricated, intermediate sleeve bearings at 48-inch- (1200-mm-) maximum intervals if basin depth is more than 48 inches (1200 mm), and grease-lubricated, ball-type thrust bearings.

F. Pump and Motor Shaft Coupling: Flexible, capable of absorbing torsional vibration and shaft misalignment.

G. Pump Discharge Piping: As directed Factory or field fabricated, galvanized, ASTM A53/A53M, Schedule 40, steel pipe with ASME B16.1, Class 125, cast-iron flanges and flanged fittings or ASME B16.4, Class 125, gray-iron threaded fittings.

H. Support Plate: Cast iron or coated steel; strong enough to support pumps, motors, and controls. See "Sump-Pump Basins and Basin Covers" Article for requirements.

I. Shaft Seal: Stuffing box, with graphite-impregnated braided-yarn rings and bronze packing gland.

J. Motor: Single speed; grease-lubricated ball bearings and mounting on vertical, cast-iron pedestal.

K. Controls:

1. Enclosure: As directed, NEMA 250, Type 1 or Type 4X.
2. Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
3. Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
4. Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches (1500 mm).
5. High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120 V ac, with transformer and contacts for remote alarm bell.

L. Controls:

1. Enclosure: As directed, NEMA 250, Type 1 or Type 4X; pedestal or wall mounted.
2. Switch Type: As directed, Mechanical-float, Mercury-float or Pressure type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.

3. Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
4. High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120 V ac, with transformer and contacts for remote alarm bell.

M. Control-Interface Features:

1. Remote Alarm Contacts: For remote alarm interface.
2. Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:

a. On-off status of pump.
b. Alarm status.

2.4 SUMP-PUMP CAPACITIES AND CHARACTERISTICS

A. Unit Capacity: As directed, gpm (L/min.).

B. Number of Pumps: As directed. One or Two.

C. Each Pump:

1. Capacity: As directed, gpm (L/min.).
2. Total Dynamic Head: As directed feet (kPa).
3. Speed: As directed.
4. Discharge Size: As directed NPS (DN).
5. Electrical Characteristics:

a. Motor Horsepower: As directed hp.
b. Volts: As directed, 120, 240, 277 or 480 V ac.
c. Phases: As directed, Single or Three.
d. Hertz: 60.

D. Unit Electrical Characteristics:

1. Full-Load Amperes: As directed.
2. Minimum Circuit Ampacity: As directed.
3. Maximum Overcurrent Protection: As directed.

2.5 SUMP-PUMP BASINS AND BASIN COVERS

A. Basins: Factory-fabricated, watertight, cylindrical, basin sump with top flange and sidewall openings for pipe connections.

1. Material: As directed, Cast iron, Fiberglass or Polyethylene.
2. Reinforcement: Mounting plates for pumps, fittings, and accessories.
3. Anchor Flange: Same material as or compatible with basin sump, cast in or attached to sump, in location and of size required to anchor basin in concrete slab.

B. Basin Covers: Fabricate metal cover with openings having gaskets, seals, and bushings; for access to pumps, pump shafts, control rods, discharge piping, vent connections, and power cables.

1. Reinforcement: Steel or cast iron, capable of supporting foot traffic for basins installed in foot-traffic areas.

C. Capacities and Characteristics:

1. Capacity: As directed gal. (L).
2. Diameter: As directed inches (mm).
3. Depth: As directed inches (mm).
4. Inlet No. 1:

    a. Drainage Pipe Size: As directed, NPS (DN).
    b. Bottom of Sump to Centerline: As directed inches (mm).
    c. Type: As directed Flanged, Hubbed or Threaded outside.

5. Inlet No. 2:

    a. Drainage Pipe Size: As directed, NPS (DN).
    b. Bottom of Sump to Centerline: As directed, inches (mm).
    c. Type: As directed Flanged, Hubbed or Threaded outside.

6. Inlet No. 3:

    a. Drainage Pipe Size: As directed, NPS (DN).
    b. Bottom of Sump to Centerline: As directed, inches (mm).
    c. Type: As directed Flanged, Hubbed or Threaded outside.

7. Sidewall Outlet:

    a. Discharge Pipe Size: As directed, NPS (DN).
    b. Bottom of Sump to Centerline: As directed, inches (mm).
    c. Type: As directed, Hubbed inside or Hubbed outside.

8. Cover Material: As directed, Cast iron, Steel with bituminous coating or Cast iron or steel with bituminous coating.
9. Cover Diameter: As directed, Value in inches (mm), but not less than outside diameter of basin top flange.
10. Manhole Required in Cover: As directed, Yes or No.
11. Vent Size: Not required.

2.6 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 220513 "Common Motor Requirements for Plumbing Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

B. Motors for submersible pumps shall be hermetically sealed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Pump Installation Standards: Comply with HI 1.4 for installation of sump pumps.

3.2 CONNECTIONS

A. Comply with requirements for piping specified in Section 221413 "Facility Storm Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to equipment, allow space for service and maintenance.

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Perform each visual and mechanical inspection.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Pumps and controls will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 221429

SECTION 221463 - FACILITY STORM-WATER RETENTION TANKS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Steel, non-pressure tanks.
2. Plastic, non-pressure tanks.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting or attachment details as directed.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of storm-water retention tanks.

C. Delegated-Design Submittal: For storm-water retention tanks.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For facility storm-water retention tanks, accessories, and components, from manufacturer.

B. Welding certificates.

1.4 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."
3. AWS D1.4/D1.4M, "Structural Welding Code - Reinforcing Steel."

B. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design facility storm-water retention tanks.

B. Structural Performance: Facility storm-water retention tank, including structural reinforcement and foundation, shall be capable of withstanding the effects of dead and live gravity loads and winds of 100 mph (161 km/h).

C. Seismic Performance: Facility storm-water retention tank, including structural reinforcement and foundation, shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the system will remain in place without separation of any parts when subjected to the seismic forces specified and the system will be fully operational after the seismic event."

D. Thermal Movements: Storm-water retention tank, including structural reinforcement and foundation, shall allow for thermal movements from ambient and surface temperature changes by preventing buckling, opening of joints, overstressing of components, failure of connections, and other detrimental effects. Base engineering calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.

1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.2 STEEL, NONPRESSURE, STORM-WATER RETENTION TANKS

A. Description: As directed Steel, horizontal or vertical, non-pressure-rated tank with cylindrical sidewalls.

B. Fabricate supports and attachments to tank with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure.

C. Construction: Steel, constructed with welded joints.

1. Comply with AWWA D100, "Welded Steel Tanks for Water Storage," and with AWWA M42, "Steel Water-Storage Tanks," for welded-steel, surface-water retention tanks.

D. Manhole: Watertight, for tank more than 36 inches (900 mm) in diameter.

E. Cover for Open Tank: As directed Plastic or Steel, with lining same as or similar to tank lining and with shape that encloses top of tank.

F. Tappings: Factory-fabricated stainless steel, welded to tank.

1. NPS 2 (DN 50) and Smaller: ASME B1.20.1, with female thread.

2. NPS 2-1/2 (DN 65) and Larger: ASME B16.5, flanged.

G. Specialties and Accessories: Include tappings in tank and the following:

1. Vacuum relief valve.
2. Free air vent with insect screen.
3. Thermometer.
4. Gage glass, brass fittings, compression stops, and gage-glass guard.

H. Horizontal Tank Supports: Factory-fabricated steel saddles, welded to tank before testing and labeling.

I. Vertical Tank Supports: Factory-fabricated steel legs or steel skirt, welded to tank before testing and labeling.

1. Lining Material: As directed Cement or Copper.
2. Coating: As directed Epoxy resin, Galvanized, Glass or Nickel.

J. Exterior Coating: As directed, Galvanized, Manufacturer's standard enamel paint or Primer paint.

2.3 PLASTIC, NONPRESSURE, STORM-WATER RETENTION TANKS

A. FRP Water Retention Tanks:
1. Description: FRP, vertical, non-pressure-rated water tank.
2. Construction: ASTM D3299, filament-wound or ASTM D4097, contact-molded FRP.
3. Tappings: Factory-fabricated, FRP flanged-end nozzle.

a. NPS 2 (DN 50) and Smaller: Include plastic-to-steel transition fitting from tank nozzle flange to ASME B1.20.1, female thread.

1) Exception: Tappings may be threaded FRP coupling integral with nozzle for connections for plastic piping.

b. NPS 2-1/2 (DN 65) and Larger: Flanged.

4. Vertical Tank Support: Separate factory-fabricated steel stand capable of supporting tank.
5. Manhole: Watertight, for tank more than 36 inches (915 mm) in diameter.
6. Cover for Open Tank: Plastic, same as or similar to tank material and with shape that encloses top of tank.
7. Specialties and Accessories: Include tappings in tank and the following:

a. Vacuum relief valve.
b. Free air vent with insect screen.
c. Thermometer.
d. Gage glass, brass fittings, compression stops, and gage-glass guard.

B. PE Water Retention Tanks:
1. Description: PE, vertical, flat-bottom, non-pressure-rated water tank.
2. Construction: ASTM D1998, molded PE.

3. Tappings: Factory-fabricated bulkhead fittings attached to tank.

    a. NPS 2 (DN 50) and Smaller: With female thread.
    b. NPS 2-1/2 (DN 65) and Larger: Flanged.

4. Vertical Tank Support: Separate factory-fabricated steel stand capable of supporting entire bottom of tank.
5. Manhole: Watertight, for tank more than 36 inches (915 mm) in diameter.
6. Cover for Open Tank: Plastic, same as or similar to tank material and with shape that encloses top of tank.
7. Specialties and Accessories: Include tappings in tank and the following:

    a. Vacuum relief valve.
    b. Free air vent with insect screen.
    c. Thermometer.
    d. Gage glass, brass fittings, compression stops, and gage-glass guard.

2.4 PAINT MATERIALS

A. Paint: Comply with AWWA D102.

B. Primer: Tank fabricator's standard epoxy-polyamide paint.

C. Tank Shell Exterior Intermediate Paint: Tank fabricator's standard, two-component epoxy paint compatible with prime and finish paint. Intermediate coat shall have a slight color contrast with finish coat.

D. Tank Shell Exterior Finish Paint: Tank fabricator's standard urethane paint.

1. Color: As selected by Owner from tank manufacturer's paint chart.

2.5 SHOP PAINTING

A. Tank Shell Exterior Finish Coat: Factory coating according to AWWA D103.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install storm-water retention tanks on concrete bases, level and plumb, firmly anchored. Arrange so devices needing servicing are accessible.

1. As directed, Install horizontal tanks on concrete piers and factory-fabricated or fabricated steel supports and saddles.

B. Anchor tank supports and tanks to substrate.

1. Use steel or FRP straps over or around plastic tanks.

C. Install thermometers and pressure gages on water retention tanks and piping if indicated. Thermometers and pressure gages are specified in Section 220519 "Meters and Gages for Plumbing Piping."

D. Install the following devices on tanks where indicated:

1. Pressure relief valves.
2. Temperature and pressure relief valves.
3. Vacuum relief valves.
4. Tank vents on nonpressure tanks.
5. Connections to accessories.

E. After installing tanks with factory finish, inspect finishes and repair damages to finishes.

3.2 CONNECTIONS

A. Where installing piping adjacent to storm-water retention tanks, allow space for service and maintenance.

B. Connect water piping to water retention tanks with unions or flanges and with shutoff valves. Connect tank drains with shutoff valves and discharge over closest floor drains.

1. Valves NPS 2 (DN 50) and Smaller: Gate valves complying with requirements in Section 220523.15 "Gate Valves for Plumbing Piping," or ball valves complying with Section 220523.12 "Ball Valves for Plumbing Piping."
2. Valves NPS 2-1/2 (DN 65) and Larger: Gate valves complying with requirements in Section 220523.15 "Gate Valves for Plumbing Piping," or butterfly valves complying with requirements in Section 220523.13 "Butterfly Valves for Plumbing Piping."
3. Drain Valves: NPS 3/4 (DN 20) Gate valves complying with requirements in Section 220523.15 "Gate Valves for Plumbing Piping," or ball valves complying with Section 220523.12 "Ball Valves for Plumbing Piping." Include outlet with, or nipple in outlet with, ASME B1.20.7, 3/4-11.5NH thread for garden-hose service, threaded cap, and chain.
4. Water Piping Connections: Make connections to dissimilar metals with dielectric fittings. Dielectric fittings are specified in Section 221116 "Domestic Water Piping."

3.3 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

END OF SECTION 221463

SECTION 221513 - GENERAL-SERVICE COMPRESSED-AIR PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes piping and related specialties for general-service compressed-air systems operating at 150 psig (1035 kPa) or less.

B. See Section 221519 "General-Service Packaged Air Compressors and Receivers" for general-service air compressors and accessories.

1.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Compressed-air piping and support and installation shall withstand effects of seismic events determined according to SEI/ASCE 7, "Minimum Design Loads for Buildings and Other Structures."

1.3 ACTION SUBMITTALS

A. Product Data: For the following:

1. Pressure regulators. Include rated capacities and operating characteristics.
2. Automatic drain valves.
3. Filters. Include rated capacities and operating characteristics.
4. Lubricators. Include rated capacities and operating characteristics.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control test reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for low-pressure compressed-air piping.

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: As directed, ASTM A53/A53M, Type E or S, Grade B, black or hot-dip zinc coated with ends threaded according to ASME B1.20.1.

1. Steel Nipples: ASTM A733, made of ASTM A53/A53M or ASTM A106, Schedule 40, galvanized seamless steel pipe. Include ends matching joining method.
2. Malleable-Iron Fittings: ASME B16.3, Class 150 or 300, threaded.
3. Malleable-Iron Unions: ASME B16.39, Class 150 or 300, threaded.
4. Steel Flanges: ASME B16.5, Class 150 or 300, carbon steel, threaded.
5. Wrought-Steel Butt-Welding Fittings: ASME B16.9, Schedule 40.
6. Steel Flanges: ASME B16.5, Class 150 or 300, carbon steel.

B. Copper Tube: ASTM B88, Type K or L (ASTM B88M, Type A or B) and ASTM B88, Type M (ASTM B88M, Type C) seamless, drawn-temper, water tube.

1. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type or MSS SP-73, wrought copper with dimensions for brazed joints.
2. Cast-Copper-Alloy Flanges: ASME B16.24, Class 150 or 300.
3. Copper Unions: ASME B16.22 or MSS SP-123.

C. Transition Couplings for Metal Piping: Metal coupling or other manufactured fitting same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

D. PVC Pipe: ASTM D1785, Schedule 40.

1. PVC Fittings: ASTM D2466, Schedule 40, socket type.

2.2 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for compressed-air piping system contents.

1. ASME B16.21, nonmetallic, flat, full-face, asbestos free, 1/8-inch (3.2-mm) maximum thickness.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Solder Filler Metals: ASTM B32, lead-free alloys. Include water-flushable flux according to ASTM B813.

D. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated.

E. Solvent Cements for Joining PVC Piping: ASTM D2564. Include primer complying with ASTM F656.

2.3 VALVES

A. Metal Ball, Butterfly, Check, and Gate Valves: Comply with requirements in Section 220523.12 "Ball Valves for Plumbing Piping," Section 220523.13 "Butterfly Valves for Plumbing Piping," Section 220523.14 "Check Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping."

2.4 DIELECTRIC FITTINGS

A. General Requirements for Dielectric Fittings: Combination fitting of copper alloy and ferrous materials with insulating material; suitable for system fluid, pressure, and temperature. Include threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Dielectric Unions: Factory-fabricated union assembly, for 250-psig (1725-kPa) minimum working pressure at 180 deg F (82 deg C).

2.5 FLEXIBLE PIPE CONNECTORS

A. Bronze-Hose Flexible Pipe Connectors: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.

1. Working-Pressure Rating: 200 psig (1380 kPa) minimum.
2. End Connections, NPS 2 (DN 50) and Smaller: Threaded copper pipe or plain-end copper tube.
3. End Connections, NPS 2-1/2 (DN 65) and Larger: Flanged copper alloy.

B. Stainless-Steel-Hose Flexible Pipe Connectors: Corrugated-stainless-steel tubing with stainless-steel wire-braid covering and ends welded to inner tubing.

1. Working-Pressure Rating: 200 psig (1380 kPa) minimum.
2. End Connections, NPS 2 (DN 50) and Smaller: Threaded steel pipe nipple.
3. End Connections, NPS 2-1/2 (DN 65) and Larger: Flanged steel nipple.

2.6 SPECIALTIES

A. Safety Valves: ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," construction; National Board certified, labeled, and factory sealed; constructed of bronze body with poppet-type safety valve for compressed-air service.

1. Pressure Settings: Higher than discharge pressure and same or lower than receiver pressure rating.

B. Air-Main Pressure Regulators: Bronze body, pilot-operated direct acting, spring-loaded manual pressure-setting adjustment, and rated for 250-psig (1725-kPa) inlet pressure, unless otherwise indicated.

C. Air-Line Pressure Regulators: As directed, Diaphragm, Diaphragm or pilot or Pilot operated, bronze body, direct acting, spring-loaded manual pressure-setting adjustment, and rated for 200-psig (1380-kPa) minimum inlet pressure, unless otherwise indicated.

D. Automatic Drain Valves: Stainless-steel body and internal parts, rated for 200-psig (1380-kPa) minimum working pressure, capable of automatic discharge of collected condensate. Include mounting bracket if wall mounting is indicated.

E. Coalescing Filters: Coalescing type with activated carbon capable of removing water and oil aerosols; with color-change dye to indicate when carbon is saturated and warning light to indicate when selected maximum pressure drop has been exceeded. Include mounting bracket if wall mounting is indicated.

F. Mechanical Filters: Two-stage, mechanical-separation-type, air-line filters. Equip with deflector plates, resin-impregnated-ribbon-type filters with edge filtration and drain cock. Include mounting bracket if wall mounting is indicated.

2.7 QUICK COUPLINGS

A. General Requirements for Quick Couplings: Assembly with locking-mechanism feature for quick connection and disconnection of compressed-air hose.

B. Automatic-Shutoff Quick Couplings: Straight-through brass body with O-ring or gasket seal and stainless-steel or nickel-plated-steel operating parts.

1. Socket End: With one-way valve and threaded inlet for connection to piping or threaded hose fitting.
2. Plug End: As directed Flow-sensor-bleeder, check-valve or Straight-through type with barbed outlet for attaching hose.

C. Valveless Quick Couplings: Straight-through brass body with stainless-steel or nickel-plated-steel operating parts.

1. Socket End: With O-ring or gasket seal, without valve, and with barbed inlet for attaching hose.
2. Plug End: With barbed outlet for attaching hose.

2.8 HOSE ASSEMBLIES

A. Description: Compatible hose, clamps, couplings, and splicers suitable for compressed-air service, of nominal diameter indicated, and rated for 300-psig (2070-kPa) minimum working pressure, unless otherwise indicated.

1. Hose: As directed Reinforced single, single- or double or double-wire-braid, CR-covered hose for compressed-air service.
2. Hose Clamps: Stainless-steel clamps or bands.
3. Hose Couplings: Two-piece, straight-through, threaded brass or stainless-steel O-ring or gasket-seal swivel coupling with barbed ends for connecting two sections of hose.
4. Hose Splicers: One-piece, straight-through brass or stainless-steel fitting with barbed ends for connecting two sections of hose.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Compressed-Air Piping between Air Compressors and Receivers: Use one of the following piping materials for each size range:

1. NPS 2 (DN 50) and Smaller: Steel pipe; threaded, malleable-iron fittings; and threaded joints.
2. NPS 2 (DN 50) and Smaller: Type K or L (Type A or B), copper tube; wrought-copper fittings; and brazed joints.

B. Low-Pressure Compressed-Air Distribution Piping: Use one of the following piping materials for each size range:

1. NPS 2 (DN 50) and Smaller: Steel pipe; threaded, malleable-iron fittings; and threaded joints.
2. NPS 2 (DN 50) and Smaller: Type K or L (Type A or B), copper tube; wrought-copper fittings; and brazed or soldered joints.

C. Drain Piping: Use one of the following piping materials:

1. NPS 2 (DN 50) and Smaller: Type M (Type C) copper tube; wrought-copper fittings; and brazed or soldered joints.
2. NPS 2 (DN 50) and Smaller: PVC pipe and fittings; and solvent-cemented joints.

3.2 VALVE APPLICATIONS

A. Comply with requirements in "Valve Applications" Article in Section 220523.12 "Ball Valves for Plumbing Piping," Section 220523.13 "Butterfly Valves for Plumbing Piping," Section 220523.14 "Check Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping."

B. Equipment Isolation Valves: Safety-exhaust, copper-alloy ball valve with exhaust vent and pressure rating at least as great as piping system operating pressure.

3.3 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of compressed-air piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, air-compressor sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping concealed from view and protected from physical contact by building occupants, unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited, unless otherwise indicated.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and to coordinate with other services occupying that space.

E. Install piping adjacent to equipment and machines to allow service and maintenance.

F. Install air and drain piping with 1 percent slope downward in direction of flow.

G. Install nipples, flanges, unions, transition and special fittings, and valves with pressure ratings same as or higher than system pressure rating, unless otherwise indicated.

H. Equipment and Specialty Flanged Connections:

1. Use steel companion flange with gasket for connection to steel pipe.
2. Use cast-copper-alloy companion flange with gasket and brazed or soldered joint for connection to copper tube. Do not use soldered joints for connection to air compressors or to equipment or machines producing shock or vibration.

I. Install branch connections to compressed-air mains from top of main. Provide drain leg and drain trap at end of each main and branch and at low points.

J. Install thermometer and pressure gage on discharge piping from each air compressor and on each receiver. Comply with requirements in Section 220519 "Meters and Gages for Plumbing Piping."

K. Install piping to permit valve servicing.

L. Install piping free of sags and bends.

M. Install fittings for changes in direction and branch connections.

N. Install seismic restraints on piping. Seismic-restraint devices are specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

O. Install unions, adjacent to each valve and at final connection to each piece of equipment and machine.

P. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

Q. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

R. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.4 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from pipe and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Apply appropriate tape or thread compound to external pipe threads.

D. Brazed Joints for Copper Tubing: Join according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.

E. Soldered Joints: Apply ASTM B813, water-flushable flux, unless otherwise indicated, to tube end. Join according to ASTM B828 or CDA's "Copper Tube Handbook."

F. Flanged Joints: Use asbestos-free, nonmetallic gasket suitable for compressed air. Join flanges with gasket and bolts according to ASME B31.9 for bolting procedure.

G. Solvent-Cemented Joints for PVC Piping: Clean and dry joining surfaces. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements. Apply primer and join according to ASME B31.9 for solvent-cemented joints and to ASTM D2672.

H. Dissimilar Metal Piping Material Joints: Use dielectric fittings.

3.5 VALVE INSTALLATION

A. General-Duty Valves: Comply with requirements in Section 220523.12 "Ball Valves for Plumbing Piping," Section 220523.13 "Butterfly Valves for Plumbing Piping," Section 220523.14 "Check Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping."

B. Install shutoff valves and unions or flanged joints at compressed-air piping to air compressors.

C. Install shutoff valve at inlet to each automatic drain valve, filter, lubricator, and pressure regulator.

D. Install check valves to maintain correct direction of compressed-air flow to and from compressed-air piping specialties and equipment.

3.6 DIELECTRIC FITTING INSTALLATION

A. Install dielectric unions in piping at connections of dissimilar metal piping and tubing.

3.7 FLEXIBLE PIPE CONNECTOR INSTALLATION

A. Install flexible pipe connectors in discharge piping and in inlet air piping from remote air-inlet filter of each air compressor.

B. Install bronze-hose flexible pipe connectors in copper compressed-air tubing.

C. Install stainless-steel-hose flexible pipe connectors in steel compressed-air piping.

3.8 SPECIALTY INSTALLATION

A. Install safety valves on receivers in quantity and size to relieve at least the capacity of connected air compressors.

B. Install air-main pressure regulators in compressed-air piping at or near air compressors.

C. Install air-line pressure regulators in branch piping to equipment.

D. Install automatic drain valves on aftercoolers, receivers, and dryers. Discharge condensate onto nearest floor drain.

E. Install coalescing filters in compressed-air piping at or near air compressors and upstream from mechanical filters. Mount on wall at locations indicated.

F. Install mechanical filters in compressed-air piping at or near air compressors and downstream from coalescing filters. Mount on wall at locations indicated.

G. Install quick couplings at piping terminals for hose connections.

H. Install hose assemblies at hose connections.

3.9 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.

B. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices.

C. Vertical Piping: MSS Type 8 or 42, clamps.

D. Individual, Straight, Horizontal Piping Runs:

1. 100 Feet (30 m) or Less: MSS Type 1, adjustable, steel clevis hangers.
2. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.

E. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.

F. Base of Vertical Piping: MSS Type 52, spring hangers.

G. Support horizontal piping within 12 inches (300 mm) of each fitting and coupling.

H. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.

I. Install hangers for Schedule 40, steel piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1/4 to NPS 1/2 (DN 8 to DN 15): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.

2. NPS 3/4 to NPS 1-1/4 (DN 20 to DN 32): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
3. NPS 1-1/2 (DN 40): 12 feet (3.7 m) with 3/8-inch (10-mm) rod.
4. NPS 2 (DN 50): 13 feet (4 m) with 3/8-inch (10-mm) rod.

J. Install supports for vertical, Schedule 40, steel piping every 15 feet (4.6 m).

K. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1/4 (DN 8): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
2. NPS 3/8 and NPS 1/2 (DN 10 and DN 15): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
3. NPS 3/4 (DN 20): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
4. NPS 1 (DN 25): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
5. NPS 1-1/4 (DN 32): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
6. NPS 1-1/2 (DN 40): 10 feet (3 m) with 3/8-inch (10-mm) rod.
7. NPS 2 (DN 50): 11 feet (3.4 m) with 3/8-inch (10-mm) rod.

L. Install supports for vertical copper tubing every 10 feet (3 m).

3.10 LABELING AND IDENTIFICATION

A. Install identifying labels and devices for general-service compressed-air piping, valves, and specialties. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment."

3.11 FIELD QUALITY CONTROL

A. Perform field tests and inspections.

B. Tests and Inspections:

1. Piping Leak Tests: Test new and modified parts of existing piping. Cap and fill general-service compressed-air piping with oil-free dry air or gaseous nitrogen to pressure of 50 psig (345 kPa) above system operating pressure, but not less than 150 psig (1035 kPa). Isolate test source and let stand for four hours to equalize temperature. Refill system, if required, to test pressure; hold for two hours with no drop in pressure.
2. Repair leaks and retest until no leaks exist.
3. Inspect As directed filters, lubricators and or pressure regulators for proper operation.

END OF SECTION 221513

SECTION 221519 - GENERAL-SERVICE PACKAGED AIR COMPRESSORS AND RECEIVERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Lubricated, reciprocating air compressors.
2. Oil-flooded, rotary-screw air compressors.
3. Oil-sealed, rotary, sliding-vane air compressors.
4. Inlet-air filters.
5. Air-cooled, compressed-air aftercoolers.
6. Refrigerant compressed-air dryers.

1.2 DEFINITIONS

A. Actual Air: Air delivered from air compressors. Flow rate is delivered compressed air measured in acfm (actual L/s).

B. Standard Air: Free air at 68 deg F (20 deg C) and 1 atmosphere (29.92 in. Hg) before compression or expansion and measured in scfm (standard L/s).

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Diagrams for power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASME Compliance: Fabricate and label receivers to comply with ASME Boiler and Pressure Vessel Code.

2.2 GENERAL REQUIREMENTS FOR PACKAGED AIR COMPRESSORS AND RECEIVERS

A. General Description: Factory-assembled, -wired, -piped, and -tested; electric-motor-driven; air-cooled; continuous-duty air compressors and receivers that deliver air of quality equal to intake air.

B. Control Panels: Automatic control station with load control and protection functions. Comply with NEMA ICS 2 and UL 508.

1. Enclosure: NEMA ICS 6, Type 12 control panel unless otherwise indicated.
2. Motor Controllers: Full-voltage, combination magnetic type with undervoltage release feature and motor-circuit-protector-type disconnecting means and short-circuit protective device.
3. Control Voltage: 120-V ac or less, using integral control power transformer.
4. Motor Overload Protection: Overload relay in each phase.
5. Starting Devices: Hand-off-automatic selector switch in cover of control panel, plus pilot device for automatic control.
6. As directed Automatic control switches to alternate lead-lag compressors for duplex or sequence lead-lag compressors for multiplex air compressors.
7. Instrumentation: Include discharge-air pressure gage, air-filter maintenance indicator, hour meter, compressor discharge-air and coolant temperature gages, and control transformer.
8. Alarm Signal Device: For connection to alarm system to indicate when backup air compressor is operating.

C. Receivers: Steel tank constructed according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

1. Pressure Rating: At least as high as highest discharge pressure of connected compressors and bearing appropriate code symbols.
2. Interior Finish: Corrosion-resistant coating.
3. Accessories: Include safety valve, pressure gage, drain, and pressure-reducing valve.

D. Mounting Frame: Fabricate mounting and attachment to pressure vessel with reinforcement strong enough to resist packaged equipment movement during a seismic event when base is anchored to building structure.

2.3 LUBRICATED, RECIPROCATING AIR COMPRESSORS

A. Compressor(s): Lubricated, reciprocating-piston type with lubricated compression chamber and crankcase.

1. Submerged gear-type oil pump.
2. Oil filter.
3. Combined high discharge-air temperature and low lubrication-oil pressure switch.
4. Belt guard totally enclosing pulleys and belts.

B. Capacities and Characteristics:

1. Air Compressor(s): As directed One, Two or Three; single, single or two or two stage.

    a. Intercooler between stages of two-stage units.

2. Standard-Air Capacity of Each Air Compressor: As directed free air.
3. Actual-Air Capacity of Each Air Compressor: As directed delivered.
4. Discharge-Air Pressure: As directed, 100 psig (690 kPa), 125 psig (860 kPa) or 175 psig (1200 kPa).
5. Intake-Air Temperature: As directed.
6. Discharge-Air Temperature: As directed.
7. Mounting: As directed Freestanding or Tank mounted.
8. Motor (Each Air Compressor):

    a. Horsepower: As directed.
    b. Speed: As directed 1750 or 3400 rpm.

9. Electrical Characteristics:

    a. Volts: As directed 120, 208 or 240.
    b. Phase(s): As directed, Single or Three.
    c. Hertz: 60.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed.
    f. Maximum Overcurrent Protection: As directed.

10. Receiver: ASME construction steel tank.

    a. Arrangement: As directed, Horizontal or Vertical.
    b. Capacity: As directed.
    c. Interior Finish: As directed, Epoxy, Epoxy or galvanized or Galvanized coating.
    d. Pressure Rating: As directed, 100 psig (690 kPa), 125 psig (860 kPa), 150 psig (1035 kPa), 200 psig (1380 kPa) or 250 psig (1725 kPa) minimum.
    e. Pressure Regulator Setting: As directed.
    f. Pressure Relief Valve Setting: As directed.
    g. Drain: As directed Automatic or Manual valve.

2.4 OIL-FLOODED, ROTARY-SCREW AIR COMPRESSORS

A. Compressor(s): Oil-flooded, rotary-screw type with lubricated helical screws and lubricated gear box.

1. Coupling: Nonlubricated, flexible type.
2. Cooling/Lubrication System: Unit-mounted, air-cooled exchanger package pre-piped to unit; with air pressure circulation system with coolant stop valve, full-flow coolant filter, and thermal bypass valve.
3. Air Filter: Dry type, with maintenance indicator and cleanable, replaceable filter element.
4. Air/Coolant Receiver and Separation System: 150-psig- (1035-kPa-) rated steel tank with ASME safety valve, coolant-level gage, multistage air-coolant separator element,

minimum pressure valve, blowdown valve, discharge check valve, coolant stop valve, full-flow coolant filter, and thermal bypass valve.

5. Capacity Control: Capacity modulation between zero and 100 percent air delivery, with operating pressures between 50 and 100 psig (345 and 690 kPa). Include necessary control to hold constant pressure. When air demand is zero, unload compressor by using pressure switch and blowdown valve.

B. Capacities and Characteristics:

1. Air Compressor(s): As directed, One or Two; single, single or two or two stage.
2. Standard-Air Capacity of Each Air Compressor: As directed free air.
3. Actual-Air Capacity of Each Air Compressor: As directed delivered.
4. Discharge-Air Pressure: As directed, 100 psig (690 kPa), 125 psig (860 kPa), 175 psig (1200 kPa) or 200 psig (1380 kPa).
5. Intake-Air Temperature: As directed.
6. Discharge-Air Temperature: As directed.
7. Motor (Each Air Compressor):

    a. Horsepower: As directed.
    b. Speed: As directed 1750 or 3400 rpm.

8. Electrical Characteristics:

    a. Volts: As directed.
    b. Phase(s): As directed, Single or Three.
    c. Hertz: 60.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed.
    f. Maximum Overcurrent Protection: As directed.

9. Receiver: ASME construction steel tank.

    a. Arrangement: As directed, Horizontal or Vertical.
    b. Capacity: As directed.
    c. Interior Finish: As directed, Epoxy, Epoxy or galvanized or Galvanized coating.
    d. Pressure Rating: As directed, 100 psig (690 kPa), 125 psig (860 kPa), 150 psig (1035 kPa), 200 psig (1380 kPa) or 250 psig (1725 kPa) minimum.
    e. Pressure Regulator Setting: As directed.
    f. Pressure Relief Valve Setting: As directed.
    g. Drain: As directed Automatic or Manual valve.

10. Enclosure: Steel with sound-attenuating material lining.

2.5 OIL-SEALED, ROTARY, SLIDING-VANE AIR COMPRESSORS

A. Compressor(s): Nonpulsating, rotary, sliding-vane type with oil-sealed sliding vanes.

1. Cleanable inlet screens.
2. Outlet silencers and oil-mist separators on discharge connections.

B. Capacities and Characteristics:

1. Air Compressor(s): As directed, One or Two; single stage.
2. Standard-Air Capacity of Each Air Compressor: As directed, free air.
3. Actual-Air Capacity of Each Air Compressor: As directed, delivered.
4. Discharge-Air Pressure: As directed, 20 psig (138 kPa), 25 psig (173 kPa), 30 psig (207 kPa), 100 psig (690 kPa) or 125 psig (860 kPa).
5. Intake-Air Temperature: As directed.
6. Discharge-Air Temperature: As directed.
7. Mounting: As directed Freestanding or Tank mounted.
8. Motor (Each Air Compressor):

    a. Horsepower: As directed.
    b. Speed: As directed 1750 or 3400 rpm.

9. Electrical Characteristics:

    a. Volts: As directed.
    b. Phase(s): As directed, Single or Three.
    c. Hertz: 60 As directed.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed.
    f. Maximum Overcurrent Protection: As directed.

10. Receiver: ASME construction steel tank.

    a. Arrangement: As directed, Horizontal or Vertical.
    b. Capacity: As directed.
    c. Interior Finish: As directed, Epoxy, Epoxy or galvanized or Galvanized coating.
    d. Pressure Rating: As directed, 100 psig (690 kPa), 125 psig (860 kPa) or 150 psig (1035 kPa) minimum.
    e. Pressure Regulator Setting: As directed.
    f. Pressure Relief Valve Setting: As directed.
    g. Drain: As directed Automatic or Manual valve.

2.6 INLET-AIR FILTERS

A. Description: Combination inlet-air filter-silencer, suitable for remote installation, for each air compressor.

1. Construction: Weatherproof housing for replaceable, dry-type filter element, with silencer tubes or other method of sound reduction.
2. Capacity: Match capacity of air compressor, with filter having collection efficiency of 99 percent retention of particles larger than 10 micrometers.

B. Description: Combination inlet-air filter-silencer, suitable for remote installation, for multiple air compressors.

1. Construction: Weatherproof housing for replaceable, dry-type filter element, with silencer tubes or other method of sound reduction.

2. Capacity: Match total capacity of connected air compressors, with filter having collection efficiency of 99 percent retention of particles larger than 10 micrometers.

2.7 AIR-COOLED, COMPRESSED-AIR AFTERCOOLERS

A. Description: Electric-motor-driven, fan-operation, finned-tube unit; rated at 250 psig (1725 kPa) and leak tested at 350-psig (2415-kPa) minimum air pressure; in capacities indicated. Size units to cool compressed air in compressor-rated capacities to 10 deg F (6 deg C) above summertime maximum ambient temperature. Include moisture separator and automatic drain.

B. Capacities and Characteristics:

1. Standard-Air Capacity of Each Aftercooler: As directed free air.
2. Pressure: As directed.
3. Entering, Compressed-Air Temperature: As directed.
4. Leaving, Compressed-Air Temperature: As directed.
5. Ambient-Air Temperature: As directed.
6. Maximum Compressed-Air-Pressure Drop: As directed.
7. Motor Horsepower: As directed.
8. Electrical Characteristics:

    a. Volts: As directed.
    b. Phase(s): As directed, Single or Three.
    c. Hertz: 60.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed.
    f. Maximum Overcurrent Protection: As directed.

2.8 REFRIGERANT COMPRESSED-AIR DRYERS

A. Description: Noncycling, air-cooled, electric-motor-driven unit with steel enclosure and capability to deliver 35 deg F (2 deg C), 100-psig (690-kPa) air at dew point. Include automatic ejection of condensate from airstream, step-down transformers, disconnect switches, inlet and outlet pressure gages, thermometers, automatic controls, and filters.

B. Capacities and Characteristics:

1. Standard-Air Capacity of Each Compressed-Air Dryer: free air.
2. Pressure: As directed.
3. Entering-Air Temperature: As directed.
4. Leaving-Air Temperature: As directed.
5. Leaving-Air Dew Point Temperature: As directed.
6. Ambient-Air Temperature: As directed.
7. Maximum Air-Pressure Drop: As directed.
8. Inlet Filter: 5 micrometers.
9. Outlet Filter: 1 micrometer(s).
10. Motor Horsepower: As directed.
11. Electrical Characteristics:

a. Volts: As directed.
b. Phase(s): As directed, Single or Three.
c. Hertz: 60.
d. Full-Load Amperes: As directed.
e. Minimum Circuit Ampacity: As directed.
f. Maximum Overcurrent Protection: As directed.

2.9 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 220513 "Common Motor Requirements for Plumbing Equipment."

1. Enclosure: As directed Open, dripproof, totally enclosed, fan cooled, totally enclosed, air over, Open, externally ventilated, totally enclosed, nonventilated, Severe duty, Explosion proof or Dust-ignition-proof machine.
2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load does not require motor to operate in service factor range above 1.0.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

A. Equipment Mounting:

1. As directed, install air compressors and aftercoolers and air dryers, aftercoolers, and air dryers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" As directed.
2. As directed, install water-cooled, compressed-air aftercoolers and desiccant compressed-air dryers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" As directed
3. Comply with requirements for vibration isolation and seismic control devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment"
4. Comply with requirements for vibration isolation devices specified in Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."

B. Install compressed-air equipment anchored to substrate.

C. Arrange equipment so controls and devices are accessible for servicing.

D. Maintain manufacturer's recommended clearances for service and maintenance.

E. Install the following devices on compressed-air equipment:

1. Thermometer, Pressure Gage, and Safety Valve: Install on each compressed-air receiver.

2. Pressure Regulators: Install downstream from air compressors and dryers.
3. Automatic Drain Valves: Install on aftercoolers, receivers, and dryers. Discharge condensate over nearest floor drain.

3.2 CONNECTIONS

A. Comply with requirements for piping specified in Section 221513 "General-Service Compressed-Air Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to machine, allow space for service and maintenance.

3.3 IDENTIFICATION

A. Identify general-service air compressors and components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or train Owner's maintenance personnel to adjust, operate, and maintain air compressors and aftercoolers and air dryers, aftercoolers, and air dryers.

END OF SECTION 221519

SECTION 223100 - DOMESTIC WATER SOFTENERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Water softeners.
2. Chemicals.
3. Water-testing sets.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for water softeners, accessories, and components, from manufacturer.

B. Source quality-control reports.

C. Field quality-control reports.

D. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of water softeners that fail in materials or workmanship within specified warranty period.

1. Water Softeners, Warranty Period: From date of Substantial Completion.

    a. Mineral Tanks: As directed, Five or 10 years.
    b. Brine Tanks: 10 years.
    c. Control Valve: One year(s).

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Drinking Water System Components - Health Effects and Drinking Water System Components - Lead Content Compliance: NSF 61 and NSF 372.

B. Seismic Performance: Water softeners shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

C. Capacities and Characteristics:

1. Water Analysis:

    a. Hardness: As directed, grains/gal. or ppm (mg/L).
    b. Iron: As directed ppm (mg/L).
    c. Dissolved Solids: As directed, ppm (mg/L).
    d. Concentration: As directed.
    e. Inlet Water Pressure: As directed, psig (kPa).
    f. Water Temperature: As directed, deg F (deg C).

2. Continuous Service Flow Rate: As directed, gpm at 15-psig (L/s at 104-kPa) pressure drop.
3. Peak Service Flow Rate: As directed, gpm at 25-psig (L/s at 173-kPa) pressure drop.
4. Water Meter Size: As directed, NPS (DN).
5. Manifold Pipe Size: As directed, NPS (DN).
6. Backwash-to-Drain Pipe Size: As directed, NPS (DN).
7. Water Consumption: As directed, gal./day (cu. m/day).
8. Water Demand: As directed.
9. Number of Mineral Tanks: As directed, One or Two.
10. Mineral Quantity, Each Tank: As directed, cu. ft. (cu. m).
11. Mineral Exchange Capacity: As directed, grains/cu. ft. per lb (kg/cu. m per kg) of salt.
12. Electrical Characteristics:

    a. Volts: As directed V.
    b. Phases: As directed.
    c. Hertz: As directed Hz.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed.

f. Maximum Overcurrent Protection: As directed.

13. Salt Capacity: As directed, lb (kg).
14. Minimum Number of Regenerations per Refill: As directed.
15. Floor Area Required: As directed, sq. ft. (sq. m).
16. Height Required: As directed, inches (mm).

2.2 WATER SOFTENERS

A. Description: Factory-assembled, pressure-type water softener.

1. Configuration: As directed, Single unit with one mineral tank or Twin unit with two mineral tanks and one brine tank.
2. Mounting: On skids.
3. Wetted Components: As directed, Suitable for water temperatures from 40 to at least 100 deg F (5 to at least 38 deg C), 40 to at least 120 deg F (5 to at least 49 deg C) or 40 to at least 150 deg F (5 to at least 66 deg C).
4. Mineral Tanks: FRP, pressure-vessel quality.

    a. Construction: As directed, Non-ASME code. Fabricated and stamped to comply with ASME Boiler and Pressure Vessel Code: Section X, "Fiber-Reinforced Plastic Pressure Vessels."
    b. Pressure Rating: As directed 100 (690) or 125 (860) psig (kPa) minimum.
    c. Freeboard: 50 percent minimum for backwash expansion above normal resin bed level.
    d. Support Legs or Skirt: Constructed of structural steel, welded to tank before testing and labeling.
    e. Upper Distribution System: Single, point type, fabricated from galvanized-steel pipe and fittings.
    f. Lower Distribution System: Hub and radial-arm or header-lateral type; fabricated from nonmetallic pipe and fittings with individual, fine-slotted, nonclogging plastic strainers, and arranged for even flow distribution through resin bed.
    g. Liner: PE, ABS, or other material suitable for potable water.

5. Mineral Tanks: As directed Steel or Stainless steel, electric welded; pressure-vessel quality.

    a. Seismic Requirements: Fabricate supports and attachments to tank with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure.
    b. Construction: As directed Non-ASME code. Fabricated and stamped to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.
    c. Pressure Rating: As directed, 100 (690), 125 (860) or 150 (1035) psig (kPa) minimum.
    d. Freeboard: 50 percent minimum for backwash expansion above normal resin bed level.
    e. Handholes: 4 inches (102 mm) round or 4 by 6 inches (102 by 152 mm) elliptical, in top head and lower sidewall of tanks 30 (762) inches (mm) and smaller in diameter.

f. Manhole: 11 by 15 inches (280 by 380 mm) in top head of tanks larger than 30 (762) inches (mm) in diameter.
g. Support Legs or Skirt: Constructed of structural steel, welded to tank before testing and labeling.
h. Finish: Hot-dip galvanized on exterior and interior of tank after fabrication unless tank is stainless steel.
i. Finish: Exterior of tank spray-painted with rust-resistant prime coat, 2- to 3-mil (0.051- to 0.076-mm) dry film thickness. Interior sandblasted and lined with epoxy-polyamide coating, 8- to 10-mil (0.203- to 0.254-mm) dry film thickness.
j. Upper Distribution System: Single, point type, fabricated from galvanized-steel pipe and fittings.
k. Lower Distribution System: Hub and radial-arm or header-lateral type; fabricated from PVC pipe and fittings with individual, fine-slotted, non-clogging PE strainers, and arranged for even flow distribution through resin bed.
l. Liner: PE, ABS, or other material suitable for potable water.

6. Controls: Automatic; 120 V; factory wired and factory mounted on unit.

a. Adjustable duration of various regeneration steps.
b. Push-button start and complete manual operation.
c. Electric time clock and switch for automatic operation except for manual return to service.
d. Sequence of Operation: Multiport pilot-control valve automatically pressure-actuates main operating valve through steps of regeneration.
e. Pointer on pilot-control valve shall indicate cycle of operation.
f. Includes means of manual operation of pilot-control valve if power fails.

7. Controls: Fully automatic; 120 V; factory wired and factory mounted on unit.

a. Adjustable duration of various regeneration steps.
b. Push-button start and complete manual operation.
c. Electric time clock and switch for fully automatic operation, adjustable to initiate regeneration at any hour of day and any day of week or at fixed intervals.
d. Sequence of Operation: Multiport pilot-control valve automatically pressure-actuates main operating valve through steps of regeneration and return to service.
e. Pointer on pilot-control valve shall indicate cycle of operation.
f. Includes means of manual operation of pilot-control valve if power fails.

8. Main Operating Valves: Industrial, automatic, multiport, diaphragm type with the following features:

a. Slow opening and closing, non-slam operation.
b. Diaphragm guiding on full perimeter from fully open to fully closed.
c. Isolated, dissimilar metals within valve.
d. Self-adjusting, internal, automatic brine injector that draws brine and rinses at constant rate independent of pressure.
e. Valve for single mineral-tank unit with internal automatic bypass of raw water during regeneration.
f. Sampling cocks for soft water.
g. Special tools are not required for service.

9. Flow Control: Automatic, to control backwash and flush rates over wide variations in operating pressure; does not require field adjustments.

    a. Meter Control: Each mineral tank is equipped with signal-register-head water meter that produces electrical signal indicating need for regeneration on reaching hand-set total in gallons (liters). Signal will continue until reset.
    b. Demand-Initiated Control: Single mineral tank is equipped with automatic-reset-head water meter that electrically activates cycle controller to initiate regeneration at preset total in gallons (liters). Head automatically resets to preset total in gallons (liters) for next service run.
    c. Demand-Initiated Control: Each mineral tank of twin mineral-tank unit is equipped with automatic-reset-head water meter that electrically activates cycle controllers to initiate regeneration at preset total in gallons (liters). Head automatically resets to preset total in gallons (liters) for next service run. Electrical lockout prevents simultaneous regeneration of both tanks.
    d. Demand-Initiated Control: Each twin mineral-tank unit is equipped with automatic-reset-head water meter, in common outlet header, that electrically activates cycle controller to automatically regenerate one mineral tank at preset total in gallons (liters) and divert flow to other tank. Automatically repeats with other tank. Electrical lockout prevents simultaneous regeneration of both tanks.

10. Brine Tank: Combination measuring and wet-salt storing system.

    a. Tank and Cover Material: Fiberglass, 3/16 inch (4.8 mm) thick; or molded PE, 3/8 inch (9.5 mm) thick.
    b. Brine Valve: Float operated and plastic fitted for automatic control of brine withdrawal and freshwater refill.
    c. Size: Large enough for at least four regenerations at full salting.

11. Factory-Installed Accessories:

    a. Piping, valves, tubing, and drains.
    b. Sampling cocks.
    c. Main-operating-valve position indicators.
    d. Water meters.

2.3 CHEMICALS

A. Mineral: High-capacity, sulfonated-polystyrene, ion-exchange resin that is stable over entire pH range with good resistance to bead fracture from attrition or shock.

    1. Exchange Capacity: 30,000 (69) grains/cu. ft. (kg.cu. m) of calcium carbonate of resin when regenerated with 15 lb (6.8 kg) of salt.

B. Salt for Brine Tanks: High-purity sodium chloride, free of dirt and foreign material. Rock and granulated forms are unacceptable.

    1. Form: Processed, as directed food-grade salt pellets, plain salt pellets, crystallized solar salt collected from shallow ponds and milled into irregular particles or plain, brine block salt.

2.4 WATER-TESTING SETS

A. Description: Manufacturer's standard water-hardness testing apparatus and chemicals with testing procedure instructions. Include metal container suitable for wall mounting.

2.5 SOURCE QUALITY CONTROL

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

B. ASME Compliance for Steel Tanks: Fabricate and label mineral tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, where indicated.

C. ASME Compliance for FRP Tanks: Fabricate and label mineral tanks to comply with ASME Boiler and Pressure Vessel Code: Section X, where indicated.

D. UL Compliance: Fabricate and label water softeners to comply with UL 979, "Water Treatment Appliances."

E. Hydrostatically test mineral tanks before shipment to a minimum of one and one-half times the pressure rating.

F. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 WATER SOFTENER INSTALLATION

A. Equipment Mounting:

1. Install water softeners on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" As directed
2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
3. Comply with requirements for vibration isolation devices specified in Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."

B. Install seismic restraints for tanks and floor-mounting accessories and anchor to building structure.

C. Install brine lines and fittings furnished by equipment manufacturer, but not specified to be factory installed.

D. Prepare mineral-tank distribution system and underbed for minerals and place specified mineral into mineral tanks.

E. Install water-testing sets mounted on wall, unless otherwise indicated, and near water softeners.

3.2 PIPING CONNECTIONS

A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to equipment, allow space for service and maintenance.

C. Install shutoff valves on raw-water inlet and soft-water outlet piping of each mineral tank, and on inlet and outlet headers.

1. Metal general-duty valves are specified in Section 220523.12 "Ball Valves for Plumbing Piping," Section 220523.13 "Butterfly Valves for Plumbing Piping," Section 220523.14 "Check Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping."
2. Plastic valves are specified in Section 221116 "Domestic Water Piping."
3. Exception: Water softeners with factory-installed shutoff valves at locations indicated.

D. Install pressure gauges on raw-water inlet and soft-water outlet piping of each mineral tank. Pressure gauges are specified in Section 220519 "Meters and Gauges for Plumbing Piping."

1. Exception: Water softeners with factory-installed pressure gauges at locations indicated.
2. Exception: Household water softeners.
3. Exception: Water softeners in hot-water service.

E. Install valved bypass in water piping around water softeners.

1. Metal general-duty valves are specified in Section 220523.12 "Ball Valves for Plumbing Piping," Section 220523.13 "Butterfly Valves for Plumbing Piping," Section 220523.14 "Check Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping."
2. Plastic valves are specified in Section 221116 "Domestic Water Piping."
3. Water piping is specified in Section 221116 "Domestic Water Piping."
4. Exception: Water softeners in hot-water service.

F. Install indirect wastes to spill into open drains or pit with drain.

3.3 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

3.4 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Water softeners will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. As directed Engage a factory-authorized service representative to perform or Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

B. Add water to brine tanks and fill with the following form of salt:

1. Water Softeners: As directed Processed, plain salt pellets, crystallized solar salt collected from shallow ponds and milled into irregular particles or plain, brine block salt.

C. Sample water softener effluent after startup and at three consecutive seven-day intervals (total of four samples) and prepare certified test reports for required water performance characteristics. Comply with the following:

1. ASTM D859, "Test Method for Silica in Water."
2. ASTM D1067, "Test Methods for Acidity or Alkalinity of Water."
3. ASTM D1068, "Test Methods for Iron in Water."
4. ASTM D1126, "Test Method for Hardness in Water."
5. ASTM D1129, "Terminology Relating to Water."
6. ASTM D3370, "Practices for Sampling Water from Closed Conduits."

3.7 MAINTENANCE SERVICE

A. Initial Maintenance Service: As directed Beginning at Substantial Completion, maintenance service shall include three, six, nine or 12 months' full maintenance by skilled employees of water softener Installer. As directed, include monthly or quarterly preventive maintenance, repair or replacement of worn or defective components, cleaning, and adjusting as required for proper water softener operation at rated capacity. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

B. Continuing Maintenance Proposal: From Installer to Owner, in the form of a standard yearly (or other period) maintenance agreement, starting on date initial maintenance service is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.

3.8 DEMONSTRATION

A. As directed Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain domestic water softeners.

END OF SECTION 223100

SECTION 223200 - DOMESTIC WATER FILTRATION EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Freestanding cartridge filters.
2. Off-floor cartridge filters.
3. Carbon filters.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: For water filtration equipment. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For freestanding cartridge filters, carbon filters, accessories, and components, from manufacturer.

B. Certificates of Shop Inspections and Data Reports: For products required to have ASME label, signed by product manufacturer.

C. Welding certificates.

D. Source quality-control reports.

E. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Cartridge-Filter Elements: As directed Elements for cartridge filters equal to 200 or 400 percent of amount installed for each size and media indicated.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NSF 61 Annex G, "Drinking Water System Components - Health Effects," for all components that will be in contact with potable water.

1.7 PROJECT CONDITIONS

A. Feedwater Analysis:

1. Alkalinity: As directed.
2. Arsenic: As directed.
3. Calcium: As directed.
4. Chlorine: As directed.
5. Color: As directed.
6. Hydrogen-Ion Concentration: As directed.
7. Hardness: As directed.
8. Hydrogen Sulfide: As directed.
9. Iron: As directed.
10. Lead: As directed.
11. Magnesium: As directed.
12. Manganese: As directed.
13. Potassium: As directed.
14. Sand: As directed.
15. Silt: As directed.
16. Sodium: As directed.
17. Total Dissolved Solids: As directed.
18. Turbidity: As directed.

B. Feedwater Properties:

1. Inlet Water Pressure: As directed.
2. Water Temperature: As directed.

PART 2 - PRODUCTS

2.1 CARTRIDGE FILTERS

A. Freestanding Cartridge Filters:

1. Description: Simplex, floor-mounted housing with replaceable element(s) for removing suspended particles from water.

    a. Housing: Corrosion resistant; designed to separate feedwater from filtrate and to direct feedwater through water filter element(s); with element support(s) and base, feet, or skirt.

        1) Fabricate supports and base, feet, or skirt and attachment to housing with reinforcement strong enough to resist filter movement during a seismic event when filter base is anchored to building structure.
        2) Pipe Connections NPS 2 (DN 50) and Smaller: Threaded according to ASME B1.20.1.
        3) Steel Tank Pipe Connections NPS 2-1/2 (DN 65) and Larger: Steel, Class 150 flanges according to ASME B16.5 or grooved according to AWWA C606. Provide stainless-steel flanges if housing is stainless steel.
        4) Plastic Housing Pipe Connections NPS 2-1/2 (DN 65) and Larger: 150-psig (1035-kPa) plastic flanges.

    b. Element(s): Replaceable; of shape to fit housing.

2. Capacity and Characteristics:

    a. Filtrate Design Concentrations:

        1) Alkalinity: As directed.
        2) Chlorine: As directed.
        3) Color: As directed.
        4) Hydrogen Sulfide: As directed.
        5) Iron: As directed.
        6) Manganese: As directed.
        7) Sand: As directed.
        8) Silt: As directed.
        9) Turbidity: As directed.

    b. Filter Design:

        1) Continuous Flow: As directed.
        2) Peak Flow: As directed.
        3) Filtration Efficiency: 98 percent retention of suspended particles As directed 1, 10 or 20 micrometers and larger from feedwater of listed filtrate design concentrations.
        4) Pressure Drop: Not to exceed 2 psig (14 kPa) at filter design flow rate when clean and a value as directed when dirty.

    c. Housing:

1) Material: As directed ,Plastic or Stainless steel.
2) Pressure Rating: As directed.
3) Seals: NBR.
4) Diameter: As directed.
5) Height or Length: As directed.
6) Inlet and Outlet Size: As directed.
7) Drain Size: Not applicable.

d. Elements:

1) Number Required: As directed, One or Two.
2) Nominal Diameter: As directed.
3) Nominal Length: As directed.
4) Media: Activated charcoal or ground charcoal.
5) Media: Pleated polyester or pleated PP.
6) Media: Wound polyester or wound PP.
7) Media: As directed.

B. Off-Floor Cartridge Filters:

1. Description: Simplex, in-line or wall-mounted housing with replaceable element for removing suspended particles from water.

a. Housing: Corrosion resistant; designed to separate feedwater from filtrate and to direct feedwater through water filter element; with element support.

1) Pipe Connections: Threaded according to ASME B1.20.1.
2) Support: Wall bracket.

b. Element: Replaceable; of shape to fit housing.

2. Capacity and Characteristics:

a. Filtrate Design Concentrations:

1) Alkalinity: As directed.
2) Chlorine: As directed.
3) Color: As directed.
4) Hydrogen Sulfide: As directed.
5) Iron: As directed.
6) Manganese: As directed.
7) Sand: As directed.
8) Silt: As directed.
9) Turbidity: As directed.

b. Filter Design:

1) Continuous Flow: As directed.
2) Peak Flow: As directed.
3) Filtration Efficiency: 98 percent retention of suspended particles 1, 10 or 20 micrometers and larger as directed from feedwater of listed filtrate design concentrations.

4) Pressure Drop: Not to exceed 2 psig (14 kPa) at filter design flow rate when clean and when dirty.

c. Housing:

1) Material: As directed, PE or PP, Plastic or Stainless steel.
2) Pressure Rating: As directed.
3) Seals: NBR as directed.
4) Diameter: As directed.
5) Height or Length: As directed.
6) Inlet and Outlet Size: As directed.
7) Drain Size: Not applicable.

d. Element:

1) Nominal Diameter: As directed.
2) Nominal Length: As directed.
3) Media: Activated charcoal or ground charcoal.
4) Media: Pleated polyester or pleated P].
5) Media: Wound polyester or wound PP.
6) Media: As directed.

2.2 CARBON FILTERS

A. Description: Simplex carbon filter, with media tank, media, and automatic backwash for removing chlorine from and improving color, odor, and taste of water.

1. Media Tank: Corrosion resistant with distribution system and media.

a. Construction:

1) Fabricate and label steel filter tanks to comply with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.
2) Fabricate and label FRP filter tanks to comply with ASME Boiler and Pressure Vessel Code, Section X, if indicated.
3) Fabricate supports and base and attachment to tank with reinforcement strong enough to resist filter movement during a seismic event when filter base is anchored to building structure.
4) Pipe Connections NPS 2 (DN 50) and Smaller: Threaded according to ASME B1.20.1.
5) Steel Tank Pipe Connections NPS 2-1/2 (DN 65) and Larger: Steel, Class 150 flanges according to ASME B16.5 or grooved according to AWWA C606. Provide stainless-steel flanges if tank is stainless steel.
6) FRP Tank Pipe Connections NPS 2-1/2 (DN 65) and Larger: Type A, integral; Designation E, 125-psig (0.862-MPa) or Designation F, 150-psig (1.034-MPa) pressure category flanges of grade same as tank material according to ASTM D5421.
7) Support: Base, feet, or skirt.

2. Controls: Automatic for control of backwash; factory wired for single, external electrical connection.

    a. Panel: NEMA 250, Type 4 enclosure.
    b. Backwash Initiation Device: Differential pressure gages, Electric time clock or Water meter.

B. Capacity and Characteristics:

1. Filtrate Design Concentrations:

    a. Alkalinity: As directed.
    b. Chlorine: As directed.
    c. Color: As directed.
    d. Hydrogen-Ion Concentration: As directed.
    e. Hydrogen Sulfide: As directed.
    f. Iron: As directed.
    g. Manganese: As directed.
    h. Total Dissolved Solids: As directed.
    i. Turbidity: As directed.

2. Filter Design:

    a. Continuous Flow: As directed.
    b. Flow Rate: As directed of media cross-sectional area.
    c. Peak Flow: As directed.
    d. Filtration Efficiency: 98 percent retention of suspended particles 20 or 40 micrometers and larger as directed from feedwater of listed filtrate design concentrations.
    e. Pressure Drop: Not to exceed 2 psig (14 kPa) at filter design flow rate when clean and when dirty.
    f. Backwash Flow: As directed.

3. Filter Backwash Interval: As directed, pressure drop measured by differential pressure gages.
4. Filter Backwash Interval: As directed, days measured by time clock.
5. Filter Backwash Interval: As directed, measured by water meter.
6. Media Tank:

    a. Material: As directed Carbon steel with NSF 61 Annex G lining material, FRP or Stainless steel.
    b. Pressure Rating: As directed.
    c. Media: As directed Activated charcoal or Ground charcoal.
    d. Media Quantity: As directed.
    e. Diameter: As directed.
    f. Height: As directed.
    g. Inlet and Outlet Size: As directed.

7. Unit Electrical Characteristics:

    a. Volts: As directed 120, 240, 277 or 480.

b. Phase: As directed Single or Three.
c. Hertz: 60.
d. Full-Load Amperes: As directed.
e. Minimum Circuit Ampacity: As directed.
f. Maximum Overcurrent Protection: As directed.

2.3 SOURCE QUALITY CONTROL

A. Before shipping, hydrostatically test carbon filters to minimum of one and one-half times pressure rating.

B. Prepare test reports.

PART 3 - EXECUTION

3.1 EQUIPMENT MOUNTING

A. Equipment Mounting: Install filters, except wall-mounted cartridge filters on concrete bases. Comply with requirements for concrete bases specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete", as directed.

3.2 CARTRIDGE-FILTER INSTALLATION

A. Install cartridge filters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

B. Equipment Mounting: Install freestanding cartridge filters on concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete", as directed.

1. Exception: Omit concrete bases if installation directly on floor is indicated.

C. Attach wall brackets for off-floor, wall-mounted, cartridge filter to vertical surface. Attach housing(s), and base if any, to wall bracket.

D. Install housings for off-floor, in-line, cartridge filters in piping.

E. Install filter elements in cartridges.

F. Install seismic restraints for freestanding cartridge-filter housings and anchor to building structure.

3.3 CARBON-FILTER INSTALLATION

A. Install carbon filters on concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete", as directed.

B. Prepare carbon-filter tank distribution system and underbed, if any, for filter media and place specified media into tanks.

C. Install seismic restraints for carbon-filter housings and anchor to building structure.

3.4 CONNECTIONS

A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

C. Make piping connections between water filtration equipment and dissimilar-metal water piping with dielectric fittings. Comply with requirements for dielectric fittings specified in Section 221116 "Domestic Water Piping."

D. Install shutoff valves on feedwater-inlet and filtrate-outlet piping of each water filtration equipment filter and on inlet and outlet headers.

1. Comply with requirements for metal general-duty valves specified in Section 220523.12 "Ball Valves for Plumbing Piping," Section 220523.13 "Butterfly Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping."
2. Comply with requirements for plastic valves specified in Section 221116 "Domestic Water Piping."
3. Exception: Water filtration equipment with factory-installed shutoff valves at locations indicated.

E. Install pressure gages on feedwater-inlet and filtrate-outlet piping of each water filtration equipment filter. Comply with requirements for pressure gages specified in Section 220519 "Meters and Gages for Plumbing Piping."

1. Exception: Water filtration equipment with factory-installed pressure gages at locations indicated.
2. Exception: Cartridge water filters.

F. Install valved bypass water piping around each water filtration equipment filter.

1. Comply with requirements for metal general-duty valves specified in Section 220523.12 "Ball Valves for Plumbing Piping," Section 220523.13 "Butterfly Valves for Plumbing Piping," Section 220523.14 "Check Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping."
2. Comply with requirements for plastic valves specified in Section 221116 "Domestic Water Piping."

3. Comply with requirements for water piping specified in Section 221116 "Domestic Water Piping."
4. Exception: Cartridge water filtration equipment.

G. Install drains as indirect wastes to spill into open drains or over floor drains.

3.5 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.6 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Domestic water filtration equipment will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION 223200

SECTION 223300 - ELECTRIC, DOMESTIC-WATER HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Commercial, electric, domestic-water booster heaters.
2. Commercial, electric, storage, domestic-water heaters.
3. Commercial, light-duty, storage, electric, domestic-water heaters.
4. Residential, electric, storage, domestic-water heaters.
5. Thermostat-control, electric, tankless, domestic-water heaters.
6. Domestic-water heater accessories.

1.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Commercial domestic-water heaters shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.3 ACTION SUBMITTALS

A. Product Data: For each type and size of domestic-water heater indicated.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings:

1. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: For commercial domestic-water heaters, accessories, and components, from manufacturer.

B. Domestic-Water Heater Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.

C. Source quality-control reports.

D. Field quality-control reports.

E. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

C. ASME Compliance: Where ASME-code construction is indicated, fabricate and label commercial, domestic-water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

D. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61 Annex G, "Drinking Water System Components - Health Effects."

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of electric, domestic-water heaters that fail in materials or workmanship within specified warranty period.

1. Warranty Periods: From date of Substantial Completion.

a. Commercial, Electric, Domestic-Water Booster Heaters:

1) Controls and Other Components: As directed, Three or Five years.

b. Commercial, Electric, Storage, Domestic-Water Heaters:

1) Storage Tank: As directed, Three or Five years.
2) Controls and Other Components: As directed, Three or Five years.

c. Commercial, Light-Duty, Storage, Electric, Domestic-Water Heaters:

1) Storage Tank: As directed, Three or Five years.
2) Controls and Other Components: As directed, Two or Three years.

d. Residential, Electric, Storage, Domestic-Water Heaters:

1) Storage Tank: As directed Five, Six or 10 years.
2) Controls and Other Components: As directed, Two or Three years.

e. Electric, Tankless, Domestic-Water Heaters: As directed, One, Two or Five year(s).
f. Compression Tanks: Five years.

PART 2 - PRODUCTS

2.1 COMMERCIAL, ELECTRIC, DOMESTIC-WATER HEATERS

A. Commercial, Electric, Domestic-Water Booster Heaters:
1. Standard: UL 1453.
2. Tank Construction: Corrosion-resistant metal or steel.

a. Tappings: ASME B1.20.1 pipe thread.
b. Pressure Rating: 150 psig (1035 kPa).
c. Interior Finish: Comply with NSF 61 Annex G barrier materials for potable-water tank linings, including extending lining material into tappings.

3. Factory-Installed Tank Appurtenances:

a. Anode Rod: Replaceable magnesium.
b. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
c. Insulation: Comply with ASHRAE/IESNA 90.1.
d. Jacket: Rectangular shaped, with stainless-steel front panel, unless otherwise indicated.
e. Heating Elements: Electric, screw-in or bolt-on immersion type arranged in multiples of three.

1) Option: Booster heaters with total of 9 kW or less may have two or three elements.

f. Temperature Control: Adjustable thermostat, to setting of at least 180 deg F (82 deg C).
g. Safety Controls: High-temperature-limit and low-water cutoff devices or systems.
h. Relief Valve: ASME rated and stamped for combination temperature-and-pressure relief valve. Include relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select relief valve with sensing element that extends into storage tank.
i. Gages: Combination temperature-and-pressure type or separate thermometer and pressure gage.

4. Special Requirements: As directed, NSF 5 construction with brackets for undercounter legs for floor installation.

B. Commercial, Electric, Storage, Domestic-Water Heaters:
1. Standard: UL 1453.
2. Storage-Tank Construction: As directed, Non-ASME-code, steel horizontal or vertical arrangement.

a. Tappings: Factory fabricated of materials compatible with tank and piping connections. Attach tappings to tank before testing.

1) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
2) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.

b. Pressure Rating: 150 psig (1035 kPa).
c. Interior Finish: Comply with NSF 61 Annex G barrier materials for potable-water tank linings, including extending lining material into tappings.

3. Factory-Installed Storage-Tank Appurtenances:

a. Anode Rod: Replaceable magnesium.
b. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
c. Insulation: Comply with ASHRAE/IESNA 90.1.
d. Jacket: Steel with enameled finish.
e. Heating Elements: Electric, screw-in or bolt-on immersion type arranged in multiples of three.
f. Temperature Control: Adjustable thermostat.
g. Safety Controls: High-temperature-limit and low-water cutoff devices or systems.
h. Relief Valves: ASME rated and stamped for combination temperature-and-pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.

4. Special Requirements: NSF 5 construction.

C. Commercial, Light-Duty, Storage, Electric, Domestic-Water Heaters:
1. Standard: UL 174.
2. Storage-Tank Construction: Steel, vertical arrangement.

a. Tappings: ASME B1.20.1 pipe thread.
b. Pressure Rating: 150 psig (1035 kPa).
c. Interior Finish: Comply with NSF 61 Annex G barrier materials for potable-water tank linings, including extending lining material into tappings.

3. Factory-Installed Storage-Tank Appurtenances:

a. Anode Rod: Replaceable magnesium.
b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
c. Drain Valve: ASSE 1005.
d. Insulation: Comply with ASHRAE/IESNA 90.1 or ASHRAE 90.2.
e. Jacket: Steel with enameled finish.
f. Heat-Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
g. Heating Elements: Two; electric, screw-in immersion type; wired for simultaneous operation unless otherwise indicated. Limited to 12 kW total.
h. Temperature Control: Adjustable thermostat.

i. Safety Control: High-temperature-limit cutoff device or system.
j. Relief Valve: ASME rated and stamped for combination temperature-and-pressure relief valves. Include relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select relief valve with sensing element that extends into storage tank.

4. Special Requirements: NSF 5 construction with legs for off-floor installation.

D. Capacity and Characteristics:

1. Capacity: As directed.
2. Recovery: As directed, gph (L/s) at 40 deg F (22 deg C), 50 deg F (28 deg C) or 100 deg F (56 deg C) temperature rise.
3. Temperature Setting: As directed 125 deg F (52 deg C), 140 deg F (60 deg C) or 180 deg F (82 deg C).
4. Power Demand: As directed.
5. Heating Elements:

a. Number of Elements: As directed, Two, Three, Six or Nine.
b. Kilowatts Each Element: As directed.
c. Number of Stages: As directed, One, Two, Three or Four.

6. Electrical Characteristics:

a. Volts: As directed 120, 240, 277 or 480.
b. Phases: As directed, Single or Three.
c. Hertz: 60.
d. Full-Load Amperes: As directed.
e. Minimum Circuit Ampacity: As directed.
f. Maximum Overcurrent Protection: As directed.

2.2 RESIDENTIAL, ELECTRIC, DOMESTIC-WATER HEATERS

A. Residential, Electric, Storage, Domestic-Water Heaters:
1. Standard: UL 174.
2. Storage-Tank Construction: Steel.

a. Tappings: ASME B1.20.1 pipe thread.
b. Pressure Rating: 150 psig (1035 kPa).
c. Interior Finish: Comply with NSF 61 Annex G barrier materials for potable-water tank linings, including extending lining material into tappings.

3. Factory-Installed Storage-Tank Appurtenances:

a. Anode Rod: Replaceable magnesium.
b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
c. Drain Valve: ASSE 1005.
d. Insulation: Comply with ASHRAE 90.2.
e. Jacket: Steel, cylindrical, with enameled finish.

f. Heat-Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
g. Heating Elements: Two; electric, screw-in immersion type; wired for non-simultaneous operation unless otherwise indicated. Limited to 12 kW total.
h. Temperature Control: Adjustable thermostat.
i. Safety Control: High-temperature-limit cutoff device or system.
j. Relief Valve: ASME rated and stamped for combination temperature-and-pressure relief valves. Include relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select relief valve with sensing element that extends into storage tank.

B. Capacity and Characteristics:

1. Capacity: As directed.
2. Recovery: As directed gph (L/s) at 100 deg F (56 deg C) temperature rise.
3. Temperature Setting: 125 deg F (52 deg C).
4. Power Demand: As directed.
5. Heating Elements: As directed.
6. Electrical Characteristics:

a. Volts: As directed 120 or 240.
b. Phases: As directed Single or Three.
c. Hertz: 60.
d. Full-Load Amperes: As directed.
e. Minimum Circuit Ampacity: As directed.
f. Maximum Overcurrent Protection: As directed.

2.3 ELECTRIC, TANKLESS, DOMESTIC-WATER HEATERS

A. Thermostat-Control, Electric, Tankless, Domestic-Water Heaters:
1. Standard: UL 499 for electric, tankless, (domestic-water heater) heating appliance.
2. Construction: Copper piping or tubing complying with NSF 61 Annex G barrier materials for potable water, without storage capacity.

a. Connections: ASME B1.20.1 pipe thread.
b. Pressure Rating: 150 psig (1035 kPa).
c. Heating Element: Resistance heating system.
d. Temperature Control: Thermostat.
e. Safety Control: High-temperature-limit cutoff device or system.
f. Jacket: Aluminum or steel with enameled finish or plastic.

3. Support: Bracket for wall mounting.
4. Capacity and Characteristics:

a. Flow Rate: As directed, gpm (L/s) at 100 deg F (56 deg C) temperature rise.
b. Temperature Setting: As directed, 125 deg F (52 deg C) or 140 deg F (60 deg C).
c. Power Demand: As directed.
d. Electrical Characteristics:

1) Volts: As directed, 120, 240, 277 or 480.

2) Phases: As directed, Single or Three.
3) Hertz: 60.
4) Full-Load Amperes: As directed.
5) Minimum Circuit Ampacity: As directed.
6) Maximum Overcurrent Protection: As directed.

2.4 DOMESTIC-WATER HEATER ACCESSORIES

A. Domestic-Water Compression Tanks:
1. Description: Steel pressure-rated tank constructed with welded joints and factory-installed butyl-rubber diaphragm. Include air pre-charge to minimum system-operating pressure at tank.
2. Construction:

a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
b. Interior Finish: Comply with NSF 61 Annex G barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
c. Air-Charging Valve: Factory installed.

3. Capacity and Characteristics:

a. Working-Pressure Rating: As directed, 100 psig (690 kPa) or 150 psig (1035 kPa).
b. Capacity Acceptable: As directed, 2 gal. (7.6 L), 4 gal. (15.1 L), 7 gal. (26.5 L) or 10 gal. (37.9 L) minimum.
c. Air Precharge Pressure:

B. Drain Pans: Corrosion-resistant metal with raised edge. Comply with ANSI/CSA LC 3. Include dimensions not less than base of domestic-water heater and include drain outlet not less than NPS 3/4 (DN 20) with ASME B1.20.1 pipe threads or with ASME B1.20.7 garden-hose threads.

C. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1 or ASHRAE 90.2.

D. Heat-Trap Fittings: ASHRAE 90.2.

E. Pressure-Reducing Valves: ASSE 1003 for water. Set at 25-psig- (172.5-kPa-) maximum outlet pressure unless otherwise indicated.

F. Combination Temperature-and-Pressure Relief Valves: ASME rated and stamped. Include relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select relief valves with sensing element that extends into storage tank.

G. Pressure Relief Valves: ASME rated and stamped. Include pressure setting less than domestic-water heater working-pressure rating.

H. Vacuum Relief Valves: ANSI Z21.22/CSA 4.4.

I. Shock Absorbers: ASSE 1010 or PDI-WH 201, Size A water hammer arrester.

J. Domestic-Water Heater Stands: Manufacturer's factory-fabricated steel stand for floor mounting, capable of supporting domestic-water heater and water. Include dimension that will support bottom of domestic-water heater a minimum of 18 inches (457 mm) above the floor.

K. Domestic-Water Heater Mounting Brackets: Manufacturer's factory-fabricated steel bracket for wall mounting, capable of supporting domestic-water heater and water.

2.5 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect domestic-water heaters specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.

B. Hydrostatically test commercial domestic-water heaters to minimum of one and one-half times pressure rating before shipment.

C. Electric, domestic-water heaters will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 014000 "Quality Requirements" for retesting and re-inspecting requirements and Section 017300 "Execution" for requirements for correcting the Work.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 DOMESTIC-WATER HEATER INSTALLATION

A. Commercial, Electric, Domestic-Water Heater Mounting: Install commercial, electric, domestic-water heaters on concrete base. Comply with requirements for concrete bases specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.

1. Exception: Omit concrete bases for commercial, electric, domestic-water heaters if installation on stand, bracket, suspended platform, or directly on floor is indicated.
2. Maintain manufacturer's recommended clearances.
3. Arrange units so controls and devices that require servicing are accessible.
4. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
5. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
6. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
7. Install anchor bolts to elevations required for proper attachment to supported equipment.
8. Anchor domestic-water heaters to substrate.

B. Residential, Electric, Domestic-Water Heater Mounting: Install residential, electric, domestic-water heaters on floor, on water-heater stand on floor or on domestic-water heater mounting bracket, as directed.

1. Maintain manufacturer's recommended clearances.
2. Arrange units so controls and devices that require servicing are accessible.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.
5. Anchor domestic-water heaters to substrate.

C. Electric, Tankless, Domestic-Water Heater Mounting: Install electric, tankless, domestic-water heaters at least 18 inches (457 mm) above floor on wall bracket.

1. Maintain manufacturer's recommended clearances.
2. Arrange units so controls and devices that require servicing are accessible.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.
5. Anchor domestic-water heaters to substrate.

D. Install electric, domestic-water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

1. Install shutoff valves on domestic-water-supply piping to domestic-water heaters and on domestic-hot-water outlet piping. Comply with requirements for shutoff valves specified in Section 220523.12 "Ball Valves for Plumbing Piping," Section 220523.13 "Butterfly Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping."

E. Install commercial, electric, domestic-water heaters with seismic-restraint devices. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

F. Install combination temperature-and-pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

G. Install combination temperature-and-pressure relief valves in water piping for electric, domestic-water heaters without storage. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

H. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for electric, domestic-water heaters that do not have tank drains. Comply with requirements for hose-end drain valves specified in Section 221119 "Domestic Water Piping Specialties."

I. Install thermometers on outlet piping of electric, domestic-water heaters. Comply with requirements for thermometers specified in Section 220519 "Meters and Gages for Plumbing Piping."

J. Install pressure-reducing valve with integral bypass relief valve in electric, domestic-water booster-heater inlet piping and water hammer arrester in booster-heater outlet piping. Set pressure-reducing valve for outlet pressure of 25 psig (172 kPa). Comply with requirements for pressure-reducing valves and water hammer arresters specified in Section 221119 "Domestic Water Piping Specialties."

K. Install piping-type heat traps on inlet and outlet piping of electric, domestic-water heater storage tanks without integral or fitting-type heat traps.

L. Fill electric, domestic-water heaters with water.

M. Charge domestic-water compression tanks with air.

3.2 CONNECTIONS

A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to electric, domestic-water heaters, allow space for service and maintenance of water heaters. Arrange piping for easy removal of domestic-water heaters.

3.3 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Electric, domestic-water heaters will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 014000 "Quality Requirements" for retesting and re-inspecting requirements and Section 017300 "Execution" for requirements for correcting the Work.

C. Prepare test and inspection reports.

END OF SECTION 223300

SECTION 223400 - FUEL-FIRED, DOMESTIC-WATER HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Commercial, atmospheric, gas-fired, storage, domestic-water heaters.
2. Commercial, power-burner, gas-fired, storage, domestic-water heaters.
3. Commercial, grid-type, finned-tube, gas-fired, domestic-water heaters.
4. Residential, atmospheric, gas-fired, storage, domestic-water heaters.
5. Residential, power-vent, gas-fired, storage, domestic-water heaters.
6. Commercial, oil-fired, storage, domestic-water heaters.
7. Domestic-water heater accessories.

1.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Commercial domestic-water heaters shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.3 ACTION SUBMITTALS

A. Product Data: For each type and size of domestic-water heater indicated.

B. Sustainable Design Submittals:

C. Shop Drawings:

1. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For fuel-fired, domestic-water heaters, accessories, and components, from manufacturer.

B. Product certificates.

C. Domestic-Water Heater Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.

D. Source quality-control reports.

E. Field quality-control reports.

F. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE/IESNA Compliance: Fabricate and label fuel-fired, domestic-water heaters to comply with ASHRAE/IESNA 90.1.

C. ASME Compliance:

1. Where ASME-code construction is indicated, fabricate and label commercial, domestic-water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Where ASME-code construction is indicated, fabricate and label commercial, finned-tube, domestic-water heaters to comply with ASME Boiler and Pressure Vessel Code: Section IV.

D. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61 Annex G, "Drinking Water System Components - Health Effects."

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of fuel-fired, domestic-water heaters that fail in materials or workmanship within specified warranty period.

1. Warranty Periods: From date of Substantial Completion.

a. Commercial, Gas-Fired, Storage, Domestic-Water Heaters:

1) Storage Tank: As directed, Three or Five years.
2) Controls and Other Components: As directed, One or Two year(s).

b. Commercial, Finned-Tube, Gas-Fired, Domestic-Water Heaters:

1) Heat Exchanger: As directed, Three or Five years.
2) Controls and Other Components: As directed, One or Two year(s).
3) Separate Hot-Water Storage Tanks: As directed, Three or Five years.

c. Residential, Gas-Fired, Storage, Domestic-Water Heaters:

1) Storage Tank: As directed, Five or Six years.
2) Controls and Other Components: As directed, Two or Three years.

d. Commercial, Oil-Fired, Domestic-Water Heaters:

1) Storage Tank: As directed, Three or Five years.
2) Burner: As directed, One or Two year(s).
3) Controls and Other Components: As directed, One, Two or Three year(s).

e. Compression Tanks: Five years.

PART 2 - PRODUCTS

2.1 COMMERCIAL, GAS-FIRED, STORAGE, DOMESTIC-WATER HEATERS

A. Commercial, Atmospheric, Gas-Fired, Storage, Domestic-Water Heaters:
1. Standard: ANSI Z21.10.3/CSA 4.3.
2. Storage-Tank Construction: Non-ASME-code steel with 150-psig (1035-kPa) working-pressure rating.

a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.

1) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
2) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.

b. Interior Finish: Comply with NSF 61 Annex G barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
c. Lining: As directed Cement, Glass, Nickel plate, Phenolic coating or Sheet copper complying with NSF 61 Annex G barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.

3. Factory-Installed Storage-Tank Appurtenances:

a. Anode Rod: Replaceable magnesium.
b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
c. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
d. Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire storage tank except connections and controls.
e. Jacket: Steel with enameled finish.
f. Burner: For use with atmospheric, gas-fired, domestic-water heaters and natural-gas or LP-gas fuel.
g. Automatic Ignition: ANSI Z21.20/CSA C22.2 No. 199, electric, automatic, gas-ignition system.
h. Temperature Control: Adjustable thermostat.

i. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
j. Combination Temperature-and-Pressure Relief Valves: ANSI Z21.22/CSA 4.4-M. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.

4. Special Requirements: NSF 5 construction.
5. Draft Hood: Draft diverter, complying with ANSI Z21.12.
6. Automatic Damper: As directed, ANSI Z21.66/CSA 6.14-M, electrically operated, mechanically activated or thermally activated, automatic-vent-damper device with size matching draft hood.

B. Commercial, Power-Burner, Gas-Fired, Storage, Domestic-Water Heaters:
1. Standard: ANSI Z21.10.3/CSA 4.3.
2. Storage-Tank Construction: Non-ASME-code steel with 150-psig (1035-kPa) working-pressure rating.

a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.

1) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
2) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.

b. Interior Finish: Comply with NSF 61 Annex barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
c. Lining: As directed Cement, Glass, Nickel plate, Phenolic coating or Sheet copper complying with NSF 61 Annex G barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.

3. Factory-Installed Storage-Tank Appurtenances:

a. Anode Rod: Replaceable magnesium.
b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
c. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
d. Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire storage tank except connections and controls.
e. Jacket: Steel with enameled finish.
f. Burner: UL 795 for power-burner, gas-fired, domestic-water heaters and natural-gas or LP-gas fuel.
g. Automatic Ignition: ANSI Z21.20/CSA C22.2 No. 199, electric, automatic, gas-ignition system.
h. Temperature Control: Adjustable thermostat.
i. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
j. Combination Temperature-and-Pressure Relief Valves: ANSI Z21.22/CSA 4.4-M. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-

pressure rating. Select one relief valve with sensing element that extends into storage tank.

4. Special Requirements: NSF 5 construction.
5. Draft Hood: Draft diverter, complying with ANSI Z21.12.

2.2 COMMERCIAL, FINNED-TUBE, GAS-FIRED, DOMESTIC-WATER HEATERS

A. Commercial, Grid-Type, Finned-Tube, Gas-Fired, Domestic-Water Heaters:
1. Standard: ANSI Z21.13/CSA 4.9 for hot-water-supply boilers.
2. Description: Packaged unit with boiler, storage tank, pump, piping, and controls.
3. Boiler Construction: ASME code with 160-psig (1100-kPa) working-pressure rating for hot-water-boiler-type, domestic-water heater.

    a. Heat Exchanger: Horizontal, straight, finned-copper tubes with bronze headers.
    b. Connections: Factory fabricated of materials compatible with boiler. Attach to boiler before testing.

        1) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
        2) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.

4. Boiler Appurtenances:

    a. Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire boiler except connections and controls.
    b. Jacket: Steel with enameled finish.
    c. Burner: As directed, for use with grid-type, finned-tube, gas-fired, domestic-water heaters and natural-gas or LP-gas fuel.
    d. Automatic Ignition: ANSI Z21.20/CSA C22.2 No. 199, intermittent electronic-ignition system.
    e. Temperature Control: Adjustable, storage-tank temperature-control fitting and flow switch, interlocked with circulator and burner.
    f. Safety Control: Automatic, high-temperature-limit cutoff device or system.

5. Support: Steel base or skids.
6. Draft Hood: Draft diverter, complying with ANSI Z21.12.
7. Automatic Damper: As directed, ANSI Z21.66/CSA 6.14-M, electrically operated, mechanically activated or thermally activated, automatic-vent-damper device with size matching draft hood.
8. Hot-Water Storage Tank: Connected with piping to circulating pump and domestic-water heater.

    a. Construction: According to ASME Boiler and Pressure Vessel Code: Section VIII, steel with 150-psig (1035-kPa) or 125-psig (860-kPa) working-pressure rating.
    b. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.

        1) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.

2) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.

c. Interior Finish: Comply with NSF 61 Annex G barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.

9. Factory-Installed Storage-Tank Appurtenances:

a. Anode Rods: Factory installed, magnesium.
b. Drain Valve: Corrosion-resistant metal complying with ASSE 1005, factory installed.
c. Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire storage tank except connections and controls.
d. Jacket: Steel with enameled finish.
e. Combination Temperature-and-Pressure Relief Valves: ANSI Z21.22/CSA 4.4-M. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.

10. Circulating Pump: UL 778, all-bronze, centrifugal, overhung-impeller, separately coupled in-line pump as defined in HI 1.1-1.2 and HI 1.3. Include mechanical seals, 125-psig (860-kPa) minimum working-pressure rating, and 225 deg F (107 deg C) continuous-water-temperature rating.
11. Piping: Copper tubing; copper, solder-joint fittings; and brazed or flanged joints.
12. Mounting: Domestic-water heater, tank, and accessories factory mounted on skids.

B. Capacity and Characteristics:

1. Hot-Water Storage-Tank Capacity: As directed.
2. Recovery: As directed gph (L/s) at 100 deg F (56 deg C) temperature rise.
3. Temperature Setting: As directed 125 deg F (52 deg C) or 140 deg F (60 deg C).
4. Fuel Gas Demand: As directed.
5. Fuel Gas Input: As directed.
6. Gas Pressure Regulator:

a. Capacity: As directed.
b. Inlet Pressure: As directed, psig (kPa) or inches (mm) water column.
c. Gas Pressure Required at Burner, psig (kPa) or inches (mm) water column, as directed.

7. Electrical Characteristics:

a. Volts: As directed 120, 240, 277 or 480.
b. Phase: As directed Single or Three.
c. Hertz: 60.
d. Full-Load Amperes: As directed.
e. Minimum Circuit Ampacity: As directed.
f. Maximum Overcurrent Protection: As directed.

8. Minimum Vent Diameter: As directed.

2.3 RESIDENTIAL, GAS-FIRED, STORAGE, DOMESTIC-WATER HEATERS

A. Residential, Atmospheric, Gas-Fired, Storage, Domestic-Water Heaters:
1. Standard: ANSI Z21.10.1/CSA 4.1.
2. Storage-Tank Construction: Steel.

a. Tappings: ASME B1.20.1 pipe thread.
b. Pressure Rating: 150 psig (1035 kPa).
c. Interior Finish: Comply with NSF 61 Annex G barrier materials for potable-water tank linings, including extending lining material into tappings.

3. Factory-Installed Storage-Tank Appurtenances:

a. Anode Rod: Replaceable magnesium.
b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
c. Drain Valve: ASSE 1005.
d. Insulation: Comply with ASHRAE/IESNA 90.1 or ASHRAE 90.2.
e. Jacket: Steel with enameled finish.
f. Heat-Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
g. Burner: As directed, for use with atmospheric, gas-fired, domestic-water heaters and natural-gas or LP-gas fuel.
h. Automatic Ignition: ANSI Z21.20/CSA C22.2 No. 199, electric, automatic, gas-ignition system.
i. Temperature Control: Adjustable thermostat.
j. Combination Temperature-and-Pressure Relief Valve: ANSI Z21.22/CSA 4.4-M. Include relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select relief valve with sensing element that extends into storage tank.

4. Draft Hood: Low-profile-type draft diverter, complying with ANSI Z21.12.
5. Automatic Damper: As directed, ANSI Z21.66/CSA 6.14-M, electrically operated, mechanically activated or thermally activated, automatic-vent-damper device with size matching draft hood.

B. Residential, Power-Vent, Gas-Fired, Storage, Domestic-Water Heaters:
1. Standard: ANSI Z21.10.1/CSA 4.1.
2. Storage-Tank Construction: Steel.

a. Tappings: ASME B1.20.1 pipe thread.
b. Pressure Rating: 150 psig (1035 kPa).
c. Interior Finish: Comply with NSF 61 Annex G barrier materials for potable-water tank linings, including extending lining material into tappings.

3. Factory-Installed Storage-Tank Appurtenances:

a. Anode Rod: Replaceable magnesium.
b. Dip Tube: Required unless cold-water inlet is near bottom of tank.

c. Drain Valve: ASSE 1005.
d. Insulation: Comply with ASHRAE/IESNA 90.1 or ASHRAE 90.2.
e. Jacket: Steel with enameled finish.
f. Heat-Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
g. Burner: As directed, For use with power-vent, gas-fired, domestic-water heaters and natural-gas or LP-gas fuel.
h. Automatic Ignition: ANSI Z21.20/CSA C22.2 No. 199, electric, automatic, gas-ignition system.
i. Temperature Control: Adjustable thermostat.
j. Combination Temperature-and-Pressure Relief Valve: ANSI Z21.22/CSA 4.4-M. Include relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select relief valve with sensing element that extends into storage tank.

4. Power-Vent System: Exhaust fan, interlocked with burner.

C. Capacity and Characteristics:

1. Capacity: As directed.
2. Recovery: As directed gph (L/s) at 100 deg F (56 deg C) temperature rise.
3. Temperature Setting: 125 deg F (52 deg C).
4. Fuel Gas Demand: As directed.
5. Fuel Gas Input: As directed.
6. Gas Pressure Regulator:

a. Capacity: As directed.
b. Inlet Pressure: As directed, psig (kPa) or inches (mm) water column.
c. Gas Pressure Required at Burner, psig (kPa) or inches (mm) water column, as directed.

7. Electrical Characteristics:

a. Volts: As directed 120 or 240.
b. Phase: As directed Single or Three.
c. Hertz: 60.
d. Full-Load Amperes: As directed.
e. Minimum Circuit Ampacity: As directed.
f. Maximum Overcurrent Protection: As directed.

8. Minimum Vent Diameter: As directed.

2.4 OIL-FIRED, DOMESTIC-WATER HEATERS

A. Commercial, Oil-Fired, Storage, Domestic-Water Heaters:
1. Standard: UL 732 for storage, domestic-water heaters.
2. Storage-Tank Construction: Non-ASME-code steel with 150-psig (1035-kPa) minimum working-pressure rating.

a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.

1) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
2) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.

b. Interior Finish: Comply with NSF 61 Annex G barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
c. Lining: As directed, Cement, Glass, Nickel plate, Phenolic coating or Sheet copper complying with NSF 61 Annex G barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.

3. Factory-Installed Storage-Tank Appurtenances:

a. Anode Rod: Replaceable magnesium.
b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
c. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
d. Insulation: Comply with ASHRAE/IESNA 90.1 or ASHRAE 90.2.
e. Jacket: Steel with enameled finish.
f. Temperature Control: Adjustable thermostat.
g. Relief Valves: ASME rated and stamped for combination temperature-and-pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.

4. Oil Burners:

a. Standard: UL 296 for use with No. 2 fuel oil.
b. Safety Control: Automatic, high-temperature-limit cutoff device or system.
c. Draft Regulator: Barometric type or adjustable-damper device.

B. Capacity and Characteristics:

1. Capacity: As directed.
2. Recovery: As directed gph (L/s) at 100 deg F (56 deg C) temperature rise.
3. Temperature Setting: 125 deg F (52 deg C) or 140 deg F (60 deg C).
4. Fuel-Oil Demand: As directed.
5. Fuel-Oil Input: As directed.
6. Electrical Characteristics:

a. Burner Horsepower: As directed.
b. Volts: As directed 120, 240, 277 or 480.
c. Phase: As directed Single or Three.
d. Hertz: 60.
e. Full-Load Amperes: As directed.
f. Minimum Circuit Ampacity: As directed.
g. Maximum Overcurrent Protection: As directed.

7. Minimum Vent Diameter: As directed.

2.5 DOMESTIC-WATER HEATER ACCESSORIES

A. Domestic-Water Compression Tanks:
   1. Description: Steel, pressure-rated tank constructed with welded joints and factory-installed butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.
   2. Construction:
      a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
      b. Interior Finish: Comply with NSF 61 Annex G barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
      c. Air-Charging Valve: Factory installed.
   3. Capacity and Characteristics:
      a. Working-Pressure Rating: 100 psig (690 kPa) or 150 psig (1035 kPa), as directed.
      b. Capacity Acceptable: As directed 2 gal. (7.6 L), 4 gal. (15.1 L), 7 gal. (26.5 L) or 10 gal. (37.9 L) minimum.
      c. Air Precharge Pressure: As directed.

B. Drain Pans: Corrosion-resistant metal with raised edge. Comply with ANSI/CSA LC 3. Include dimensions not less than base of domestic-water heater and include drain outlet not less than NPS 3/4 (DN 20) with ASME B1.20.1 pipe threads or with ASME B1.20.7 garden-hose threads.

C. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1 or ASHRAE 90.2.

D. Heat-Trap Fittings: ASHRAE 90.2.

E. Gas Shutoff Valves: ANSI Z21.15/CSA 9.1-M, manually operated. Furnish for installation in piping.

F. Gas Pressure Regulators: ANSI Z21.18/CSA 6.3, appliance type. Include 1/2-psig (3.5-kPa), 2-psig (13.8-kPa) or 5-psig (34.5-kPa) pressure rating as required to match gas supply.

G. Automatic Gas Valves: ANSI Z21.21/CSA 6.5, appliance, electrically operated, on-off automatic valve.

H. Combination Temperature-and-Pressure Relief Valves: Include relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select relief valves with sensing element that extends into storage tank.
   1. Gas-Fired, Domestic-Water Heaters: ANSI Z21.22/CSA 4.4-M.
   2. Oil-Fired, Domestic-Water Heaters: ASME rated and stamped.

I. Pressure Relief Valves: Include pressure setting less than domestic-water heater working-pressure rating.

1. Gas-Fired, Domestic-Water Heaters: ANSI Z21.22/CSA 4.4-M.
2. Oil-Fired, Domestic-Water Heaters: ASME rated and stamped.

J. Vacuum Relief Valves: ANSI Z21.22/CSA 4.4-M.

K. Domestic-Water Heater Stands: Manufacturer's factory-fabricated steel stand for floor mounting, capable of supporting domestic-water heater and water. Provide dimension that will support bottom of domestic-water heater a minimum of 18 inches (457 mm) above the floor.

L. Domestic-Water Heater Mounting Brackets: Manufacturer's factory-fabricated steel bracket for wall mounting, capable of supporting domestic-water heater and water.

2.6 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect assembled domestic-water heaters and storage tanks specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.

B. Hydrostatically test commercial domestic-water heaters and storage tanks to minimum of one and one-half times pressure rating before shipment.

C. Domestic-water heaters will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 014000 "Quality Requirements" for retesting and re-inspecting requirements and Section 017300 "Execution" for requirements for correcting the Work.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 DOMESTIC-WATER HEATER INSTALLATION

A. Commercial, Domestic-Water Heater Mounting: Install commercial domestic-water heaters on concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" As directed.

1. Exception: Omit concrete bases for commercial domestic-water heaters if installation on stand, bracket, suspended platform, or directly on floor is indicated.
2. Maintain manufacturer's recommended clearances.
3. Arrange units so controls and devices that require servicing are accessible.
4. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
5. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
6. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

7. Install anchor bolts to elevations required for proper attachment to supported equipment.
8. Anchor domestic-water heaters to substrate.

B. Residential, Domestic-Water Heater Mounting: As directed Install residential domestic-water heaters on floor, water-heater stand on floor or domestic-water heater mounting bracket.

1. Maintain manufacturer's recommended clearances.
2. Arrange units so controls and devices that require servicing are accessible.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.
5. Anchor domestic-water heaters to substrate.

C. Install domestic-water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

1. Install shutoff valves on domestic-water-supply piping to domestic-water heaters and on domestic-hot-water outlet piping. Comply with requirements for shutoff valves specified in Section 220523.12 "Ball Valves for Plumbing Piping," Section 220523.13 "Butterfly Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping."

D. Install gas-fired, domestic-water heaters according to NFPA 54.

1. Install gas shutoff valves on gas supply piping to gas-fired, domestic-water heaters without shutoff valves.
2. Install gas pressure regulators on gas supplies to gas-fired, domestic-water heaters without gas pressure regulators if gas pressure regulators are required to reduce gas pressure at burner.
3. Install automatic gas valves on gas supplies to gas-fired, domestic-water heaters if required for operation of safety control.
4. Comply with requirements for gas shutoff valves, gas pressure regulators, and automatic gas valves specified in Section 231123 "Facility Natural-Gas Piping" or Section 231126 "Facility Liquefied-Petroleum Gas Piping" As directed

E. Install oil-fired, domestic-water heaters according to NFPA 31.

1. Install shutoff valves on fuel-oil supply piping to oil-fired water-heater burners without shutoff valves. Comply with requirements for shutoff valves specified in Section 231113 "Facility Fuel-Oil Piping."

F. Install commercial domestic-water heaters with seismic-restraint devices. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

G. Install combination temperature-and-pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

H. Install combination temperature-and-pressure relief valves in water piping for domestic-water heaters without storage. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

I. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for domestic-water heaters that do not have tank drains. Comply with requirements for hose-end drain valves specified in Section 221119 "Domestic Water Piping Specialties."

J. Install thermometer on outlet piping of domestic-water heaters. Comply with requirements for thermometers specified in Section 220519 "Meters and Gages for Plumbing Piping."

K. Install piping-type heat traps on inlet and outlet piping of domestic-water heater storage tanks without integral or fitting-type heat traps.

L. Fill domestic-water heaters with water.

M. Charge domestic-water compression tanks with air.

3.2 CONNECTIONS

A. Comply with requirements for domestic-water piping specified in Section 221116 "Domestic Water Piping."

B. Comply with requirements for fuel-oil piping specified in Section 231113 "Facility Fuel-Oil Piping."

C. Comply with requirements for gas piping specified in Section 231123 "Facility Natural-Gas Piping" or Section 231126 "Facility Liquefied-Petroleum Gas Piping" As directed

D. Drawings indicate general arrangement of piping, fittings, and specialties.

E. Where installing piping adjacent to fuel-fired, domestic-water heaters, allow space for service and maintenance of water heaters. Arrange piping for easy removal of domestic-water heaters.

3.3 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Domestic-water heaters will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 014000 "Quality Requirements" for retesting and re-inspecting requirements and Section 017300 "Execution" for requirements for correcting the Work.

C. Prepare test and inspection reports.

3.5 DEMONSTRATION

A. As directed Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain commercial, gas-fired, storage, or commercial, oil-fired, domestic-water heaters.

END OF SECTION 223400

SECTION 223500 - DOMESTIC-WATER HEAT EXCHANGERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Instantaneous, domestic-water heaters.
2. Semi-instantaneous, domestic-water heaters.
3. Drainline heat exchangers.
4. Accessories.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings:

1. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Equipment room drawing or BIM model, drawn to scale and coordinated with all building trades.

B. Seismic Qualification Data: Certificates, for domestic-water heaters, accessories, and components, from manufacturer.

C. Product Certificates: As directed for each type of instantaneous water heater or semi-instantaneous water heater from manufacturer.

1. Domestic-Water Heater Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.

D. Source quality-control reports.

E. Field quality-control reports.

F. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of domestic-water heaters that fail in materials or workmanship within specified warranty period.

1. Warranty Periods: From date of Substantial Completion.

a. Instantaneous, Domestic-Water Heaters:

1) Tank: As directed Five or Ten years.
2) Tube Coil: Five or Ten years.
3) Controls and Other Components: Three years.

b. Semi-Instantaneous, Domestic-Water Heaters:

1) Tank: Five years.
2) Tube Coil: Five years.
3) Controls and Other Components: Three years.

c. Drainline Heat Exchanger: One year(s).
d. Compression Tanks: One year(s).

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.

B. ASME Compliance: Where ASME-code construction is indicated, fabricate and label heat-exchanger storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

C. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61and NSF 372.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

E. Seismic Performance: Domestic-water heat exchangers and heaters shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: As directed 1.5 or 1.0.

2.2 INSTANTANEOUS, DOMESTIC-WATER HEATERS

A. Description: Factory-packaged assembly of heat exchanger, blending valve, controls, and specialties for heating domestic water in coils with steam in shell utilizing feed forward principle design.

B. Construction: ASME code, with cast-iron or steel shell for steam.

1. Cast-Iron Shell Pressure Rating: As directed 50 psig (345 kPa) or 75 psig (517 kPa).
2. Steel Shell Pressure Rating: 150 psig (1035 kPa).
3. Standard: Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1.

C. Heat-Exchanger Coils: As directed, Spiral-wound, double or single-wall copper or copper-alloy or stainless steel coils for domestic water.

D. Temperature Control: Adjustable thermostat that operates blending valve and is capable of maintaining outlet water temperature within 4 deg F (2 deg C) of setting.

E. Safety Control: Automatic feed forward blending valve actuated by differential pressure.

F. Miscellaneous Components: Strainers (main and drip), main trap, drip trap, outlet water temperature gauge, steam pressure gauge, and piping.

G. Stand: Factory-fabricated steel skid for floor mounting.

H. Insulation: Factory-fabricated and -installed cover placed over top of the exchanger.

I. Required Connections: Domestic cold water in; domestic hot water out; steam supply in; condensate return out.

J. Capacity and Characteristics:

1. Domestic Water:

a. Recovery: As directed, gpm (L/s) at 100 deg F (56 deg C) temperature rise.
b. Hot-Water Temperature Setting: As directed.
c. Pipe Size: As directed.

2. Steam Supply:

a. Inlet Pressure: As directed.
b. Demand Rate: As directed.
c. Input Rating: As directed.
d. Steam Pipe Size: As directed.

3. Condensate Pipe Size: As directed.

K. Recirculation Kit: Provide an integrally mounted recirculation package.

2.3 SEMI-INSTANTANEOUS, DOMESTIC-WATER HEATERS

A. Semi-Instantaneous, Heating-Fluid-in-Coil, Packaged, Compact, Less than 100-Gallon (378 L), Domestic-Water Heater:

1. Description: Factory-packaged assembly of shell, heat-exchanger coils, and specialties for heating domestic water with steam in coils.
2. Construction:

    a. Fabricate and label heat exchanger to comply with ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1.

3. Configuration: Vertical-stacked helically shaped coils.
4. Shell Materials: Carbon steel, copper-lined shell with 250- psig (1725-kPa) minimum working-pressure rating.

    a. Tappings: Factory fabricated of materials compatible with heat-exchanger shell. Attach tappings to shell before testing and labeling.

        1) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
        2) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.

5. Head: Cast iron, flanged and bolted to shell.
6. Heat-Exchanger Coil: As directed, Double or Single-wall, copper or copper-nickel coils for domestic water. Include pressure rating equal to or greater than heating-fluid supply pressure.
7. Relief Valves: ASME rated and stamped for combination temperature- and pressure-relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting of less than working-pressure rating of heat exchanger. Select one relief valve with sensing element that extends into storage tank.
8. Miscellaneous Components: Strainers, steam-control valve, steam trap, valves, pressure gauge, thermometer, and piping. Include components fitted for pneumatic control.

    a. Exception: Steam trap is not required if manufacturer's written instructions direct that it not be used.

9. Stand: Factory fabricated on skid for floor mounting.
10. Insulation: Complying with ASHRAE/IES 90.1, unless otherwise indicated, and suitable for operating temperature. Surround entire shell and nozzle, except connections and controls.
11. Required Connections: Domestic cold water in; domestic hot water out; steam supply in; condensate return out.
12. Capacity and Characteristics:

    a. Domestic Water: As directed.
    b. Recovery: As directed gpm (L/s) at 100 deg F (56 deg C) temperature rise.

        1) Hot-Water Temperature Setting: As directed.
        2) Pipe Size: As directed.

c. Steam Supply:

1) Inlet Pressure: As directed.
2) Demand Rate: As directed.
3) Input Rating: As directed.
4) Steam Pipe Size: As directed.

d. Condensate Pipe Size: As directed.

B. Semi-Instantaneous, Heating-Fluid-in-Shell, Packaged, Compact, Less than 100-Gallon (378 L), Domestic-Water Heat Exchangers:

1. Description: Factory packaged, less than 100-gallon (378-L) storage-capacity hot-water storage tank with heat-exchanger coil, circulator, controls, and specialties for heating domestic water with heating hot water or steam in coil, as directed.
2. Flow Pattern: Standard-flow arrangement, with water from bottom of storage tank circulated across heat-exchanger coil and returned to tank. Include hot-water outlet located at top of tank and temperature sensor in tank.
3. Construction:

a. Fabricate and label semi-instantaneous domestic-water heater to comply with ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1.

4. Configuration: Vertical or horizontal.
5. Shell Materials: ASME-code, copper-silicon or corrosion-resistant metal with 150-psig (1035-kPa) working-pressure rating. Include nozzle and head for heat-exchanger tube coil.

a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing and labeling.

1) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
2) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.

6. Heat-Exchanger Coil: As directed, Double or Single copper or copper-alloy U tubes with tube sheet and supporting baffles. Include heat-exchanger pressure rating equal to or greater than heating-fluid supply pressure.
7. Temperature Control: Adjustable thermostat.
8. Safety Control: Automatic, high-temperature-limit cutoff device or system. Include automatic low-water cutoff device or system.
9. Relief Valves: ASME rated and stamped for combination temperature- and pressure-relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting of less than working-pressure rating of heat exchanger. Select one relief valve with sensing element that extends into storage tank.
10. Gauges: Factory-mounted thermometer and pressure gauge.
11. Circulating Pump: UL 778, all-bronze, centrifugal, overhung-impeller, separately coupled in-line pump as defined in HI 1.1-1.2 and HI 1.3. Include mechanical seals, 125- psig

(860- kPa) minimum working-pressure rating, and 225 deg F (107 deg C) continuous-water-temperature rating.

a. Pump Control: Sensor for operating pump and control valve.

12. Miscellaneous Components for Heating Hot-Water Units: Control valve, valves, and piping.
13. Miscellaneous Components for Steam Units: Strainers, steam-control valve, steam trap, valves, pressure gauge, thermometer, and piping.
14. Support: Factory mounted on skid for floor mounting.
15. Energy Management System Interface: Normally closed dry contacts for enabling and disabling heat exchanger.
16. Insulation: Complying with ASHRAE/IES 90.1, unless otherwise indicated, and suitable for operating temperature. Surround entire storage tank and nozzle, except connections and controls.
17. Required Connections: Domestic cold water in; domestic hot water out; heating hot-water or steam supply in; heating hot water or condensate return out, as directed.
18. Capacity and Characteristics:

a. Domestic Water: As directed
b. Recovery: As directed gpm (L/s) at 100 deg F (56 deg C) temperature rise.

1) Hot-Water Temperature Setting: As directed.
2) Pipe Size: As directed.

c. Heating Hot-Water Supply:

1) Inlet Temperature: As directed.
2) Outlet Temperature: As directed.
3) Pipe Size: As directed.

d. Steam Supply:

1) Inlet Pressure: As directed.
2) Demand Rate: As directed.
3) Input Rating: As directed.
4) Steam Pipe Size: As directed.

e. Condensate Pipe Size: As directed.

2.4 DRAINLINE HEAT EXCHANGER

A. Description: Drainline heat exchanger, full-size vertical or horizontal drainage tube with domestic-water preheat coil around drainage tube.

1. Drainage Tube: ASTM B306, Type DWV copper drainage tube of size indicated.
2. Domestic-Water Preheat Coil: ASTM B88, Type L (ASTM B88M, Type B) copper water tube of connection size indicated attached to drainage tube.
3. Working-Pressure Rating: 150 psig (1035 kPa) on domestic-water supply tubing.
4. Standards:

a. All surfaces coming into contact with potable water must be NSF approved for potable water applications.
b. Thermal effectiveness of heat exchanger shall be certified to CSA B55.1.
c. Construction of heat exchanger shall be certified to CSA B55.2.

B. Capacities and Characteristics:

1. As directed, 2-inch (DN 50), 3-inch (DN 80) or 4-inch (DN 100) DWV Drainage Tube:

a. Unit Length: As directed.
b. Domestic-Water Preheat Coil Connection: As directed ½- inch (DN 15), ¾- inch (DN 20) or 1 inch (DN 25).

2.5 ACCESSORIES

A. Domestic-Water Compression Tanks:
1. Description: Steel pressure-rated tank constructed with welded joints and factory-installed butyl-rubber diaphragm. Include air precharge to minimum system operating pressure at tank.
2. Construction:

a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
b. Interior Finish: Comply with NSF 61 barrier materials for potable water tank linings, including extending finish into and through tank fittings and outlets.
c. Air-Charging Valve: Factory installed.

3. Capacity and Characteristics:

a. Working Pressure Rating: As directed 100 psig (690 kPa) or 150 psig (1035 kPa).
b. Capacity Acceptable: As directed 2 gal. (7.6 L), 4 gal. (15.1 L), 7 gal. (26.5 L) or 10 gal. (37.9 L) minimum.
c. Air Precharge Pressure: As directed.

B. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IES 90.1 or ASHRAE 90.2.

C. Heat-Trap Fittings: ASHRAE 90.2.

D. Combination Temperature- and Pressure-Relief Valves: ASME rated and stamped. Include relieving capacity at least as great as heat input, and include pressure setting less than heat-exchanger working-pressure rating. Select relief valves with sensing element that extends into storage tank.

E. Pressure-Relief Valves: ASME rated and stamped. Include pressure setting less than heat-exchanger working pressure rating.

F. Vacuum-Relief Valves: ANSI Z21.22/CSA 4.4.

2.6 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect domestic-water heat exchangers and domestic-water heaters specified to ASME-code construction, according to ASME Boiler and Pressure Vessel Code.

B. Hydrostatically test domestic-water heat exchangers and domestic-water heaters to minimum of one and one-half times pressure rating before shipment.

C. Domestic-water heat exchangers and domestic-water heaters will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 014000 "Quality Requirements" for retesting and reinspecting requirements and Section 017300 "Execution" for requirements for correcting the Work.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION OF DOMESTIC-WATER HEATERS

A. Domestic-Water Heaters Mounting: Install domestic-water heaters on concrete base. Comply with requirements for concrete bases specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" As directed

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.
5. Anchor heaters to substrate.

B. Install domestic-water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

1. Install shutoff valves on domestic cold-water supply piping to domestic-water heat exchangers and domestic-water heaters and on domestic-hot-water outlet piping. Comply with requirements for shutoff valves specified in Section 220523.12 "Ball Valves for Plumbing Piping," Section 220523.13 "Butterfly Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping."
2. Install shutoff valves on heating hot-water piping to domestic-water heat exchangers and domestic-water heaters. Comply with requirements for shutoff valves specified in Section 230523.12 "Ball Valves for HVAC Piping," Section 230523.13 "Butterfly Valves for HVAC Piping," and Section 230523.15 "Gate Valves for HVAC Piping."
3. Install shutoff valves on steam and condensate piping to domestic-water heat exchangers and domestic-water heaters. Comply with requirements for shutoff valves specified in

Section 230523.12 "Ball Valves for HVAC Piping," Section 230523.13 "Butterfly Valves for HVAC Piping," and Section 230523.15 "Gate Valves for HVAC Piping."

C. Install domestic-water heaters with seismic-restraint devices. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

D. Install temperature- and pressure-relief valves in top portion of domestic-water tank shells. Use relief valves with sensing elements that extend into shells. Extend relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

E. Install combination temperature- and pressure-relief valves in water piping for domestic-water heaters without storage. Extend relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

F. Install domestic-water heaters drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in domestic-water piping for heat exchangers and heaters that do not have tank drains. Comply with requirements for hose-end drain valves specified in Section 221119 "Domestic Water Piping Specialties."

G. Install thermometer on each domestic-water heater inlet and outlet piping and install thermometer on each heat exchanger and heater heating-fluid inlet and outlet piping. Comply with requirements for thermometers specified in Section 220519 "Meters and Gauges for Plumbing Piping."

H. Install pressure gauges on domestic-water heater heating-fluid piping. Comply with requirements for pressure gauges specified in Section 220519 "Meters and Gauges for Plumbing Piping."

I. Fill domestic-water heaters with water.

J. Charge domestic-water compression tanks with air.

3.2 PIPING CONNECTIONS

A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping."

B. Comply with requirements for heating hot-water piping specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."

C. Comply with requirements for steam and condensate piping specified in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties."

D. Drawings indicate general arrangement of piping, fittings, and specialties.

E. Where installing piping adjacent to domestic-water heat exchangers and heaters, allow space for service and maintenance. Arrange piping for easy removal of heat exchangers and heaters.

3.3 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Domestic-water heat exchangers and domestic-water heaters will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.5 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain domestic-water heat exchangers and instantaneous, semi-instantaneous or indirect-fired domestic-water heaters.

END OF SECTION 223500

SECTION 224100 - RESIDENTIAL PLUMBING FIXTURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bathtubs.
2. Faucets.
3. Bidets.
4. Lavatories.
5. Showers.
6. Kitchen sinks.
7. Laundry trays.
8. Dishwasher air-gap fittings.
9. Disposers.
10. Water closets.
11. Toilet seats.
12. Supply fittings.
13. Waste fittings.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Counter cutout templates for mounting of counter-mounted plumbing fixtures.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance data.

PART 2 - PRODUCTS

2.1 BATHTUBS

A. Bathtubs: As directed Enameled cast iron, Enameled steel, FRP or PMMA, with shower.

1. Enameled Cast-Iron Bathtubs: As directed.

2. Enameled-Steel Bathtubs: As directed.

3. FRP Bathtubs: As directed.

4. PMMA (Acrylic) Bathtubs: As directed.

5. Fixture:

    a. Standard: As directed, ASME A112.19.1/CSA B45.2 for enameled cast-iron or enameled-steel bathtubs.
    b. Standard: As directed, ANSI Z124.1.2 for FRP or PMMA bathtubs.
    c. Bathing Surface: Slip resistant according to ASTM F462.
    d. Size: As directed, 48 by 30 inches (1219 by 762 mm), 60 by 30 inches (1525 by 762 mm) or 66 by 30 inches (1680 by 762 mm) with front apron or drop-in type.
    e. Color: White.
    f. Drain Location: As directed, Left or Right end.
    g. Drain: NPS 1-1/2 (DN 40); chrome-plated-brass, pop-up waste and overflow.

6. Faucet: As directed.
7. Supply Fittings: Included in faucet.
8. Tub Filler: Chrome-plated-brass diverter spout.
9. Waste Fittings:

    a. Standard: ASME A112.18.2/CSA B45.125.2.
    b. Drain: Stainless steel or chrome-plated brass, removable strainer.
    c. Overflow: Chrome-plated-brass escutcheon with toggle drain-plug device.
    d. Drain Piping: NPS 1-1/2 (DN 40) cast-brass overflow, P-trap, and waste.
    e. Drain Piping: Schedule 40 ABS or PVC, NPS 1-1/2 (DN 40) P-trap and waste.

2.2 BATHTUB FAUCETS

A. NSF Standard: Comply with NSF/ANSI 61 Annex G, "Drinking Water System Components - Health Effects," for faucet materials that will be in contact with potable water.

B. Bathtub Faucets: As directed, Single handle, pressure balance or thermostatic.

1. Pressure-Balance Faucets: As directed.

2. Thermostatic Faucets: As directed.

3. Standards: ASME A112.18.1/CSA B125.1 and ASSE 1016.
4. Faucet:

    a. Body Material: Solid brass.
    b. Finish: Polished chrome plate.
    c. Maximum Flow Rate: 2.5 gpm (9.5 L/min.) unless otherwise indicated.
    d. Mounting: As directed, Concealed or Exposed.

e. Operation: Single handle, push-pull or twist or rotate control, with hot- and cold-water indicators.
f. Antiscald Device: As directed, Integral with mixing valve, Separate unit or Not required.
g. Check Stops: Check-valve type, integral with or attached to body; on hot- and cold-water supply connections.
h. Diverter: In-tub filler spout.
i. Supply Connections: NPS 1/2 (DN 15).

5. Shower Head:

a. Standard: ASME A112.18.1/CSA B125.1.
b. Type: As directed, Ball joint with arm and flange, Without ball joint, but with arm and flange, Ball joint and head integral with mounting flange, Integral with mounting flange or Hand shower. Include wall-mounting device.
c. Backflow-Prevention Device: ASSE 1014.
d. Shower Head Material: Metallic with chrome-plated finish.
e. Spray Pattern: As directed, Adjustable or Fixed.
f. Integral Volume Control: As directed, Not required or Required.
g. Shower-Arm, Flow-Control Fitting: As directed, Not required, 1.5 gpm (5.7 L/min.) or 2.0 gpm (7.6 L/min.).
h. Temperature Indicator: As directed, Integral with faucet or Not required.

6. Bathtub Filler Spout: Chrome-plated brass.

2.3 BIDETS

A. Bidets:
1. Fixture:

a. Standard: ASME A112.19.2/CSA B45.1 for vitreous-china bidets.
b. Type: As directed, with spray, flushing rim, spray and flushing rim or no spray.
c. Hole Punching: Number and spacing to match faucet.
d. Mounting: Floor.
e. Overflow: As directed, Not required or Required.
f. Color: White.

2. Faucet:

a. Standard: ASME A112.18.3.
b. Type: As directed, Manufacturer's standard with vacuum breaker, diverter, and submerged spray or over-rim filling, pop-up drain, NPS 1-1/4 (DN 32) tailpiece, and chrome-plated finish. As directed, include manufacturer's standard, cross, lever or wrist-blade handles.

3. Supply Fittings: Comply with requirements in "Supply Fittings" Article.
4. Waste Fittings: Comply with requirements in "Waste Fittings" Article, except faucet includes pop-up drain.

2.4 LAVATORIES

A. Lavatories: As directed, Oval, Rectangular, Round, enameled cast iron, enameled steel, PMMA, solid surface, stainless steel or vitreous china, counter mounted.

1. Enameled Cast-Iron Lavatories: As directed.

2. Enameled-Steel Lavatories: As directed.

3. PMMA (Acrylic) Lavatories: As directed.

4. Solid-Surface Lavatories: As directed.

5. Stainless-Steel Lavatories: As directed.

6. Vitreous-China Lavatories: As directed.

7. Fixture:

    a. Standard: ASME A112.19.1/CSA B45.2 for enameled cast-iron-steel lavatories.
    b. Standard: ANSI Z124.3 for PMMA lavatories.
    c. Standard: ANSI Z124.3 and ANSI/ICPA SS-1 for solid-surface lavatories.
    d. Standard: ASME A112.19.3/CSA B45.4 for stainless-steel lavatories.
    e. Standard: ASME A112.19.2/CSA B45.1 for vitreous-china lavatories.
    f. Type: As directed Flat-rim with ledge or Self-rimming.
    g. Oval Nominal Size: As directed 19 by 16 inches (483 by 406 mm) or 20 by 17 inches (508 by 432 mm).
    h. Rectangular Nominal Size: As directed 18 by 15 inches (457 by 381 mm), 19 by 16 inches (483 by 406 mm), 20 by 18 inches (508 by 457 mm) or 24 by 20 inches (610 by 508 mm).
    i. Round Nominal Size: As directed 18 inches (457 mm) or 19 inches (483 mm) in diameter.
    j. Faucet-Hole Punching: As directed One hole, Three holes, 2-inch (51-mm) centers or Three holes, 4-inch (102-mm) centers.
    k. Faucet-Hole Location: As directed None or Rim.
    l. Color: As directed Not applicable or White.

8. Faucet: As directed.
9. Supply Fittings: Comply with requirements in "Supply Fittings" Article.
10. Waste Fittings: Comply with requirements in "Waste Fittings" Article.

B. Lavatories: As directed Oval or Rectangular, vitreous china, pedestal.
1. Fixture:

    a. Standard: ASME A112.19.2/CSA B45.1.
    b. Oval Nominal Size: As directed, 20 by 17 inches (508 by 432 mm) or 24 by 18 inches (610 by 457 mm).
    c. Rectangular Nominal Size: As directed, 18 by 15 inches (457 by 381 mm), 19 by 16 inches (483 by 406 mm), 20 by 18 inches (508 by 457 mm) or 24 by 20 inches (610 by 508 mm).

d. Faucet-Hole Punching: As directed, One hole, Three holes, 2-inch (51-mm) centers or Three holes, 4-inch (102-mm) centers.
e. Faucet-Hole Location: As directed, Top, Front wall or Inclined panel.
f. Color: White.

2. Faucet: As directed.
3. Supply Fittings: Comply with requirements in "Supply Fittings" Article.
4. Waste Fittings: Comply with requirements in "Waste Fittings" Article.

2.5 LAVATORY FAUCETS

A. NSF Standard: Comply with NSF/ANSI 61 Annex G, "Drinking Water System Components - Health Effects," for faucet materials that will be in contact with potable water.

B. Lavatory Faucets: As directed, Single-control mixing, Single-control nonmixing or Two-handle mixing valve.

1. General-Duty, Solid-Brass Faucets: As directed.

2. General-Duty, Copper- or Brass-Underbody Faucets: As directed.

3. Standard: ASME A112.18.1/CSA B125.1.
4. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.
5. Body Material: As directed, General-duty, solid brass or General-duty, copper or brass underbody with brass cover plate.
6. Finish: As directed Polished chrome plate or Polished brass.
7. Maximum Flow Rate: As directed, 2.2 gpm (8.3 L/min.) or 2.5 gpm (9.5 L/min.).
8. Centers: As directed 3-3/8 inches (86 mm), 4 inches (102 mm), 6 inches (152 mm), 8 inches (203 mm), Single hole or Adjustable.
9. Mounting: As directed, Deck, exposed, Deck, concealed, Back/wall, exposed or Back/wall, concealed.
10. Valve Handle(s): As directed, Lever, Knob, Knob, nonmetallic, Cross, four arm, Wrist blade, 4 inches (102 mm), Elbow, 6 inches (152 mm), Push button or Not applicable.
11. Inlet(s): As directed, NPS 3/8 (DN 10) tubing, plain end, NPS 3/8 (DN 10) tubing, with NPS 1/2 (DN 15) male adaptor, NPS 1/2 (DN 15) male shank or NPS 1/2 (DN 15) female shank.
12. Spout: As directed, Rigid, Swing, Rigid, gooseneck or Swivel, gooseneck.
13. Spout Outlet: As directed, Aerator, Spray, Plain end or Spray, 0.5 gpm (1.9 L/min.).
14. Operation: As directed, Compression, manual, Noncompression, manual, Sensor or Self-closing, metering.
15. Drain: As directed, Pop up, Stopper with chain or Grid.

2.6 SHOWERS

A. Showers: Standard As directed FRP or PMMA with base and faucet.

1. FRP Showers: As directed.

2. PMMA (Acrylic) Showers: As directed.

3. Standard: ANSI Z124.1.2.
4. Nominal Size: As directed, 36 by 34 inches (915 by 865 mm), 42 by 36 inches (1065 by 915 mm), 43 by 39 inches (1090 by 990 mm) or 48 by 34 inches (1219 by 865 mm).
5. Surround: One piece or sealed, multiple pieces.
6. Surround: One piece.
7. Bathing Surface: Slip resistant according to ASTM F462.
8. Color: White.
9. Drain Location: As directed, Left side, Center or Right side.
10. Faucet: As directed.

B. Showers: As directed Accessible FRP or PMMA with seat, grab bar, base, and faucet.

1. FRP Showers: As directed.

2. PMMA Showers: As directed.

3. Standards: ANSI Z124.1.2 and ICC/ANSI A117.1 for roll-in shower compartments.
4. Nominal Size: As directed 60 by 36 inches (1525 by 915 mm) or 72 by 36 inches (1830 by 915 mm).
5. Surround: One piece or sealed, multiple pieces.
6. Surround: One piece.
7. Bathing Surface: Slip resistant according to ASTM F462.
8. Color: White.
9. Drain Location: As directed, Left side, Center or Right side.
10. Accessibility Options: Include grab bar and bench.
11. Faucet: Shower As directed.
12. Drain: Grid, NPS 2 (DN 50).

2.7 SHOWER FAUCETS

A. NSF Standard: Comply with NSF/ANSI 61 Annex G, "Drinking Water System Components - Health Effects," for faucet materials that will be in contact with potable water.

B. Shower Faucets: As directed, Single handle, pressure-balance, mixing valve, Single handle, thermostatic, mixing valve or Two handle, non-pressure-balance and non-thermostatic, mixing valve.

1. Single-Handle, Pressure-Balance Faucets: As directed.

2. Single-Handle, Thermostatic Faucets: As directed.

3. Two-Handle, Non-Pressure-Balance, and Non-Thermostatic Mixing Faucets: As directed.

4. Fixture:

a. Standard: ASME A112.18.1/CSA B125.1 and ASSE 1016.

b. General: Include hot- and cold-water indicators; check stops; and As directed fixed shower head, arm, and flange or hand head complying with ASSE 1014 with arm, flange, hose, and bracket. Coordinate faucet inlets with supplies.
c. Body Material: As directed Solid brass with nonmetallic trim.
d. Finish: As directed Polished chrome plate or Polished brass.
e. Maximum Flow Rate: 2.5 gpm (9.5 L/min.) unless otherwise indicated.
f. Mounting: As directed, Exposed or Concealed.
g. Backflow-Prevention Device for Hand-Held Shower: As directed Required or Not required.
h. Operation: As directed, Compression, manual or non-compression, manual.
i. Antiscald Device: As directed, integral with mixing valve, Separate unit or Not required.
j. Check Stops: Check-valve type, integral with or attached to body; on hot- and cold-water supply connections.

5. Supply Connections: As directed, NPS 1/2 (DN 15) or NPS 3/4 (DN 20).
6. Shower Head:

a. Type: As directed, Ball joint, without ball joint, Ball joint and head integral with mounting flange, Integral with mounting flange, Hand-held, slide-bar mounted or Hand-held, hook mounted.
b. Shower Head Material: As directed, Metallic, Nonmetallic or Combined, metallic and nonmetallic with chrome-plated finish.
c. Spray Pattern: As directed, Fixed or Adjustable.
d. Integral Volume Control: As directed, Required or Not required.
e. Shower-Arm, Flow-Control Fitting: As directed, Not required, 1.5 gpm (5.7 L/min.) or 2.0 gpm (7.6 L/min.).

2.8 KITCHEN SINKS

A. Kitchen Sinks: As directed, One, Two or Three bowl, counter mounted, enameled cast iron, enameled steel, PMMA, solid surface or stainless steel.

1. Enameled Cast-Iron Kitchen Sinks: As directed.

2. Enameled-Steel Kitchen Sinks: As directed.

3. PMMA Kitchen Sinks: As directed.

4. Solid-Surface Kitchen Sinks: As directed.

5. Stainless-Steel Kitchen Sinks: As directed.

6. Fixture:

a. Standard: ASME A112.19.1/CSA B45.2 for enameled cast-iron or -steel kitchen sinks.
b. Standard: ANSI Z124.3 for PMMA kitchen sinks.
c. Standard: ANSI Z124.3 and ANSI/ICPA SS-1 for solid-surface kitchen sinks.

d. Standard: ASME A112.19.3/CSA B45.4 for stainless-steel kitchen sinks.
e. Overall Dimensions: As directed.
f. Metal Thickness: As directed, 0.038 inch (1.0 mm) or 0.050 inch (1.3 mm).
g. Bowl:

1) Dimensions: As directed.
2) Drain: 3-1/2-inch (89-mm) crumb cup, grid or outlet for disposer.

a) Location: As directed, Centered in bowl or Near back of bowl.

h. Left Bowl:

1) Dimensions: As directed.
2) Drain: As directed 3-1/2-inch (89-mm) crumb cup, grid, grid with offset waste or outlet for disposer.

a) Location: As directed, Centered in bowl or Near back of bowl.

i. Right Bowl:

1) Dimensions: As directed.
2) Drain: 3-1/2-inch (89-mm) crumb cup, grid, grid with offset waste or outlet for disposer.

a) Location: As directed, Centered in bowl or Near back of bowl.

j. Center Bowl:

1) Dimensions: As directed.
2) Drain: As directed, 1-1/2-inch (38-mm), 3-1/2-inch (89-mm), crumb cup, grid or grid with offset waste.

a) Location: Centered in bowl.

7. Faucet: As directed.
8. Supply Fittings: Comply with requirements in "Supply Fittings" Article.
9. Waste Fittings: Comply with requirements in "Waste Fittings" Article, except include continuous waste for multi-bowl sinks.

a. Disposer: Not required.
b. Dishwasher Air-Gap Fitting: As directed, Not required or Comply with requirements in "Dishwasher Air-Gap Fittings" Article.

2.9 LAUNDRY TRAYS

A. Laundry Trays: Plastic.
1. Fixture:

a. Standard: IAPMO/ANSI Z124.6.
b. Style: Flat-rim ledge.

c. Material: As directed, Plastic, cast polymer, FRP, PMMA or PP.
d. Nominal Size: As directed, 24 by 21 inches (610 by 535 mm) or 25 by 22 inches (635 by 559 mm).
e. Color: White.
f. Mounting: Freestanding on manufacturer's standard legs or separate, painted-steel stand.

2. Faucet: As directed.
3. Supply Fittings: Comply with requirements in "Supply Fittings" Article.
4. Waste Fittings: Comply with requirements in "Waste Fittings" Article.

2.10 SINK FAUCETS

A. NSF Standard: Comply with NSF/ANSI 61 Annex G, "Drinking Water System Components - Health Effects," for faucet materials that will be in contact with potable water.

B. Sink Faucets: As directed, Solid brass, Copper underbody, kitchen sink, bar sink or laundry tray.

1. General-Duty, Solid-Brass Faucets: As directed.

2. General-Duty, Copper-Underbody Faucets: As directed.

3. Standard: ASME A112.18.1/CSA B125.1.
4. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.
5. Kitchen Sink Option: Separate hand spray complying with ASSE 1025.
6. Finish: As directed, Polished chrome plate, Polished brass, Nonmetallic, Polished or rough brass or Rough brass.
7. Maximum Flow Rate: As directed, 2.5 gpm (9.5 L/min.) or 4.0 gpm (15 L/min.) unless otherwise indicated.
8. Mixing Valve: As directed, Single control or Two-lever handle.
9. Backflow-Prevention Device for Hand Spray: As directed Required or Not required.
10. Centers: As directed, 4 inches (102 mm), 6 inches (152 mm) or 8 inches (203 mm), Single hole or Adjustable.
11. Mounting: As directed, Deck, Back/wall, exposed or concealed.
12. Handle(s): As directed, Lever, Knob, Knob, nonmetallic, Cross, four arm, Wrist blade, 4 inches (102 mm), Elbow, 6 inches (152 mm) or Not applicable.
13. Spout Type: As directed, Rigid, solid brass, Rigid, solid brass with wall brace, Swing, round tubular, Swing, shaped tube, Swing, solid brass, Rigid gooseneck or Swivel gooseneck.
14. Spout Outlet: As directed, Aerator, Swivel aerator/spray, Spray or Plain end.
15. Drain: As directed, Stopper with chain, Grid or Lift and turn.

2.11 DISHWASHER AIR-GAP FITTINGS

A. Dishwasher Air-Gap Fittings:
1. Standard: ASSE 1021.

2. Description: Device designed to prevent backflow of contaminated liquid into domestic dishwashers.
3. Material: Plastic body with chrome-plated-brass cover.
4. Hose Connections: 5/8-inch- (16-mm-) ID inlet and 7/8-inch- (22-mm-) ID outlet.
5. Capacity: At least 5 gpm (0.32 L/s); at inlet pressure of at least 5 psig (35 kPa) and at temperature of at least 140 deg F (60 deg C).
6. Mounting: Deck.
7. Hoses: Rubber and suitable for temperature of at least 140 deg F (60 deg C).

    a. Inlet Hose: 5/8- inch (16 mm) ID and 48 inches (1219 mm) long.
    b. Outlet Hose: 7/8- inch (22 mm) ID and 48 inches (1219 mm) long.

2.12 DISPOSERS

A. Disposers: Continuous-feed household, food waste.
1. Standards: ASSE 1008 and UL 430, and listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. General: Include reset button; wall switch; corrosion-resistant chamber with jam-resistant, cutlery- or stainless-steel grinder or shredder; NPS 1-1/2 (DN 40) outlet; quick-mounting, stainless-steel sink flange; antisplash guard; and combination cover/stopper.
3. Model: As directed, Not applicable, Sound-insulated chamber or Sound-insulated chamber and stainless-steel outer shell.
4. Motor: As directed, 115 V ac, 1725 rpm, 1/3, ½, ¾ or 1 hp with overload protection.

2.13 WATER CLOSETS

A. Water Closets: Floor mounted, floor outlet, close coupled (gravity tank), vitreous china.
1. Bowl:

    a. Standards: ASME A112.19.2/CSA B45.1, ASME A112.19.5, and ASSE 1037.
    b. Bowl Type: Siphon jet.
    c. Height: As directed, Standard, Child or Handicapped/elderly.
    d. Rim Contour: As directed, Elongated or Regular.
    e. Water Consumption: As directed, Water saving or Low.
    f. Color: White.

2. Toilet Seat: As directed.
3. Supply Fittings:

    a. Standard: ASME A112.18.1/CSA B125.1.
    b. Supply Piping: Chrome-plated-brass pipe or chrome-plated-copper tube matching water-supply piping size. Include chrome-plated wall flange.
    c. Stop: Chrome-plated-brass, one-quarter-turn, ball-type or compression stop with inlet connection matching water-supply piping type and size.

        1) Operation: As directed, Loose key or Wheel handle.

    d. Riser:

1) Size: As directed, NPS 3/8 (DN 10) or NPS 1/2 (DN 15).
2) Material: As directed, Chrome-plated, soft-copper flexible tube or ASME A112.18.6, braided- or corrugated-stainless-steel flexible hose riser.

B. Water Closets: Floor mounted, floor outlet, close coupled (flushometer tank), vitreous china.

1. Sloan's "Flushmate" Flushometer-Tank, 1.0-Gal./Flush (3.8-L/Flush) Water Closets:

2. Sloan's "Flushmate" Flushometer-Tank, 1.6-Gal./Flush (6-L/Flush) Water Closets:

3. Geberit's "PF/2 Energizer" Flushometer-Tank, 1.6-Gal./Flush (6-L/Flush) Water Closets:

4. Briggs's Vacuum-Assist, Flushometer-Tank, 1.6-Gal./Flush (6-L/Flush) Water Closets:

5. Bowl:

a. Standards: ASME A112.19.2/CSA B45.1 and ASME A112.19.5.
b. Bowl Type: Siphon jet.
c. Height: As directed, Standard, Child or Handicapped/elderly.
d. Rim Contour: As directed, Elongated or Regular.
e. Water Consumption: As directed, Water saving or Low.
f. Color: White.

6. Toilet Seat: As directed.
7. Supply Fittings:

a. Standard: ASME A112.18.1/CSA B125.1.
b. Supply Piping: Chrome-plated-brass pipe or chrome-plated-copper tube matching water-supply piping size. Include chrome-plated wall flange.
c. Stop: Chrome-plated-brass, one-quarter-turn, ball-type or compression stop with inlet connection matching water-supply piping type and size.

1) Operation: As directed, Loose key or Wheel handle.

d. Riser:

1) Size: As directed, NPS 3/8 (DN 10) or NPS 1/2 (DN 15).
2) Material: As directed, Chrome-plated, soft-copper flexible tube or ASME A112.18.6, braided- or corrugated-stainless-steel flexible hose riser.

2.14 TOILET SEATS

A. Toilet Seats:
1. Standard: IAPMO/ANSI Z124.5.
2. Material: Plastic.
3. Type: As directed, Residential or Commercial (Standard).
4. Shape: As directed, Regular rim (Open front), Regular rim (Closed front), Elongated rim (Open front) or Elongated rim (Closed front).
5. Configuration: As directed, Closed or Open front with or without cover.

6. Size: As directed, Elongated or Regular.
7. Hinge Type: As directed, Check, Self-sustaining, Self-sustaining, check or Self-raising.
8. Hinge Material: As directed, Noncorroding metal or Plastic.
9. Seat Cover: As directed, Required or Not required.
10. Color: As directed, White or Black.

2.15 SUPPLY FITTINGS

A. NSF Standard: Comply with NSF/ANSI 61 Annex G, "Drinking Water System Components - Health Effects," for faucet materials that will be in contact with potable water.

B. Standard: ASME A112.18.1/CSA B125.1.

C. As directed Bidet, Lavatory, Kitchen Sink and Laundry Tray Supply Fittings:

1. Supply Piping: Chrome-plated-brass pipe or chrome-plated-copper tube matching water-supply piping size. Include chrome-plated wall flange.
2. Stops: Chrome-plated-brass, one-quarter-turn, ball-type or compression stop with inlet connection matching water-supply piping type and size.

    a. Operation: As directed, Loose key or Wheel handle.

3. Risers:

    a. Size: NPS 3/8 (DN 10) for bidets and lavatories.
    b. Size: As directed, NPS 3/8 (DN 10), NPS 1/2 (DN 15) for kitchen sinks and laundry trays.
    c. Material: As directed, Chrome-plated, soft-copper flexible tube or ASME A112.18.6, braided- or corrugated-stainless-steel flexible hose riser.

2.16 WASTE FITTINGS

A. Standard: ASME A112.18.2/CSA B125.2.

B. Drain: Grid type with NPS 1-1/4 (DN 32) offset tailpiece for accessible lavatories.

C. Drain: Pop-up type with NPS 1-1/4 (DN 32) straight tailpiece as part of faucet for standard lavatories.

D. Drain: Grid type with NPS 1-1/2 (DN 40) offset tailpiece for accessible kitchen sinks.

E. Drain: Grid type with NPS 1-1/2 (DN 40) straight tailpiece for standard kitchen sinks and laundry trays.

F. Trap:

1. Size: As directed, NPS 1-1/4 (DN 32), NPS 1-1/2 by NPS 1-1/4 (DN 40 by DN 32), NPS 1-1/2 (DN 40) for bidets and lavatories.
2. Size: As directed NPS 1-1/2 (DN 40) for kitchen sinks and laundry trays.

3. Material: As directed, Chrome-plated, two-piece, cast-brass trap and swivel elbow with 0.032-inch (0.83-mm) thick brass tube to wall, two-piece, cast-brass trap and ground-joint swivel elbow with 0.032-inch (0.83-mm) thick brass tube to wall or one-piece, cast-brass trap with swivel 0.029-inch (73-mm) thick tubular brass wall bend; and chrome-plated-brass or -steel wall flange.
4. Material: Stainless-steel, two-piece trap and swivel elbow with 0.012-inch (0.30-mm) thick stainless-steel tube to wall; and stainless-steel wall flange.
5. Material: ASTM F409 ABS or PVC one two-piece trap and waste to wall and wall flange.

2.17 GROUT

A. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Non-shrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install plumbing fixtures level and plumb according to roughing-in drawings.

B. Install floor-mounted water closets on closet flange attachments to drainage piping.

C. Install counter-mounting fixtures in and attached to casework.

D. Install pedestal lavatories on pedestals and secured to wood blocking in wall.

E. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.

1. Exception: Use ball or gate valves if supply stops are not specified with fixture. Comply with valve requirements specified in Section 220523.12 "Ball Valves for Plumbing Piping" and Section 220523.15 "Gate Valves for Plumbing Piping."

F. Install tanks for accessible, tank-type water closets with lever handle mounted on wide side of compartment.

G. Install toilet seats on water closets.

H. Install faucet flow-control fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

I. Install shower flow-control fittings with specified maximum flow rates in shower arms.

J. Install traps on fixture outlets.

1. Exception: Omit trap on fixtures with integral traps.
2. Exception: Omit trap on indirect wastes unless otherwise indicated.

K. Install disposer in outlet of each sink indicated to have disposer. Install switch where indicated or in wall adjacent to sink if location is not indicated.

L. Install dishwasher air-gap fitting at each sink indicated to have air-gap fitting. Install in sink deck or on countertop at sink. Connect inlet hose to dishwasher and outlet hose to disposer.

M. Set bathtubs and shower receptors in leveling bed of cement grout.

N. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories and sinks. Comply with requirements in Section 220719 "Plumbing Piping Insulation."

O. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

P. Seal joints between plumbing fixtures, counters, floors, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

3.2 CONNECTIONS

A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

D. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories and sinks. Comply with requirements in Section 220719 "Plumbing Piping Insulation."

3.3 ADJUSTING

A. Operate and adjust plumbing fixtures and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.

B. Adjust water pressure at faucets to produce proper flow.

3.4 CLEANING AND PROTECTION

A. After completing installation of plumbing fixtures, inspect and repair damaged finishes.

B. Clean plumbing fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.

C. Provide protective covering for installed plumbing fixtures and fittings.

D. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 224100

SECTION 224213.13 - COMMERCIAL WATER CLOSETS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Water closets.
2. Flushometer valves and tanks.
3. Toilet seats.
4. Supports.

B. Related Requirements:

1. Section 224100 "Residential Plumbing Fixtures" for residential water closets.
2. Section 224300 "Medical Plumbing Fixtures" for healthcare water closets.
3. Section 224600 "Security Plumbing Fixtures" for security water closets.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For flushometer valves and electronic sensors to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 FLOOR-MOUNTED, BOTTOM-OUTLET WATER CLOSETS

A. Water Closets: Floor mounted, bottom outlet, top spud.
1. Bowl:

a. Standards: ASME A112.19.2/CSA B45.1 and ASME A112.19.5.
b. Material: Vitreous china.
c. Type: Siphon jet.
d. Style: Flushometer valve.
e. Height: As directed, Standard, Child or Handicapped/elderly, complying with ICC/ANSI A117.1.

f. Rim Contour: Elongated.
g. Water Consumption: As directed, 1.28 gal. (4.8 L) or 1.6 gal. (6 L) per flush.
h. Spud Size and Location: NPS 1-1/2 (DN 40); top.
i. Color: White.

2. Bowl-to-Drain Connecting Fitting: ASTM A1045 or ASME A112.4.3.
3. Flushometer Valve: As directed.
4. Toilet Seat: As directed.

B. Water Closets: Floor mounted, bottom outlet, close-coupled flushometer tank.
1. Bowl:

a. Standards: ASME A112.19.2/CSA B45.1 and ASSE/ASME 1037/CSA B125.37.
b. Material: Vitreous china.
c. Type: Siphon jet.
d. Style: Pressure assisted.
e. Height: Standard, Handicapped/elderly, complying with ICC/ANSI A117.1.
f. Rim Contour: Elongated.
g. Water Consumption: As directed, Maximum 1.1 gal (4.2 L) or 1.6 gal. (6 L) per flush.
h. Color: White.

2. Bowl-to-Drain Connecting Fitting: ASTM A1045 or ASME A112.4.3.
3. Flushometer Tank: Pressure assisted.
4. Toilet Seat: As directed.

2.2 WALL-MOUNTED WATER CLOSETS

A. Water Closets: Wall mounted, top spud, accessible.
1. Bowl:

a. Standards: ASME A112.19.2/CSA B45.1 and ASME A112.19.5.
b. Material: Vitreous china.
c. Type: Siphon jet.
d. Style: Flushometer valve.
e. Height: Standard.
f. Rim Contour: Elongated.
g. Water Consumption: 1.28 gal. (4.8 L) or 1.6 gal. (6 L) per flush.
h. Spud Size and Location: NPS 1-1/2 (DN 40); top.

2. Flushometer Valve: As directed.
3. Toilet Seat: As directed.
4. Support: Water closet carrier.
5. Water-Closet Mounting Height: As directed, Standard, Child or Handicapped/elderly according to ICC A117.1.

2.3 FLUSHOMETER VALVES

A. Lever-Handle, Diaphragm Flushometer Valves:
   1. Standard: ASSE 1037.
   2. Minimum Pressure Rating: 125 psig (860 kPa).
   3. Features: Include integral check stop and backflow-prevention device.
   4. Material: Brass body with corrosion-resistant components.
   5. Exposed Flushometer-Valve Finish: Chrome plated.
   6. Panel Finish: Chrome plated or stainless steel.
   7. Style: As directed Exposed or Concealed.
   8. Consumption: As directed, 1.28 gal. (4.8 L), 1.6 gal. (6 L) or 3.5 gal. (13.2 L) per flush.
   9. Minimum Inlet: NPS 1 (DN 25).
   10. Minimum Outlet: NPS 1-1/4 (DN 32).

B. Lever-Handle, Piston Flushometer Valves:
   1. Standard: ASSE 1037.
   2. Minimum Pressure Rating: 125 psig (860 kPa).
   3. Features: Include integral check stop and backflow-prevention device.
   4. Material: Brass body with corrosion-resistant components.
   5. Exposed Flushometer-Valve Finish: Chrome plated.
   6. Panel Finish: Chrome plated or stainless steel.
   7. Style: As directed Exposed or Concealed.
   8. Consumption: As directed, 1.28 gal. (4.8 L), 1.6 gal. (6 L) or 3.5 gal. (13.2 L) per flush.
   9. Minimum Inlet: NPS 1 (DN 25).
   10. Minimum Outlet: NPS 1-1/4 (DN 32).

2.4 TOILET SEATS

A. Toilet Seats:
   1. Standard: IAPMO/ANSI Z124.5.
   2. Material: Plastic.
   3. Type: As directed, Commercial (Standard) or Commercial (Heavy duty).
   4. Shape: As directed, Elongated rim, open front or Elongated rim, closed front.
   5. Hinge: As directed, Check, Self-sustaining, Self-sustaining, check or Self-raising.
   6. Hinge Material: Noncorroding metal.
   7. Seat Cover: As directed, Required or Not required.
   8. Color: As directed White or Black.

2.5 SUPPORTS

A. Water Closet Carrier:
   1. Standard: ASME A112.6.1M.
   2. Description: Waste-fitting assembly, as required to match drainage piping material and arrangement with faceplates, couplings gaskets, and feet; bolts and hardware matching fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Water-Closet Installation:

1. Install level and plumb according to roughing-in drawings.
2. Install floor-mounted water closets on bowl-to-drain connecting fitting attachments to piping or building substrate.
3. Install accessible, wall-mounted water closets at mounting height for handicapped/elderly, according to ICC/ANSI A117.1.

B. Support Installation:

1. Install supports, affixed to building substrate, for floor-mounted, back-outlet water closets.
2. Use carrier supports with waste-fitting assembly and seal.
3. Install wall-mounted, back-outlet water-closet supports with waste-fitting assembly and waste-fitting seals; and affix to building substrate.

C. Flushometer-Valve Installation:

1. Install flushometer-valve, water-supply fitting on each supply to each water closet.
2. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
3. Install lever-handle flushometer valves for accessible water closets with handle mounted on open side of water closet.
4. Install actuators in locations that are easy for people with disabilities to reach.

D. Install toilet seats on water closets.

E. Wall Flange and Escutcheon Installation:

1. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations and within cabinets and millwork.
2. Install deep-pattern escutcheons if required to conceal protruding fittings.
3. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

F. Joint Sealing:

1. Seal joints between water closets and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
2. Match sealant color to water-closet color.
3. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

3.2 CONNECTIONS

A. Connect water closets with water supplies and soil, waste, and vent piping. Use size fittings required to match water closets.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

D. Where installing piping adjacent to water closets, allow space for service and maintenance.

3.3 ADJUSTING

A. Operate and adjust water closets and controls. Replace damaged and malfunctioning water closets, fittings, and controls.

B. Adjust water pressure at flushometer valves to produce proper flow.

3.4 CLEANING AND PROTECTION

A. Clean water closets and fittings with manufacturers' recommended cleaning methods and materials.

B. Install protective covering for installed water closets and fittings.

C. Do not allow use of water closets for temporary facilities unless approved in writing by Owner.

END OF SECTION 224213.13

SECTION 224213.16 - COMMERCIAL URINALS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Urinals.
2. Flushometer valves.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For flushometer valves and electronic sensors to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 WALL-HUNG URINALS

A. Urinals: Wall hung, back outlet, siphon jet, accessible.
1. Fixture:

a. Standards: ASME A112.19.2/CSA B45.1 and ASME A112.19.5.
b. Material: Vitreous china.
c. Type: Siphon jet with extended shield.
d. Strainer or Trapway: Manufacturer's standard strainer with integral trap.
e. Water Consumption: As directed, Water saving or Low.
f. Spud Size and Location: NPS 3/4 (DN 20); As directed, back or top.
g. Outlet Size and Location: NPS 2 (DN 50); back.
h. Color: White.

2. Flushometer Valve: As directed.
3. Waste Fitting:

a. Standard: ASME A112.18.2/CSA B125.2 for coupling.
b. Size: NPS 2 (DN 50).

4. Support: Type I Urinal Carrier with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture. Include rectangular, steel uprights.
5. Urinal Mounting Height: As directed, Standard, Child or Handicapped/elderly according to ICC A117.1.

B. Urinals: Wall hung, back outlet, washout, accessible
1. Fixture:

a. Standards: ASME A112.19.2/CSA B45.1 and ASME A112.19.5.
b. Material: Vitreous china.
c. Type: Washout with extended shields.
d. Strainer or Trapway: Manufacturer's standard strainer with integral trap.
e. Water Consumption: As directed, Water saving or Low.
f. Spud Size and Location: NPS 3/4 (DN 20), back or top.
g. Outlet Size and Location: As directed, NPS 2 (DN 50), back.
h. Color: White.

2. Flushometer Valve: As directed.
3. Waste Fitting:

a. Standard: ASME A112.18.2/CSA B125.2 for coupling.
b. Size: NPS 2 (DN 50).

4. Support: Type I Urinal Carrier with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture. Include rectangular, steel uprights.
5. Urinal Mounting Height: As directed, Standard, Child or Handicapped/elderly according to ICC A117.1.

2.2 WATERLESS URINALS

A. Urinals: Wall hung, back outlet, waterless, vitreous china, designed for liquid-trap-seal operation.
1. Fixture:

a. Standard: ASME A112.19.2/CSA B45.1, except without water supply.
b. Trap-Seal Method: Proprietary cartridge with liquid seal.
c. Outlet Size and Location: NPS 2 (DN 50) flange; back.
d. Trap-Sealing Liquid: Proprietary.
e. Color: White.

2. Waste Fitting:

a. Standard: ASME A112.18.2/CSA B125.2 for transition coupling, trap, and waste pipe.
b. Size: NPS 2 (DN 50).

3. Support: Type I Urinal Carrier with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture. Include rectangular, steel uprights.

4. Urinal Mounting Height: As directed, Standard, Child or Handicapped/elderly according to ICC A117.1.

2.3 URINAL FLUSHOMETER VALVES

A. Lever-Handle, Diaphragm Flushometer Valves:
1. Standard: ASSE 1037.
2. Minimum Pressure Rating: 125 psig (860 kPa).
3. Features: Include integral check stop and backflow-prevention device.
4. Material: Brass body with corrosion-resistant components.
5. Exposed Flushometer-Valve Finish: Chrome plated.
6. Style: Exposed.
7. Consumption: As directed, 0.5 gal. (1.9 L) or 1.0 gal. (3.8 L) per flush.
8. Minimum Inlet: As directed, NPS 3/4 (DN 20) or NPS 1 (DN 25).
9. Minimum Outlet: As directed, NPS 3/4 (DN 20) or NPS 1-1/4 (DN 32).

B. Solenoid-Actuator, Diaphragm Flushometer Valves:
1. Standard: ASSE 1037.
2. Minimum Pressure Rating: 125 psig (860 kPa).
3. Features: Include integral check stop and backflow-prevention device.
4. Material: Brass body with corrosion-resistant components.
5. Exposed Flushometer-Valve Finish: Chrome plated.
6. Style: Exposed.
7. Actuator: Solenoid complying with UL 1951; listed and labeled as defined in NFPA 70, by a qualified testing agency; and marked for intended location and application.
8. Trip Mechanism: As directed, Battery-powered or Hard-wired, electronic sensor complying with UL 1951; listed and labeled as defined in NFPA 70, by a qualified testing agency; and marked for intended location and application.
9. Consumption: As directed, 0.5 gal. (1.9 L) or 1.0 gal. (3.8 L) per flush.
10. Minimum Inlet: As directed, NPS 3/4 (DN 20) or NPS 1 (DN 25).
11. Minimum Outlet: As directed, NPS 3/4 (DN 20) or NPS 1-1/4 (DN 32).

C. Lever-Handle, Piston Flushometer Valves:
1. Standard: ASSE 1037.
2. Minimum Pressure Rating: 125 psig (860 kPa).
3. Features: Include integral check stop and backflow-prevention device.
4. Material: Brass body with corrosion-resistant components.
5. Exposed Flushometer-Valve Finish: Chrome plated.
6. Style: Exposed.
7. Consumption: As directed, 0.5 gal. (1.9 L) or 1.0 gal. (3.8 L) per flush.
8. Minimum Inlet: As directed, NPS 3/4 (DN 20) or NPS 1 (DN 25).
9. Minimum Outlet: As directed, NPS 3/4 (DN 20) or NPS 1-1/4 (DN 32).

D. Battery-Powered, Solenoid-Actuator, Piston Flushometer Valves:
1. Standard: ASSE 1037.
2. Minimum Pressure Rating: 125 psig (860 kPa).
3. Features: Include integral check stop and backflow-prevention device.
4. Material: Brass body with corrosion-resistant components.
5. Exposed Flushometer-Valve Finish: Chrome plated.
6. Style: Exposed.

7. Actuator: Solenoid complying with UL 1951; listed and labeled as defined in NFPA 70, by a qualified testing agency; and marked for intended location and application.
8. Trip Mechanism: Battery-powered electronic sensor complying with UL 1951; listed and labeled as defined in NFPA 70, by a qualified testing agency; and marked for intended location and application.
9. Consumption: As directed, 0.5 gal. (1.9 L) or 1.0 gal. (3.8 L) per flush.
10. Minimum Inlet: As directed, NPS 3/4 (DN 20) or NPS 1 (DN 25).
11. Minimum Outlet: As directed, NPS 3/4 (DN 20) or NPS 1-1/4 (DN 32).

2.4 SUPPORTS

A. Type I Urinal Carrier:
   1. Standard: ASME A112.6.1M.

B. Type II Urinal Carrier:
   1. Standard: ASME A112.6.1M.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before urinal installation.

B. Examine walls and floors for suitable conditions where urinals will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Urinal Installation:

   1. Install urinals level and plumb according to roughing-in drawings.
   2. Install wall-hung, back-outlet urinals onto waste fitting seals and attached to supports.
   3. Install wall-hung, bottom-outlet urinals with tubular waste piping attached to supports.
   4. Install accessible, wall-mounted urinals at mounting height for the handicapped/elderly, according to ICC/ANSI A117.1.
   5. Install trap-seal liquid in waterless urinals.

B. Support Installation:

   1. Install supports, affixed to building substrate, for wall-hung urinals.
   2. Use off-floor carriers with waste fitting and seal for back-outlet urinals.
   3. Use carriers without waste fitting for urinals with tubular waste piping.
   4. Use chair-type carrier supports with rectangular steel uprights for accessible urinals.

C. Flushometer-Valve Installation:

1. Install flushometer-valve water-supply fitting on each supply to each urinal.
2. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
3. Install lever-handle flushometer valves for accessible urinals with handle mounted on open side of compartment.
4. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

D. Wall Flange and Escutcheon Installation:

1. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations.
2. Install deep-pattern escutcheons if required to conceal protruding fittings.
3. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

E. Joint Sealing:

1. Seal joints between urinals and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
2. Match sealant color to urinal color.
3. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

3.3 CONNECTIONS

A. Connect urinals with water supplies and soil, waste, and vent piping. Use size fittings required to match urinals.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

D. Where installing piping adjacent to urinals, allow space for service and maintenance.

3.4 ADJUSTING

A. Operate and adjust urinals and controls. Replace damaged and malfunctioning urinals, fittings, and controls.

B. Adjust water pressure at flushometer valves to produce proper flow.

C. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

3.5 CLEANING AND PROTECTION

A. Clean urinals and fittings with manufacturers' recommended cleaning methods and materials.

B. Install protective covering for installed urinals and fittings.

C. Do not allow use of urinals for temporary facilities unless approved in writing by Owner.

END OF SECTION 224213.16

SECTION 224216.13 - COMMERCIAL LAVATORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Lavatories.
2. Faucets.
3. Supports.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: Include diagrams for power, signal, and control wiring of automatic faucets.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Counter cutout templates for mounting of counter-mounted lavatories.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For lavatories and faucets to include in operation and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Servicing and adjustments of automatic faucets.

PART 2 - PRODUCTS

2.1 VITREOUS-CHINA, COUNTER-MOUNTED LAVATORIES

A. Lavatory: As directed Oval or Round, self-rimming, vitreous china, counter mounted.
1. Fixture:

a. Standard: ASME A112.19.2/CSA B45.1.
b. Type: Self-rimming for above-counter mounting.

c. Nominal Size: As directed Oval, 19 by 17 inches (483 by 432 mm) or 20 by 17 inches (508 by 432 mm).
d. Nominal Size: Round, 19 inches (483 mm).
e. Faucet-Hole Punching: As directed One hole, Three holes, 2-inch (51-mm) centers or Three holes, 4-inch (102-mm) centers.
f. Faucet-Hole Location: Top.
g. Color: White.
h. Mounting Material: Sealant.

2. Faucet: As directed.

B. Lavatory: Oval, vitreous china, undercounter mounted.
1. Fixture:

a. Standard: ASME A112.19.2/CSA B45.1.
b. Type: For undercounter mounting.
c. Nominal Size: As directed Oval, 19 by 16 inches (483 by 406 mm), 22 by 14 inches (559 by 356 mm) or 23 by 15 inches (584 by 381 mm).
d. Faucet-Hole Punching: No holes.
e. Faucet-Hole Location: On countertop.
f. Color: White.
g. Mounting Material: Sealant and undercounter mounting kit.

2. Faucet: As directed.

2.2 VITREOUS-CHINA, WALL-MOUNTED LAVATORIES

A. Lavatory: Vitreous china, wall mounted, with back.
1. Fixture:

a. Standard: ASME A112.19.2/CSA B45.1.
b. Type: For wall hanging.
c. Nominal Size: As directed, Oval, 19 by 16 inches (483 by 406 mm), 22 by 14 inches (559 by 356 mm) or 23 by 15 inches (584 by 381 mm).
d. Faucet-Hole Punching: As directed ,One hole, Three holes, 2-inch (51-mm) centers or Three holes, 4-inch (102-mm) centers.
e. Faucet-Hole Location: Top.
f. Color: White.
g. Mounting Material: Chair carrier.

2. Faucet: As directed.
3. Support: As directed, Type I, exposed-arm lavatory carrier, Type II, concealed-arm lavatory carrier, Type II, concealed-arm lavatory carrier with escutcheons. Include rectangular, steel uprights.
4. Lavatory Mounting Height: As directed, Standard, Child or Handicapped/elderly according to ICC A117.1.

B. Lavatory: Ledge back, vitreous china, wall mounted.
1. Fixture:

a. Standard: ASME A112.19.2/CSA B45.1.
b. Type: For wall hanging.
c. Nominal Size: As directed, Oval, 19 by 16 inches (483 by 406 mm), 22 by 14 inches (559 by 356 mm) or 23 by 15 inches (584 by 381 mm).
d. Faucet-Hole Punching: As directed, One hole, Three holes, 2-inch (51-mm) centers or Three holes, 4-inch (102-mm) centers.
e. Faucet-Hole Location: Top.
f. Color: White.
g. Mounting Material: Chair carrier.

2. Faucet: As directed.
3. Support: As directed, Type I, exposed-arm lavatory carrier, Type II, concealed-arm lavatory carrier or Type II, concealed-arm lavatory carrier with escutcheons. Include rectangular, steel uprights.
4. Lavatory Mounting Height: As directed, Standard, Child or Handicapped/elderly according to ICC A117.1.

C. Lavatory: Wheelchair, vitreous china, wall mounted.
1. Fixture:

a. Standard: ASME A112.19.2/CSA B45.1.
b. Type: Slab or wheelchair.
c. Nominal Size: Rectangular, 27 by 20 inches (686 by 508 mm).
d. Faucet-Hole Punching: Three holes, 2-inch (51-mm) centers.
e. Faucet-Hole Location: Top.
f. Color: White.
g. Mounting: For concealed-arm carrier.

2. Faucet: As directed.
3. Support: As directed, Type II, concealed-arm lavatory carrier, Type II, concealed-arm lavatory carrier with escutcheons. Include rectangular, steel uprights.
4. Lavatory Mounting Height: As directed, Child or Handicapped/elderly according to ICC A117.1.

2.3 SOLID-BRASS, MANUALLY OPERATED FAUCETS

A. NSF Standard: Comply with NSF/ANSI 61 Annex G, "Drinking Water System Components - Health Effects," for faucet materials that will be in contact with potable water.

B. Lavatory Faucets: As directed, Manual-type, single-control mixing, single-control nonmixing, two-handle mixing, commercial or general-duty, solid-brass valve.
1. Standard: ASME A112.18.1/CSA B125.1.
2. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and fixture receptor.
3. Body Type: As directed, Centerset, Widespread or Single hole.
4. Body Material: Commercial, solid brass.
5. Finish: Polished chrome plate.
6. Maximum Flow Rate: 0.5 gpm (1.5 L/min.).
7. Maximum Flow: 0.25 gal. (0.95 L) per metering cycle.

8. Mounting Type: As directed, Deck, exposed, Deck, concealed, Back/wall, exposed or Back/wall, concealed.
9. Valve Handle(s): As directed, Single lever, Knob, Knob, nonmetallic, Cross, three arm, Cross, four arm, Wrist blade, 4 inches (102 mm), Elbow, 6 inches (152 mm) or Push button.
10. Spout: Rigid, Swing, Rigid, gooseneck or Swivel, gooseneck type.
11. Spout Outlet: As directed, Aerator, Laminar flow or Spray.
12. Operation: As directed, Compression, manual or Noncompression, manual.
13. Drain: Not part of faucet.

2.4 SUPPORTS

A. Type II Lavatory Carrier:
   1. Standard: ASME A112.6.1M.

B. Type III Lavatory Carrier:
   1. Standard: ASME A112.6.1M.

2.5 SUPPLY FITTINGS

A. NSF Standard: Comply with NSF/ANSI 61 Annex G, "Drinking Water System Components - Health Effects," for supply-fitting materials that will be in contact with potable water.

B. Standard: ASME A112.18.1/CSA B125.1.

C. Supply Piping: Chrome-plated-brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated-brass or stainless-steel wall flange.

D. Supply Stops: Chrome-plated-brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.

E. Operation: As directed Loose key or Wheel handle.

F. Risers:

   1. As directed, NPS 3/8 (DN 10) or NPS 1/2 (DN 15).
   2. As directed, Chrome-plated, soft-copper flexible tube or ASME A112.18.6, braided- or corrugated-stainless-steel, flexible hose riser.

2.6 WASTE FITTINGS

A. Standard: ASME A112.18.2/CSA B125.2.

B. Drain: Grid type with NPS 1-1/4 (DN 32) offset and straight tailpiece.

C. Trap:

   1. Size: As directed, NPS 1-1/2 by NPS 1-1/4 (DN 40 by DN 32) or NPS 1-1/4 (DN 32).

2. Material: As directed Chrome-plated, two-piece, cast-brass trap and swivel elbow with 0.032-inch (0.83-mm) thick brass tube to wall, two-piece, cast-brass trap and ground-joint swivel elbow with 0.032-inch (0.83-mm) thick brass tube to wall or one-piece, cast-brass trap with swivel 0.029-inch (73-mm) thick tubular brass wall bend; and chrome-plated, brass or steel wall flange.
3. Material: Stainless-steel, two-piece trap and swivel elbow with 0.012-inch (0.30-mm) thick stainless-steel tube to wall; and stainless-steel wall flange.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before lavatory installation.

B. Examine counters and walls for suitable conditions where lavatories will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install lavatories level and plumb according to roughing-in drawings.

B. Install supports, affixed to building substrate, for wall-mounted lavatories.

C. Install accessible wall-mounted lavatories at handicapped/elderly mounting height for people with disabilities or the elderly, according to ICC/ANSI A117.1.

D. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

E. Seal joints between lavatories and counters and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

F. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories. Comply with requirements in Section 220719 "Plumbing Piping Insulation."

3.3 CONNECTIONS

A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.4 ADJUSTING

A. Operate and adjust lavatories and controls. Replace damaged and malfunctioning lavatories, fittings, and controls.

B. Adjust water pressure at faucets to produce proper flow.

C. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

3.5 CLEANING AND PROTECTION

A. After completing installation of lavatories, inspect and repair damaged finishes.

B. Clean lavatories, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.

C. Provide protective covering for installed lavatories and fittings.

D. Do not allow use of lavatories for temporary facilities unless approved in writing by Owner.

END OF SECTION 224216.13

SECTION 224216.16 - COMMERCIAL SINKS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Service basins.
2. Service sinks.
3. Utility sinks.
4. Handwash sinks.
5. Sink faucets.
6. Laminar-flow, faucet-spout outlets.
7. Supports.
8. Supply fittings.
9. Waste fittings.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Counter cutout templates for mounting of counter-mounted lavatories.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance data.

PART 2 - PRODUCTS

2.1 SERVICE BASINS

A. Service Basins: Plastic, floor mounted.
   1. Fixture:

      a. Standard: IAPMO/ANSI Z124.6.
      b. Material: Cast polymer.
      c. Nominal Size: As directed, 24 by 36 by 10 inches (610 by 915 mm by 255 mm) or 36 by 36 by 10 inches (915 by 915 by 255 mm).

d. Tiling Flange: As directed, Not required, On one side, On two sides or On three sides.
e. Rim Guard: On front or all top surfaces.
f. Color: Not applicable.
g. Drain: Grid with as directed NPS 2 (DN 50) or NPS 3 (DN 80) outlet.

2. Mounting: On floor and flush to wall.
3. Faucet: As directed.

2.2 SERVICE SINKS

A. Service Sinks: Enameled, cast iron, trap standard mounted.
1. Fixture:

a. Standard: ASME A112.19.1/CSA B45.2.
b. Type: Service sink with back.
c. Back: As directed, Two faucet holes or Plain.
d. Nominal Size: As directed, 22 by 18 inches (560 by 457 mm) or 24 by 20 inches (610 by 508 mm).
e. Color: White.
f. Mounting: As directed, NPS 2 (DN 50) or NPS 3 (DN 80) P-trap standard with grid strainer inlet, cleanout, and floor flange.
g. Rim Guard: On front and sides.

2. Faucet: As directed.
3. Support: Type II sink carrier.
4. Lavatory Mounting Height: As directed, Standard, Child or Handicapped/elderly according to ICC A117.1.

2.3 UTILITY SINKS

A. Utility Sinks: Stainless steel, counter mounted.
1. Fixture:

a. Standard: ASME A112.19.3/CSA B45.4.
b. Type: Ledge back.
c. Number of Compartments: As directed, One, Two or Three.
d. Overall Dimensions: As directed.
e. Metal Thickness: 0.050 inch (1.3 mm).
f. Compartment:

1) Dimensions: As directed.
2) Drain: As directed, Grid with NPS 1-1/2 (DN 40) tailpiece and twist drain, Grid with NPS 2 (DN 50) tailpiece and twist drain or NPS 1-1/2 (DN 40) tailpiece with stopper.
3) Drain Location: As directed, Centered in compartment, Near back of compartment, Near left side of compartment or Near right side of compartment.

g. Each Compartment:

1) Dimensions: As directed.
2) Drains: As directed, Grid with NPS 1-1/2 (DN 40) tailpiece and twist drain, Grid with NPS 2 (DN 50) tailpiece and twist drain or NPS 1-1/2 (DN 40) tailpiece with stopper.
3) Drain Location: As directed, Centered in compartment or Near back of compartment.

2. Faucet(s): As directed.

a. Number Required: As directed One or Two.
b. Mounting: On ledge.

3. Supply Fittings:

a. Standard: ASME A112.18.1/CSA B125.1.
b. Supplies: Chrome-plated brass compression stop with inlet connection matching water-supply piping type and size.

1) Operation: As directed, Loose key or Wheel handle.
2) Risers: As directed, NPS 1/2 (DN 15), chrome-plated, rigid-copper pipe, chrome-plated, soft-copper flexible tube or ASME A112.18.6, braided or corrugated stainless-steel flexible hose.

4. Waste Fittings:

a. Standard: ASME A112.18.2/CSA B125.2.
b. Trap(s):

1) Size: As directed, NPS 1-1/2 (DN 40) or NPS 2 (DN 50).
2) Material: As directed, Chrome-plated, two-piece, cast-brass trap and swivel elbow with 0.032-inch (0.83-mm) thick brass tube to wall or two-piece, cast-brass trap and ground-joint swivel elbow with 0.032-inch (0.83-mm) thick brass tube to wall; and chrome-plated brass or steel wall flange.
3) Material: Stainless-steel, two-piece trap and swivel elbow with 0.012-inch- (0.30-mm-) thick stainless-steel tube to wall; and stainless-steel wall flange.

c. Continuous Waste:

1) Size: As directed, NPS 1-1/2 (DN 40) or NPS 2 (DN 50).
2) Material: Chrome-plated, 0.032-inch- (0.83-mm-) thick brass tube.

5. Mounting: On counter with sealant.

2.4 HANDWASH SINKS

A. Handwash Sinks: Stainless steel, wall mounted.
1. Fixture:

a. Standards: ASME A112.19.3/CSA B45.4 and NSF/ANSI 2.

b. Type: Basin with radius corners, back for faucet, and support brackets.
c. Nominal Size: 17 by 16 by 5 inches (432 by 406 by 127 mm).

2. Faucet: As directed
3. Supply Fittings: Comply with requirements in "Supply Fittings" Article.
4. Waste Fittings: Comply with requirements in "Waste Fittings" Article.
5. Support: Type II sink carrier.
6. Lavatory Mounting Height: As directed, Standard, Child or Handicapped/elderly according to ICC A117.1.

2.5 SINK FAUCETS

A. NSF Standard: Comply with NSF 372 for faucet-spout materials that will be in contact with potable water.

B. Sink Faucets: As directed, Manual type, single-control or two-lever-handle mixing valve.

1. Commercial, Solid-Brass Faucets: As directed.

2. General-Duty, Solid-Brass Faucets: As directed.

3. Copper- or Brass-Underbody Faucets: As directed.

4. Standard: ASME A112.18.1/CSA B125.1.
5. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and sink receptor.
6. Body Type: As directed, Centerset, Widespread or Single hole.
7. Body Material: As directed, Commercial, solid brass, General-duty, solid brass or Copper or brass underbody.
8. Finish: As directed, Chrome plated or Polished chrome plate.
9. Maximum Flow Rate: As directed, 2.2 gpm (8.3 L/min.) or 4.0 gpm (15 L/min.).
10. Handle(s): As directed Lever, Cross, four arm, Wrist blade, 4 inches (102 mm), Elbow, 6 inches (152 mm) or Not applicable.
11. Mounting Type: As directed, Deck, concealed, Deck, exposed or Back/wall, exposed.
12. Spout Type: As directed, Rigid, solid brass, Rigid, solid brass with wall brace, Swing, round tubular, Swing, shaped tube, Swing, solid brass, Rigid gooseneck or Swivel gooseneck.
13. Vacuum Breaker: As directed, Required or Not required for hose outlet.
14. Spout Outlet: As directed, Aerator, Laminar flow or Hose thread according to ASME B1.20.7, Plain end or Spray.

C. Sink Faucets: Automatic, sensor-operated type, 120 V ac hard-wired or battery-powered, mixing valve.

1. Commercial, Solid-Brass Faucets.

2. General-Duty, Solid-Brass Faucets.

3. Standard: ASME A112.18.1/CSA B125.1.

4. General: Coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and sink receptor.
5. Body Type: As directed, Centerset or Single hole.
6. Body Material: As directed, Commercial, solid brass or General-duty, solid brass.
7. Finish: As directed, Chrome plated or Polished chrome plate.
8. Maximum Flow Rate: 0.5 gpm (1.9 L/min.).
9. Mounting Type: As directed, Deck or Back/wall.
10. Spout Type: As directed, Rigid spout or Rigid gooseneck.
11. Spout Outlet: As directed, Aerator or Laminar flow.
12. Thermostatic Mixing Valve: As directed, Above deck, Below deck, single temperature or adjustable temperature manual side handle, with hot/cold water indicators, with check valves.
13. Control module: As directed, Above deck, Below deck, water-resistant module with internal flow setting switches.

2.6 LAMINAR-FLOW, FAUCET-SPOUT OUTLETS

A. NSF Standard: Comply with NSF 372 for faucet-spout-outlet materials that will be in contact with potable water.

B. Description: Chrome-plated brass, faucet-spout outlet that produces non-aerating, laminar stream. Include external or internal thread that mates with faucet outlet for attachment to faucets where indicated and flow-rate range that includes flow of faucet.

2.7 SUPPORTS

A. Type II Sink Carrier:
1. Standard: ASME A112.6.1M.

2.8 SUPPLY FITTINGS

A. NSF Standard: Comply with NSF 372 for supply-fitting materials that will be in contact with potable water.

B. Standard: ASME A112.18.1/CSA B125.1.

C. Supply Piping: Chrome-plated brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated brass or stainless-steel wall flange.

D. Supply Stops: Chrome-plated brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.

E. Operation: As directed, Loose key or Wheel handle.

F. Risers:

1. As directed, NPS 3/8 (DN 10) or NPS 1/2 (DN 15).
2. As directed, Chrome-plated, rigid-copper pipe, Chrome-plated, soft-copper flexible tube or ASME A112.18.6, braided or corrugated stainless-steel flexible hose.

2.9 WASTE FITTINGS

A. Standard: ASME A112.18.2/CSA B125.2.

B. Drain: Grid type with NPS 1-1/2 (DN 40) offset and straight tailpiece.

C. Trap:

1. Size: NPS 1-1/2 (DN 40).
2. Material: As directed, Chrome-plated, two-piece, cast-brass trap and swivel elbow with 0.032-inch (0.83-mm) thick brass tube to wall, two-piece, cast-brass trap and ground-joint swivel elbow with 0.032-inch (0.83-mm) thick brass tube to wall or one-piece, cast-brass trap with swivel 0.029-inch (73-mm) thick tubular brass wall bend; and chrome-plated brass or steel wall flange.
3. Material: Stainless-steel, two-piece trap and swivel elbow with 0.012-inch (0.30-mm) thick stainless-steel tube to wall; and stainless-steel wall flange.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before sink installation.

B. Examine walls, floors, and counters for suitable conditions where sinks will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install sinks level and plumb according to roughing-in drawings.

B. Install supports, affixed to building substrate, for wall-hung sinks.

C. Install accessible wall-mounted sinks at handicapped/elderly mounting height according to ICC/ANSI A117.1.

D. Set floor-mounted sinks in leveling bed of cement grout.

E. Install water-supply piping with stop on each supply to each sink faucet.

1. Exception: Use ball or gate valves if supply stops are not specified with sink. Comply with valve requirements specified in Section 220523.12 "Ball Valves for Plumbing Piping" and Section 220523.15 "Gate Valves for Plumbing Piping."
2. Install stops in locations where they can be easily reached for operation.

F. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

G. Seal joints between sinks and counters, floors, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

H. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible sinks. Comply with requirements in Section 220719 "Plumbing Piping Insulation."

3.3 CONNECTIONS

A. Connect sinks with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.4 ADJUSTING

A. Operate and adjust sinks and controls. Replace damaged and malfunctioning sinks, fittings, and controls.

B. Adjust water pressure at faucets to produce proper flow.

3.5 CLEANING AND PROTECTION

A. After completing installation of sinks, inspect and repair damaged finishes.

B. Clean sinks, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.

C. Provide protective covering for installed sinks and fittings.

D. Do not allow use of sinks for temporary facilities unless approved in writing by Owner.

END OF SECTION 224216.16

SECTION 224223 - COMMERCIAL SHOWERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Individual showers.
2. Shower faucets.
3. Grout.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

1.3 CLOSEOUT SUBMITTALS

A. Maintenance data.

PART 2 - PRODUCTS

2.1 INDIVIDUAL SHOWERS

A. Individual FRP Showers:
1. General: FRP, accessible, shower enclosure with faucet and receptor and appurtenances.
2. Standard: ANSI Z124.1.2.
3. Type: As directed, One-piece unit with top, One-piece unit without top, Sectional unit with top or Sectional unit without top.
4. Style: As directed, Standard residential or Handicapped/wheelchair.
5. Faucet: As directed.
6. Nominal Size and Shape: As directed, 30 by 30 inches (762 by 762 mm) square, 32 by 32 inches (813 by 813 mm) square, 34 by 34 inches (864 by 864 mm) square, 36 by 36 inches (915 by 915 mm) square, 48 by 34 to 36 inches (1219 by 864 to 915 mm) rectangular, 60 by 34 to 36 inches (1524 by 864 to 915 mm) rectangular, 36 inches (915 mm) neo-corner (two walls), 36 inches (915 mm) neo-corner (four walls), 38 inches (965 mm) neo-corner (two walls), 38 inches (965 mm) neo-corner (four walls), 42 inches (1067 mm) neo-corner (two walls) or 42 inches (1067 mm) neo-corner (four walls).
7. Color: White.
8. Bathing Surface: Slip resistant according to ASTM F462.
9. Outlet: Drain with NPS 2 (DN 50) outlet.
10. Shower Rod and Curtain: As directed, Not required or Required.
11. Grab Bar: STM F446, mounted on support area back wall or Not required.

B. Individual PMMA Showers:
   1. General: PMMA shower enclosure with faucet and receptor and appurtenances.
   2. Standard: ANSI Z124.1.2.
   3. Type: As directed, One-piece unit with top, One-piece unit without top, Sectional unit with top or Sectional unit without top.
   4. Style: As directed, Standard residential or Handicapped/wheelchair.
   5. Faucet: As directed.
   6. Nominal Size and Shape: As directed, 30 by 30 inches (762 by 762 mm) square, 32 by 32 inches (813 by 813 mm) square, 34 by 34 inches (864 by 864 mm) square, 36 by 36 inches (915 by 915 mm) square, 48 by 34 to 36 inches (1219 by 864 to 915 mm) rectangular, 60 by 34 to 36 inches (1524 by 864 to 915 mm) rectangular, 36 inches (915 mm) neo-corner (two walls), 36 inches (915 mm) neo-corner (four walls), 38 inches (965 mm) neo-corner (two walls), 38 inches (965 mm) neo-corner (four walls), 42 inches (1067 mm) neo-corner (two walls) or 42 inches (1067 mm) neo-corner (four walls).
   7. Color: White.
   8. Bathing Surface: Slip resistant according to ASTM F462.
   9. Outlet: Drain with NPS 2 (DN 50) outlet.
   10. Shower Rod and Curtain: As directed, Not required or Required.
   11. Grab Bar: As directed ASTM F446, mounted on support area back wall or Not required.

2.2 SHOWER FAUCETS

A. NSF Standard: Comply with NSF 61 Annex G, "Drinking Water System Components - Health Effects," for shower materials that will be in contact with potable water.

B. Shower Faucets:
   1. Description: Single-handle, pressure-balance mixing valve with hot- and cold-water indicators; check stops; and shower head.
   2. Faucet:

      a. Standards: ASME A112.18.1/CSA B125.1 and ASSE 1016.
      b. Body Material: Solid brass.
      c. Finish: Polished chrome plate.
      d. Shower-Arm, Flow-Control Fitting: As directed, Not required, 1.5 gpm (5.7 L/min.), 2.0 gpm (7.6 L/min.) or 2.5 gpm (9.5 L/min.).
      e. EPA WaterSense: Required.
      f. Mounting: As directed Concealed or Exposed.
      g. Operation: Single-handle, push-pull or twist or rotate control.
      h. Antiscald Device: As directed, Integral with mixing valve, Separate unit or Not required.
      i. Check Stops: Check-valve type, integral with or attached to body; on hot- and cold-water supply connections.

   3. Supply Connections: NPS 1/2 (DN 15).
   4. Shower Head:

      a. Standard: ASME A112.18.1/CSA B125.1.

b. Type: As directed Ball joint with arm and flange, Without ball joint, but with arm and flange, Ball joint and head integral with mounting flange or Integral with mounting flange.
c. Shower Head Material: Metallic with chrome-plated finish.
d. Spray Pattern: As directed, Adjustable or Fixed.
e. Integral Volume Control: As directed, Not required or Required.
f. Shower-Arm, Flow-Control Fitting: As directed, Not required, 1.5 gpm (5.7 L/min.) or 2.0 gpm (7.6 L/min.).
g. Temperature Indicator: As directed, Integral with faucet or Not required.

C. Shower Faucets:
1. Description: Single-handle, thermostatic mixing valve with hot- and cold-water indicators; check stops; and shower head.
2. Faucet:

a. Standards: ASME A112.18.1/CSA B125.1 and ASSE 1016.
b. Body Material: Solid brass.
c. Finish: Polished chrome plate.
d. Shower-Arm, Flow-Control Fitting: As directed, Not required, 1.5 gpm (5.7 L/min.), 2.0 gpm (7.6 L/min.) or 2.5 gpm (9.5 L/min.).
e. EPA WaterSense: Required.
f. Mounting: As directed Concealed or Exposed.
g. Operation: Single-handle, push-pull or twist or rotate control.
h. Antiscald Device: As directed, Integral with mixing valve, Separate unit or Not required.
i. Check Stops: Check-valve type, integral with or attached to body; on hot- and cold-water supply connections.

3. Supply Connections: NPS 1/2 (DN 15).
4. Shower Head:

a. Standard: ASME A112.18.1/CSA B125.1.
b. Type: As directed, Ball joint with arm and flange, Without ball joint, but with arm and flange, Ball joint and head integral with mounting flange or Integral with mounting flange.
c. Shower Head Material: Metallic with chrome-plated finish.
d. Spray Pattern: As directed, Adjustable or Fixed.
e. Integral Volume Control: As directed, Not required or Required.
f. Shower-Arm, Flow-Control Fitting: Not required, 1.5 gpm (5.7 L/min.) or 2.0 gpm (7.6 L/min.).
g. Temperature Indicator: As directed, Integral with faucet or Not required.

2.3 GROUT

A. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Assemble shower components according to manufacturers' written instructions.

B. Install showers level and plumb according to roughing-in drawings.

C. Install water-supply piping with stop on each supply to each shower faucet.

1. Exception: Use ball or gate valves if supply stops are not specified with shower. Comply with valve requirements specified in Section 220523.12 "Ball Valves for Plumbing Piping" and Section 220523.15 "Gate Valves for Plumbing Piping."
2. Install stops in locations where they can be easily reached for operation.

D. Install shower flow-control fittings with specified maximum flow rates in shower arms.

E. Set shower receptors in leveling bed of cement grout.

F. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheons requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

G. Seal joints between showers and floors and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

3.2 CONNECTIONS

A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Comply with traps and soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.3 ADJUSTING

A. Operate and adjust showers and controls. Replace damaged and malfunctioning showers, fittings, and controls.

B. Adjust water pressure at faucets to produce proper flow.

3.4 CLEANING AND PROTECTION

A. After completing installation of showers, inspect and repair damaged finishes.

B. Clean showers, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.

C. Provide protective covering for installed fixtures and fittings.

D. Do not allow use of showers for temporary facilities unless approved in writing by Owner.

END OF SECTION 224223

SECTION 224233 - WASH FOUNTAINS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Circular wash fountains.
2. Semicircular wash fountains.
3. Linear wash fountains.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: For each type of wash fountain.

1. Include plans, elevations, sections, and mounting or attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 SOLID-SURFACE, CIRCULAR WASH FOUNTAINS

A. Wash Fountains: Solid-surface, circular receptor.
1. Standard: IAPMO IGC 156.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Receptor:

a. Standard: ICPA SS-1 for solid-surface receptor.
b. Nominal Diameter: As directed 36 to 39 inches (914 to 990 mm), 39 inches (990 mm), 42 inches (1067 mm) or 54 inches (1370 mm).
c. Height to Rim: 34 inches (864 mm) above floor.

d. Color or Finish: Not applicable.
e. Drain: Grid with NPS 2 (DN 50) tailpiece.

4. Spray Head:

a. Material: Stainless steel.
b. Number of User Stations: As directed Five, Six or Eight.
c. Spray Nozzles: Chrome-plated brass or stainless steel complying with NSF 61 Annex G and ASME A112.18.1/CSA B125.1.
d. Control: As directed Collective, foot-rail, Individual foot-pedal, Individual push-button, Individual, hardwired sensor, Individual, battery-powered sensor actuation with pressure-balancing or thermostatic mixing valve complying with ASSE 1016 and having check stops; comply with NSF 61 Annex G.
e. Sensor: ASME A112.18.1/CSA B125.1 and UL 1951.

5. Liquid-Soap Dispensers: As directed Manual, Hardwired, sensor actuated, Battery powered, sensor actuated or Not required, for each user station.

a. Sensor: ASME A112.18.1/CSA B125.1 and UL 1951.

6. Pedestal: As directed Manufacturer's standard, Painted or coated steel or Stainless steel with access panel.
7. Supply Fittings:

a. Piping: As directed NPS 3/4 (DN 20) or NPS 1 (DN 25) copper tubing.
b. Valves: Shutoff valve on each supply.
c. Supply Piping: As directed from bottom or top.

8. Waste Fittings:

a. Standard: ASME A112.18.2/CSA B125.2.
b. Trap and Drain Piping: NPS 2 (DN 50).
c. Vent Piping: As directed Not required or NPS 1-1/2 (DN 40) to ceiling.

9. Shroud: As directed Not required or Stainless steel of size to cover supply and vent piping.
10. Mounting: Floor bracket.

2.2 STAINLESS-STEEL, CIRCULAR WASH FOUNTAINS

A. Wash Fountains: Stainless-steel, circular receptor.
1. Standard: IAPMO IGC 156.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Receptor:

a. Standard: IAPMO IGC 156 for stainless-steel receptor.
b. Nominal Diameter: As directed, 36 to 39 inches (914 to 990 mm), 39 inches (990 mm), 42 inches (1067 mm) or 54 inches (1372 mm).

c. Height to Rim: 34 inches (864 mm) above floor.
d. Color or Finish: Not applicable.
e. Drain: Grid with NPS 2 (DN 50) tailpiece.

4. Spray Head:

a. Material: Stainless steel.
b. Number of User Stations: As directed, Five, Six or Eight.
c. Spray Nozzles: Chrome-plated brass or stainless steel complying with NSF 61 Annex G and ASME A112.18.1/CSA B125.1.
d. Control: As directed, Collective, foot-rail, Individual foot-pedal, Individual push-button, Individual, hardwired sensor, Individual, battery-powered sensor actuation with pressure-balancing or thermostatic mixing valve complying with ASSE 1016 and having check stops; comply with NSF 61 Annex G.
e. Sensor: ASME A112.18.1/CSA B125.1 and UL 1951.

5. Liquid-Soap Dispensers: As directed, Manual, Hardwired, sensor actuated, Battery powered, sensor actuated or Not required, for each user station.

a. Sensor: ASME A112.18.1/CSA B125.1 and UL 1951.

6. Pedestal: Stainless steel with access panel.
7. Supply Fittings:

a. Piping: As directed, NPS 3/4 (DN 20) or NPS 1 (DN 25) copper tubing.
b. Valves: Shutoff valve on each supply.
c. Supply Piping: As directed, from bottom or top.

8. Waste Fittings:

a. Standard: ASME A112.18.2/CSA B125.2.
b. Trap and Drain Piping: NPS 2 (DN 50).
c. Vent Piping: As directed, not required or NPS 1-1/2 (DN 40) to ceiling.

9. Shroud: As directed, not required or Stainless steel of size to cover supply and vent piping.
10. Mounting: Floor bracket.

2.3 SOLID-SURFACE, SEMICIRCULAR WASH FOUNTAINS

A. Wash Fountains: As directed, Off or On-floor, solid-surface, semicircular receptor.
1. Standard: IAPMO IGC 156.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Receptor:

a. Standard: ICPA SS-1 for solid-surface receptor.
b. Nominal Diameter: As directed, 36 to 39 inches (914 to 990 mm), 39 inches (990 mm), 42 inches (1067 mm) or 54 inches (1372 mm).

c. Height to Rim: 34 inches (864 mm) above floor.
d. Color or Finish: Not applicable.
e. Drain: Grid with NPS 1-1/2 (DN 40) or NPS 2 (DN 50) tailpiece, as directed.

4. Spray Head:

a. Material: Stainless steel or integral part of receptor back.
b. Number of User Stations: As directed, Two, Three or Four.
c. Spray Nozzles: Chrome-plated brass or stainless steel complying with NSF 61 Annex G and ASME A112.18.1/CSA B125.1.
d. Control: As directed, Collective, foot-rail, Individual foot-pedal, Individual push-button, Individual, hardwired sensor, Individual or battery-powered sensor actuation with pressure-balancing or thermostatic mixing valve complying with ASSE 1016 and having check stops; comply with NSF 61 Annex G.
e. Sensor: ASME A112.18.1/CSA B125.1 and UL 1951.

5. Liquid-Soap Dispensers: As directed, Manual, Hardwired, sensor actuated, Battery powered, sensor actuated or Not required, for each user station.

a. Sensor: ASME A112.18.1/CSA B125.1 and UL 1951.

6. Supply Fittings:

a. Piping: As directed, NPS 1/2 (DN 15) or NPS 3/4 (DN 20) copper tubing.
b. Valves: Shutoff valve on each supply.
c. Supply Piping: As directed, from bottom, top or wall.

7. Waste Fittings:

a. Standard: ASME A112.18.2/CSA B125.2.
b. Trap and Drain Piping: As directed, NPS 1-1/2 (DN 40) or NPS 2 (DN 50).
c. Vent Piping: As directed, Not required or NPS 1-1/2 (DN 40) to ceiling.

8. Shroud: As directed, Not required or Stainless steel of size to cover supply and vent piping.
9. Off-Floor Mounting: Wall bracket and ASME A112.6.1M, Type II urinal carrier.
10. On-Floor Mounting: As directed Floor bracket and wall bracket attached to reinforcement in wall or concrete or block wall.

a. Supplies: As directed, NPS 1/2 (DN 15) or NPS 3/4 (DN 20) copper tubing with ball, gate, or globe valves.
b. Drain: Grid with NPS 1-1/2 (DN 40) or NPS 2 (DN 50) tailpiece, as directed.
c. Drain Piping: As directed, NPS 1-1/2 (DN 40) or NPS 2 (DN 50) P-trap, waste to wall, and wall flange.

2.4 STAINLESS-STEEL, SEMICIRCULAR WASH FOUNTAINS

A. Wash Fountains: As directed, Off or On-floor, stainless-steel, semicircular receptor.
1. Standard: IAPMO IGC 156.

2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Receptor:

    a. Standard: ASME A112.19.3/CSA B45.4 for stainless-steel receptor.
    b. Nominal Diameter: As directed, 36 to 39 inches (914 to 990 mm), 39 inches (990 mm), 42 inches (1067 mm) or 54 inches (1372 mm).
    c. Height to Rim: 34 inches (864 mm) above floor.
    d. Color or Finish: Not applicable.
    e. Drain: Grid with NPS 1-1/2 (DN 40) or NPS 2 (DN 50) tailpiece, as directed.

4. Spray Head:

    a. Material: Stainless steel or integral part of receptor back.
    b. Number of User Stations: As directed, Two, Three or Four.
    c. Spray Nozzles: Chrome-plated brass or stainless steel complying with NSF 61 Annex G and ASME A112.18.1/CSA B125.1.
    d. Control: As directed, Collective, foot-rail, Individual foot-pedal, Individual push-button, Individual, hardwired sensor, Individual or battery-powered sensor actuation with pressure-balancing or thermostatic mixing valve complying with ASSE 1016 and having check stops; comply with NSF 61 Annex G.
    e. Sensor: ASME A112.18.1/CSA B125.1 and UL 1951.

5. Liquid-Soap Dispensers: As directed, Manual, Hardwired, sensor actuated or Battery powered, sensor actuated or not required, for each user station.

    a. Sensor: ASME A112.18.1/CSA B125.1 and UL 1951.

6. Supply Fittings:

    a. Piping: As directed NPS 1/2 (DN 15) or NPS 3/4 (DN 20) copper tubing.
    b. Valves: Shutoff valve on each supply.
    c. Supply Piping: As directed, From bottom, top or wall.

7. Waste Fittings:

    a. Standard: ASME A112.18.2/CSA B125.2.
    b. Trap and Drain Piping: As directed, NPS 1-1/2 (DN 40) or NPS 2 (DN 50).
    c. Vent Piping: As directed, not required or NPS 1-1/2 (DN 40) to ceiling.

8. Shroud: As directed, not required or Stainless steel of size to cover supply and vent piping.
9. Off-Floor Mounting: Wall bracket and ASME A112.6.1M, Type II urinal carrier.
10. On-Floor Mounting: As directed, Floor bracket and wall bracket attached to reinforcement in wall or concrete or block wall.

    a. Supplies: As directed NPS 1/2 (DN 15) or NPS 3/4 (DN 20) copper tubing with ball, gate, or globe valves.
    b. Drain: Grid with NPS 1-1/2 (DN 40) or NPS 2 (DN 50) tailpiece, as directed.

c. Drain Piping: As directed NPS 1-1/2 (DN 40) or NPS 2 (DN 50) P-trap, waste to wall, and wall flange.

2.5 SOLID-SURFACE, LINEAR WASH FOUNTAINS

A. Wash Fountains: Solid-surface, linear (side-by-side) receptor.
1. Standard: IAPMO IGC 156.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Bowl(s) and Counter:

a. Standard: ICPA SS-1 for solid-surface bowls.
b. Height to Rim: 34 inches (864 mm) above floor.
c. Color or Finish: Not applicable.
d. Number of Bowls: As directed, One, Two or Three or Four.
e. Drain: Grid with NPS 1-1/2 (DN 40) tailpiece, each bowl.

4. Pedestal: As directed, not required or Required, with access panel.
5. Faucets:

a. Standards: ASME A112.18.1/CSA B125.1 and NSF 61 Annex G.
b. Type: Manufacturer's standard, chrome-plated solid brass, each bowl.
c. Control: As directed, Manual, push-button, Hardwired, sensor-actuated, Battery-powered, sensor-actuated, pressure-balancing mixing valve with check stops for each user station.
d. Sensor: ASME A112.18.1/CSA B125.1 and UL 1951.

6. Liquid-Soap Dispensers: As directed, Manual, Hardwired, sensor actuated, Battery powered, sensor actuated or Not required, for each user station.

a. Sensor: ASME A112.18.1/CSA B125.1 and UL 1951.

7. Mounting: Off floor on wall brackets and ASME A112.6.1M, Type II urinal carriers, each bowl.
8. Supply Fittings:

a. Piping: NPS 1/2 (DN 15) copper tubing, each bowl.
b. Valves: Shutoff valve on each supply.
c. Supply Piping: From wall.

9. Waste Fittings:

a. Standard: ASME A112.18.2/CSA B125.2.
b. Trap and Drain Piping: NPS 1-1/2 (DN 40), each bowl.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install wash fountains level and plumb according to roughing-in drawings.

B. Set freestanding wash fountains on floor.

C. Install off-floor carrier supports, affixed to building substrate, for wall-mounted wash fountains.

D. Install accessible, wall-mounted wash fountains at mounting height for handicapped/elderly according to ICC A117.1.

E. Install water-supply piping with shutoff valve on each supply to each wash fountain to be connected to domestic-water distribution piping. Use ball or gate valve. Install valves in locations where they can be easily reached for operation. Valves are specified in Section 220523.12 "Ball Valves for Plumbing Piping" and Section 220523.15 "Gate Valves for Plumbing Piping."

F. Install trap and waste piping on each drain outlet of each wash fountain to be connected to sanitary drainage system.

G. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

H. Seal joints between fixtures and walls using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

3.2 CONNECTIONS

A. Connect wash fountains with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

B. Comply with requirements for water piping specified in Section 221116 "Domestic Water Piping."

C. Comply with requirements for soil and waste drainage piping and vent piping specified in Section 221316 "Sanitary Waste and Vent Piping."

D. Install protective-shielding pipe covers and enclosures on exposed supplies and waste piping of accessible wash fountains. Comply with requirements in Section 220719 "Plumbing Piping Insulation."

3.3 ADJUSTING

A. Operate and adjust wash fountains and controls. Replace damaged and malfunctioning wash fountains, fittings, and controls.

B. Adjust water pressure at faucets to produce proper flow.

C. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

3.4 CLEANING AND PROTECTION

A. After installing wash fountains, inspect and repair damaged finishes.

B. Clean wash fountains, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.

C. Provide protective covering for installed wash fountains and fittings.

D. Do not allow use of wash fountains for temporary facilities unless approved in writing by Owner.

END OF SECTION 224233

SECTION 224300 - HEALTHCARE PLUMBING FIXTURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following healthcare fixtures and specialties:

1. Healthcare water closets.
2. Healthcare showers.
3. Healthcare bathing units.
4. Bedpan washers.
5. Clinic sinks.
6. Plaster sinks.
7. Scrub sinks.
8. Supports.

B. Related Requirements:

1. Section 224100 "Residential Plumbing Fixtures" for residential fixtures for use in healthcare facilities, but not requiring special healthcare fixture attributes.
2. Section 224213.13 "Commercial Water Closets" for conventional water closets, flushometer valves, carriers, and seats for use healthcare facilities, but not requiring special healthcare fixture attributes.
3. Section 224213.16 "Commercial Urinals" for urinals for use in healthcare facilities.
4. Section 224216.13 "Commercial Lavatories" for lavatories for use in healthcare facilities, but not requiring special healthcare fixture attributes.
5. Section 224216.16 "Commercial Sinks" for sinks for use in healthcare facilities, but not requiring special healthcare fixture attributes.
6. Section 224223 "Commercial Showers" for showers for use in healthcare facilities, but not requiring special healthcare fixture attributes.
7. Section 224500 "Emergency Plumbing Fixtures" for emergency showers and eye-wash units.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For plumbing fixtures and faucets to include in operation and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

    a. Servicing and adjustments of flushometer valves, healthcare bathing units and bedpan washer/sanitizers.

PART 2 - PRODUCTS

2.1 HEALTHCARE WATER CLOSETS

A. Healthcare Water Closets: As directed, wall mounted, top, back spud, accessible.
    1. Bowl:

        a. Standards: ASME A112.19.2/CSA B45.1 and ASME A112.19.5.
        b. Material: Vitreous china.
        c. Type: Siphon jet.
        d. Style: Flushometer valve.
        e. Height: Standard.
        f. Rim Contour: Elongated with bedpan lugs or slots.
        g. Water Consumption: As directed 1.28 gal. (4.8 L) or 1.6 gal. (6 L) per flush.
        h. Spud Size: NPS 1-1/2 (DN 40).

    2. Flushometer Valve: As directed.
    3. Toilet Seat: As directed.
    4. Support: Water closet carrier.
    5. Water-Closet Mounting Height: As directed Standard or Child, Handicapped/elderly according to ICC A117.1.

B. Healthcare Water Closets: As directed, floor mounted, floor outlet, top or back spud, accessible.
    1. Bowl:

        a. Standards: ASME A112.19.2/CSA B45.1 and ASME A112.19.5.
        b. Material: Vitreous china.
        c. Type: Siphon jet.
        d. Style: Flushometer valve.
        e. Height: As directed, Standard or Handicapped/elderly.
        f. Rim Contour: Elongated with bedpan lugs or slots.
        g. Water Consumption: As directed 1.28 gal. (4.8 L) or 1.6 gal. (6 L) per flush.
        h. Spud Size: NPS 1-1/2 (DN 40).

    2. Flushometer Valve: As directed.
    3. Toilet Seat: As directed.

2.2 FLUSHOMETER VALVES

A. Lever-Handle, Diaphragm Flushometer Valves.
    1. Standard: ASSE 1037.
    2. Minimum Pressure Rating: 125 psig (860 kPa).

3. Features: Integral check stop, backflow-prevention device, and outlet-tube-mounted bedpan washer.
4. Material: Brass body with corrosion-resistant components.
5. Exposed Flushometer-Valve Finish: Chrome plated.
6. Style: Exposed.
7. Consumption: As directed, 1.28 gal. (4.8 L), 1.6 gal. (6 L) or 3.5 gal. (13.2 L) per flush.
8. Minimum Inlet: NPS 1 (DN 25).
9. Minimum Outlet: NPS 1-1/4 (DN 32), extended length.

2.3 TOILET SEATS

A. Toilet Seats.
1. Standard: IAPMO Z124.5.
2. Material: Plastic with antimicrobial agent.
3. Type: As directed Commercial (standard) or Commercial (heavy duty).
4. Shape: Elongated rim, open front.
5. Hinge: Check.
6. Hinge Material: Noncorroding metal.
7. Color: White.

2.4 HEALTHCARE SHOWERS

A. Healthcare Showers: As directed Accessible, glass-fiber-reinforced plastic or acrylic.
1. Standard: ANSI Z124.1.2 and complying with ICC A117.1 for roll-in shower compartments.
2. Nominal Size: 60 by 36 inches (1524 by 915 mm).
3. Surround: One piece or sealed, multiple pieces.
4. Surround: One piece.
5. Bathing Surface: Slip resistant according to ASTM F462.
6. Color: White.
7. Drain Location: As directed, Left side, Center or Right side.
8. Accessibility Options: Include grab bar and bench.
9. Faucet: As directed.
10. Drain: Grid, NPS 2 (DN 50), complying with ASME A112.18.2/CSA B125.2.

2.5 HEALTHCARE SHOWER FAUCETS

A. NSF Standard: Comply with NSF 61 Annex G, "Drinking Water System Components - Health Effects," for faucet materials that will be in contact with potable water.

B. Healthcare Shower Faucets: Pressure-balance mixing valve.
1. Faucet:

a. Standards: ASME A112.18.1/CSA B125.1 and ASSE 1016.
b. Body Material: Solid brass.
c. Finish: Polished chrome plate.
d. Maximum Flow Rate: 2.5 gpm (9.5 L/min.) unless otherwise indicated.
e. Mounting: As directed, Concealed or Exposed.

f. Operation: Single-handle, push-pull or twist or rotate control.
g. Antiscald Device: As directed, Integral with mixing valve, Separate unit or Not required.
h. Check Stops: Check-valve type, integral with or attached to body; on hot- and cold-water-supply connections.
i. Indicators: For hot and cold water.

2. Shower Head:

a. Standard: ASME A112.18.1/CSA B125.1.
b. Type: As directed, Ball joint with arm and flange, without ball joint, but with arm and flange, Ball joint and head integral with mounting flange, Integral with mounting flange, Hand held, slide bar mounted or Hand held, hook mounted.
c. Shower Head Material: Metallic with chrome-plated finish.
d. Spray Pattern: As directed, Adjustable or Fixed.
e. Integral Volume Control: As directed, not required or Required.
f. Shower-Arm, Flow-Control Fitting: As directed, Not required, 1.5 gpm (5.7 L/min.) or 2.0 gpm (7.6 L/min.).
g. Temperature Indicator: As directed, Integral with faucet or not required.

2.6 HEALTHCARE BATHING UNITS

A. Healthcare Bathing Units: As directed, Side, Transfer-lift or Slide-on entry, adjustable or fixed height.
1. Fixture: Plastic-tub, institutional bath fixture with integral controls.

a. Tub Size: 60 by 30 inches (1524 by 762 mm).
b. Controls: Vacuum breakers on supplies, thermostatic mixing valve, tub fill spout, and hand-held shower head.

2. Supply Connections: As directed, NPS 3/4 (DN 20) or NPS 1 (DN 25) with shutoff valve.
3. Drain: Manufacturer's standard as directed NPS 1-1/2 (DN 40) or NPS 2 (DN 50) with tailpiece.
4. Drain Piping: As directed, NPS 1-1/2 (DN 40) or NPS 2 (DN 50) cast-brass P-trap, waste to wall, and wall flange complying with ASME A112.18.2/CSA B125.2. Include combined drain piping if two drains.
5. Lift System: Not required.
6. Unit Electrical Characteristics:

a. Volts: As directed 120, 240, 277 or 480.
b. Phase(s): As directed, One or Three.
c. Hertz: 60.
d. Full-Load Amperes: As directed.
e. Minimum Circuit Ampacity: As directed.
f. Maximum Overcurrent Protection: As directed.

B. Healthcare Bathing Units: Front-entry shower.
1. Fixture: Plastic-tub, institutional fixture with integral controls.

a. Cabinet Size: 35 by 41 inches (889 by 1041 mm).

b. Controls: Vacuum breakers on supplies, thermostatic mixing valve, tub fill spout, and hand-held shower head.

2. Supply Connections: As directed, NPS 3/4 (DN 20) or NPS 1 (DN 25) with shutoff valve.
3. Drain: Manufacturer's standard NPS 2 (DN 50) with tailpiece.
4. Drain Piping: NPS 2 (DN 50) P-trap, waste to wall, and wall flange complying with ASME A112.18.2/CSA B125.2. Include combined drain piping if two drains.
5. Unit Electrical Characteristics:

a. Volts: As directed 120, 240, 277 or 480.
b. Phase(s): One or Three.
c. Hertz: 60.
d. Full-Load Amperes: As directed.
e. Minimum Circuit Ampacity: As directed.
f. Maximum Overcurrent Protection: As directed.

2.7 BEDPAN WASHERS

A. Bedpan Washers: Wall mounted, compact.
1. Standard: ASME A112.18.1/CSA B125.1.
2. Hose Assembly: 48-inch- (1220-mm-) long rubber or vinyl hose with self-closing, hand-held spray nozzle, wall bracket, and hook.
3. Vacuum Breaker: ASSE 1001, atmospheric, wall mounted.
4. Shutoff Valve: Wall mounted, cross-handle supply stop upstream of vacuum breaker.
5. Connecting Piping: Concealed.
6. Finish: Polished chrome-plated finish on exposed metal parts.
7. Supply Connection: NPS 1/2 (DN 15).

2.8 BEDPAN WASHING EQUIPMENT

A. Bedpan Washers/Sanitizers: As directed, recessed or wall mounted.
1. Fixture:

a. Construction: As directed, Cast-iron chamber and P-trap waste assembly with spray nozzles and enameled or stainless-steel front panel and cover box.
b. Controls: Electric, 120-V ac, automatic operation with timer, solenoid valves, and circuit breaker.
c. Door Mechanism: Foot-pedal operation.

2. Supply Connections: NPS 1 (DN 25) cold water and NPS 3/8 (DN 10) hot water or steam.
3. Drain Piping: NPS 3 (DN 80) P-trap and soil pipe.
4. Atmospheric Vent Connection: NPS 2 (DN 50).
5. Mounting Hardware: Matching fixture-mounting arrangement.
6. Accessories:

a. Bedpan Rack(s): As directed, One or Two.
b. Urinal Rack(s): As directed, One or Two.
c. Drain Tray(s): As directed, One or Two.

2.9 CLINIC SINKS

A. Clinic Sinks: Floor mounted.
   1. Fixture: Bottom-outlet, vitreous-china, siphon-jet, flushing-rim, service sink.
      a. Standard: ASME A112.19.2/CSA B45.1.
      b. Nominal Size: 27 by 20 inches (685 by 510 mm).
      c. Color: White.
      d. Rim Guards: Stainless steel on front.
   2. Sink Base: 10 inches (254 mm) high; cast terrazzo if required.
   3. Flushometer Valve: As directed.
   4. Faucet: As directed.
   5. Supply Fittings: Comply with requirements in "Supply Fittings" Article.

2.10 PLASTER SINKS

A. Plaster Sinks: Wall mounted, vitreous china.
   1. Fixture:
      a. Standard: ASMA A112.19.2/CSA B45.1.
      b. Type: Utility sink.
      c. Nominal Size: As directed, 24 by 22 inches (610 by 560 mm) or 30 by 22 inches (762 by 560 mm) with back.
      d. Color: White.
      e. Faucet Holes: As directed, One or Two in back.
      f. Drain: Grid, NPS 1-1/2 (DN 40) with NPS 1-1/2 (DN 40) to NPS 2 (DN 50) adaptor.
   2. Faucet: As directed.
   3. Supply Fittings: Comply with requirements in "Supply Fittings" Article.
   4. Drain Piping: As directed, NPS 1-1/2 (DN 40) or NPS 2 (DN 50) chrome-plated brass; 0.045-inch- (1.1-mm-) thick waste to interceptor; interceptor to wall; and wall flange complying with ASME A112.18.2/CSA B125.2.
   5. Plaster Interceptor:
      a. Description: Cast-iron or steel body and removable cover with acid-resistant-enameled interior lining and outside coating; removable, corrosion-resistant metal screens or strainer; and NPS 1-1/2 (DN 40) or NPS 2 (DN 50) inlet and outlet.
   6. Support: Type III sink carrier with white-enameled-steel brackets.
   7. Sink Mounting Height: As directed, Standard or Child or Handicapped/elderly according to ICC A117.1.

2.11 SCRUB SINKS

A. Scrub Sinks: Vitreous china, wall mounted.
   1. Fixture:
      a. Standard: ASME A112.19.2/CSA B45.1.

b. Nominal Size: As directed, 28 by 22 inches (710 by 560 mm) or 30 by 22 inches (762 by 560 mm) with back or ledge with one faucet hole.
c. Color: White.
d. Drain: Grid, NPS 1-1/2 (DN 40).

2. Faucet: As directed.
3. Supply Fittings: Comply with requirements in "Supply Fittings" Article.
4. Waste Fittings: Comply with requirements in "Waste Fittings" Article.
5. Support: Type II sink carrier.
6. Sink Mounting Height: As directed, Standard, Child or Handicapped/elderly according to ICC A117.1.

2.12 SINK FAUCETS

A. NSF Standard: Comply with NSF 61 Annex G, "Drinking Water System Components - Health Effects," for faucet-spout materials that will be in contact with potable water.

B. Sink Faucets: Manual-operation mixing valve.
1. Standard: ASME A112.18.1/CSA B125.1.
2. Configuration: Hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and sink receptor.
3. Body Type: As directed, Centerset, Widespread or Single hole.
4. Body Material: Solid brass.
5. Finish: As directed Chrome plated or Polished chrome plate.
6. Maximum Flow Rate: As directed, 2.2 gpm (8.3 L/min.) or 2.5 gpm (9.5 L/min.).
7. Control: As directed Lever, Cross, four-arm, Wrist-blade, 4-inch (102-mm) or Elbow, 6-inch (152-mm) handle(s).
8. Control: As directed Foot pedal or Knee action.
9. Mounting Type: As directed, Deck, concealed, Deck, exposed, Back/wall or exposed.
10. Spout Type: As directed Rigid, Swivel, low profile or gooseneck.
11. Vacuum Breaker: As directed, Required or Not required for hose outlet.
12. Spout Outlet: As directed, Aerator, Laminar flow, Hose thread, Plain end or Spray.

2.13 LAMINAR-FLOW, FAUCET-SPOUT OUTLETS

A. Description: Chrome-plated brass, faucet-spout outlet that produces non-aerating, laminar stream. Include external or internal thread that mates with faucet outlet for attachment to faucets where indicated and flow-rate range that includes faucet flow.

B. NSF Standard: Comply with NSF 61 Annex G, "Drinking Water System Components - Health Effects," for faucet-spout-outlet materials that will be in contact with potable water.

2.14 SUPPORTS

A. Description: Waste-fitting assembly as required to match drainage piping material and arrangement with faceplates, couplings gaskets, and feet; bolts and hardware matching

fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space.

1. Water Closet Carrier: ASME A112.6.1M.

B. Type I Sink Carrier: ASME A112.6.1M.

C. Type II Sink Carrier: ASME A112.6.1M.

D. Type III Sink Carrier: ASME A112.6.1M, with white-enameled-steel brackets.

E. Type IV Sink Carrier: ASME A112.6.1M.

2.15 SUPPLY FITTINGS

A. NSF Standard: Comply with NSF 61 Annex G, "Drinking Water System Components - Health Effects," for supply-fitting materials that will be in contact with potable water.

B. Standard: ASME A112.18.1/CSA B125.1.

C. Supply Piping: Chrome-plated brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated brass or stainless-steel wall flange.

D. Supply Stops: Chrome-plated brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.

E. Operation: As directed, Loose key or Wheel handle.

F. Risers: As directed, NPS 1/2 (DN 15) chrome-plated, rigid-copper pipe and brass straight or offset tailpieces, chrome-plated, soft-copper flexible tube or ASME A112.18.6, braided or corrugated stainless-steel, flexible hose.

2.16 WASTE FITTINGS

A. Standard: ASME A112.18.2/CSA B125.2.

B. Drain: Grid with NPS 1-1/2 DN 40 tailpiece.

C. Trap:

1. Size: NPS 1-1/2 (DN 40).
2. Material: As directed, Chrome-plated, two-piece, cast-brass trap and swivel elbow with 0.032-inch (0.83-mm) thick brass tube to wall, two-piece, cast-brass trap and ground-joint swivel elbow with 0.032-inch (0.83-mm) thick brass tube to wall or one-piece, cast-brass trap with swivel 0.029-inch (73-mm) thick tubular brass wall bend; and chrome-plated brass or steel wall flange.
3. Material: Stainless-steel, two-piece trap and swivel elbow with 0.012-inch (0.30-mm) thick stainless-steel tube to wall; and stainless-steel wall flange.

2.17 GROUT

A. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install healthcare plumbing fixtures level and plumb according to roughing-in drawings.

B. Install supports, affixed to building substrate, for wall-mounted fixtures.

1. Use carrier supports with waste fitting and seal for back-outlet fixtures.
2. Use carrier supports without waste fitting for fixtures with tubular waste piping.
3. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.

C. Install floor-mounted healthcare water closets on bowl-to-drain, connecting fitting attachments to piping or building substrate.

D. Install counter-mounted fixtures in and attached to casework.

E. Install water-supply piping with stop on each supply to each fixture to be connected to water-distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.

1. Exception: Use ball or gate valve if supply stops are not specified with fixture. Comply with valve requirements specified in Section 220523.12 "Ball Valves for Plumbing Piping" and Section 220523.15 "Gate Valves for Plumbing Piping."

F. Install flushometer valves on healthcare water closets.

G. Install flushometer valves for accessible healthcare water closets, with lever handle mounted on wide side of compartment.

H. Install toilet seats on healthcare water closets.

I. Install faucet flow-control fittings with specified flow rates and patterns in faucet spouts, if faucets are not available with required rates and patterns. Include adapters if required.

J. Install laminar-flow, faucet-spout fittings in faucet spouts where laminar-flow fittings are specified.

K. Install shower flow-control fittings with specified maximum flow rates in shower arms.

L. Install traps on fixture outlets.

1. Exception: Omit trap on fixtures with integral traps.

M. Set healthcare showers in leveling bed of cement grout.

N. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible sinks. Comply with requirements in Section 220719 "Plumbing Piping Insulation."

O. Seal joints between healthcare plumbing fixtures, counters, floors, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

P. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

Q. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

R. Comply with requirements for water piping specified in Section 221116 "Domestic Water Piping."

S. Comply with requirements for soil and waste drainage piping and vent piping specified in Section 221316 "Sanitary Waste and Vent Piping."

T. Comply with requirements for atmospheric vent piping specified in Section 221316 "Sanitary Waste and Vent Piping."

U. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible sinks. Comply with requirements in Section 220719 "Plumbing Piping Insulation."

3.2 ADJUSTING

A. Operate and adjust faucets and controls. Replace damaged and malfunctioning healthcare plumbing fixtures, fittings, and controls.

B. Adjust water pressure at faucets and flushometer valves to produce proper flow.

C. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

3.3 CLEANING AND PROTECTION

A. After installing healthcare plumbing fixtures, inspect and repair damaged finishes.

B. Clean healthcare plumbing fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.

C. Provide protective covering for installed fixtures and fittings.

D. Do not allow use of healthcare plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 224300

SECTION 224500 - EMERGENCY PLUMBING FIXTURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Emergency showers.
2. Eyewash equipment.
3. Eye/face wash equipment.
4. Combination units.
5. Water-tempering equipment.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting or attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
4. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Product Certificates: Submit certificates of performance testing specified in "Source Quality Control" Article.

B. Field quality-control test reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ISEA Standard: Comply with ISEA Z358.1.

C. NSF Standard: Comply with NSF 61 and NSF 372, for fixture materials that will be in contact with potable water.

D. Regulatory Requirements: Comply with requirements in ICC A117.1; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; for plumbing fixtures for people with disabilities.

2.2 EMERGENCY SHOWERS

A. Freestanding, Plumbed Emergency Showers:
1. Capacity: Not less than 20 gpm (76 L/min.) for at least 15 minutes.
2. Supply Piping: As directed, NPS 1 (DN 25), NPS 1-1/4 (DN 32) or galvanized steel, chrome-plated brass or stainless steel or PVC with flow regulator and stay-open control valve.
3. Control-Valve Actuator: As directed, Pull rod or Foot treadle.
4. Shower Head: 8-inch- (200-mm-) minimum-diameter, chrome-plated brass, stainless steel, or plastic.
5. Mounting: Pedestal.

B. Freeze-Protected, Plumbed Emergency Showers:
1. Capacity: Not less than 20 gpm (76 L/min.) for at least 15 minutes.
2. Supply Piping: NPS 1-1/4 (DN 32) galvanized steel with flow regulator and stay-open control valve.
3. Control-Valve Actuator: Pull rod.
4. Shower Head: 8-inch (200-mm) minimum-diameter, chrome-plated brass, stainless steel, or plastic.
5. Heating System: As directed, 120 or 240 V ac electric; insulation enclosed in a protective jacket.
6. Mounting: Pedestal.

2.3 EYEWASH EQUIPMENT

A. Standard, Freestanding, Plumbed Eyewash Units:
1. Capacity: Not less than 0.4 gpm (1.5 L/min.) for at least 15 minutes.
2. Supply Piping: NPS 1/2 (DN 15) chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
3. Control-Valve Actuator: Paddle or Treadle.
4. Spray-Head Assembly: Two receptor-mounted spray heads.
5. Receptor: As directed Chrome-plated brass or stainless-steel or Plastic bowl.

6. Drain Piping:

    a. Size: NPS 1-1/4 (DN 32) minimum.
    b. Finish: Chrome-plated brass.
    c. Fittings: Receptor drain, P-trap, waste to wall, and wall flange complying with ASME A112.18.2/CSA B125.2.

7. Drain Piping: Include galvanized-steel indirect connection to drainage system.
8. Mounting: Pedestal.

B. Accessible, Freestanding, Plumbed Eyewash Units:
1. Capacity: Not less than 0.4 gpm (1.5 L/min.) for at least 15 minutes.
2. Supply Piping: NPS 1/2 (DN 15) chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
3. Control-Valve Actuator: Paddle.
4. Spray-Head Assembly: Two receptor-mounted spray heads.
5. Receptor: Chrome-plated brass or stainless-steel or Plastic bowl.
6. Drain Piping:

    a. Size: NPS 1-1/4 (DN 32) minimum.
    b. Finish: Chrome-plated brass.
    c. Fittings: Receptor drain, P-trap, waste to wall, and wall flange complying with ASME A112.18.2/CSA B125.2.

7. Mounting: Offset pedestal.
8. Special Construction: Comply with ICC A117.1.

2.4 EYE/FACE WASH EQUIPMENT

A. Standard, Freestanding, Plumbed Eye/Face Wash Units:
1. Capacity: Not less than 3.0 gpm (11.4 L/min.) for at least 15 minutes.
2. Supply Piping: NPS 1/2 (DN 15) chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
3. Control-Valve Actuator: As directed, Paddle or Treadle.
4. Spray-Head Assembly: Two or four receptor-mounted spray heads.
5. Receptor: As directed Chrome-plated brass or stainless-steel or Plastic bowl.
6. Drain Piping:

    a. Size: NPS 1-1/4 (DN 32) minimum.
    b. Finish: Chrome-plated brass.
    c. Fittings: Receptor drain, P-trap, waste to wall, and wall flange complying with ASME A112.18.2/CSA B125.2.

7. Drain Piping: Include galvanized-steel indirect connection to drainage system.
8. Mounting: Pedestal.

B. Accessible, Freestanding, Plumbed Eye/Face Wash Units:
1. Capacity: Not less than 3.0 gpm (11.4 L/min.) for at least 15 minutes.
2. Supply Piping: NPS 1/2 (DN 15) chrome-plated brass or stainless steel with flow regulator and stay-open control valve.

3. Control-Valve Actuator: Paddle.
4. Spray-Head Assembly: Two or four receptor-mounted spray heads.
5. Receptor: As directed Chrome-plated brass or stainless-steel or Plastic bowl.
6. Drain Piping:

    a. Size: NPS 1-1/4 (DN 32) minimum.
    b. Finish: Chrome-plated brass.
    c. Fittings: Receptor drain, P-trap, waste to wall, and wall flange complying with ASME A112.18.2/CSA B125.2.

7. Drain Piping: Include galvanized-steel indirect connection to drainage system.
8. Mounting: Offset pedestal.
9. Special Construction: Comply with ICC A117.1.

2.5 COMBINATION UNITS

A. Standard, Plumbed Emergency Shower with Eyewash Combination Units:
1. Piping:

    a. Material: As directed, Galvanized steel, Chrome-plated brass or stainless steel or PVC.
    b. Unit Supply: As directed, NPS 1-1/4 (DN 32) minimum or NPS 1-1/2 (DN 40).
    c. Unit Drain: Outlet at back or side near bottom.

2. Shower:

    a. Capacity: Not less than 20 gpm (76 L/min.) for at least 15 minutes.
    b. Supply Piping: NPS 1 (DN 25) with flow regulator and stay-open control valve.
    c. Control-Valve Actuator: As directed, Pull rod or Treadle.
    d. Shower Head: As directed, 8-inch (200-mm) minimum diameter, chrome-plated brass or stainless steel or plastic.
    e. Mounting: Pedestal.

3. Eyewash Unit:

    a. Capacity: Not less than 0.4 gpm (1.5 L/min.) for at least 15 minutes.
    b. Supply Piping: NPS 1/2 (DN 15) with flow regulator and stay-open control valve.
    c. Control-Valve Actuator: Paddle.
    d. Spray-Head Assembly: Two receptor-mounted spray heads.
    e. Receptor: As directed, Chrome-plated brass or stainless-steel or Plastic bowl.
    f. Mounting: Attached shower pedestal.
    g. Drench-Hose Option: May be provided instead of eyewash unit.

        1) Capacity: Not less than 0.4 gpm (1.5 L/min.) for at least 15 minutes.
        2) Drench Hose: Hand-held spray head with squeeze-handle actuator and hose.
        3) Mounting: Bracket on shower pedestal.

B. Accessible, Plumbed Emergency Shower with Eyewash Combination Units:
1. Piping:

a. Material: As directed, Galvanized steel, Chrome-plated brass or stainless steel or PVC.
b. Unit Supply: As directed, NPS 1-1/4 (DN 32) minimum or NPS 1-1/2 (DN 40).
c. Unit Drain: Outlet at back or side near bottom.

2. Shower:

a. Capacity: Not less than 20 gpm (76 L/min.) for at least 15 minutes.
b. Supply Piping: NPS 1 (DN 25) with flow regulator and stay-open control valve.
c. Control-Valve Actuator: Pull rod.
d. Shower Head: As directed, 8-inch (200-mm) minimum diameter, chrome-plated brass or stainless steel or plastic.
e. Mounting: Pedestal.

3. Eyewash Unit:

a. Capacity: Not less than 0.4 gpm (1.5 L/min.) for at least 15 minutes.
b. Supply Piping: NPS 1/2 (DN 15) with flow regulator and stay-open control valve.
c. Control-Valve Actuator: Paddle.
d. Spray-Head Assembly: Two receptor-mounted spray heads.
e. Receptor: As directed, Chrome-plated brass or stainless-steel or Plastic bowl.
f. Mounting: Attached shower pedestal.
g. Drench-Hose Option: May be provided instead of eyewash unit.

1) Capacity: Not less than 0.4 gpm (1.5 L/min.) for at least 15 minutes.
2) Drench Hose: Hand-held spray head with squeeze-handle actuator and hose.
3) Mounting: Bracket on shower pedestal.

C. Standard, Plumbed Emergency Shower with Eye/Face Wash Combination Units:

1. Piping:

a. Material: As directed, Galvanized steel, Chrome-plated brass or stainless steel or PVC.
b. Unit Supply: As directed, NPS 1-1/4 (DN 32) minimum or NPS 1-1/2 (DN 40).
c. Unit Drain: Outlet at back or side near bottom.

2. Shower:

a. Capacity: Not less than 20 gpm (76 L/min.) for at least 15 minutes.
b. Supply Piping: NPS 1 (DN 25) with flow regulator and stay-open control valve.
c. Control-Valve Actuator: As directed, Pull rod or Treadle.
d. Shower Head: 8-inch (200-mm) minimum diameter, chrome-plated brass or stainless steel or plastic.
e. Mounting: Pedestal.

3. Eye/Face Wash Unit:

a. Capacity: Not less than 3.0 gpm (11.4 L/min.) for at least 15 minutes.
b. Supply Piping: NPS 1/2 (DN 15) with flow regulator and stay-open control valve.
c. Control-Valve Actuator: Paddle.
d. Spray-Head Assembly: Two or four receptor-mounted spray heads.

e. Receptor: As directed, Chrome-plated brass or stainless-steel or Plastic bowl.
f. Mounting: Attached shower pedestal.
g. Drench-Hose Option: May be provided instead of eye/face wash unit.

1) Capacity: Not less than 3.0 gpm (11.4 L/min.) for at least 15 minutes.
2) Drench Hose: Hand-held spray head with squeeze-handle actuator and hose.
3) Mounting: Bracket on shower pedestal.

D. Accessible, Plumbed Emergency Shower with Eye/Face Wash Combination Units:
1. Piping:

a. Material: As directed, Galvanized steel or Chrome-plated brass or stainless steel or PVC.
b. Unit Supply: As directed, NPS 1-1/4 (DN 32) minimum or NPS 1-1/2 (DN 40).
c. Unit Drain: Outlet at back or side near bottom.

2. Shower:

a. Capacity: Not less than 20 gpm (76 L/min.) for at least 15 minutes.
b. Supply Piping: NPS 1 (DN 25) with flow regulator and stay-open control valve.
c. Control-Valve Actuator: Pull rod.
d. Shower Head: As directed, 8-inch (200-mm) minimum diameter, chrome-plated brass or stainless steel or plastic.
e. Mounting: Pedestal.

3. Eye/Face Wash Unit:

a. Capacity: Not less than 3.0 gpm (11.4 L/min.) for at least 15 minutes.
b. Supply Piping: NPS 1/2 (DN 15) with flow regulator and stay-open control valve.
c. Control-Valve Actuator: Paddle.
d. Spray-Head Assembly: Two or four receptor-mounted spray heads.
e. Receptor: As directed, Chrome-plated brass or stainless-steel or Plastic bowl.
f. Mounting: Attached to shower pedestal.
g. Drench-Hose Option: May be provided instead of eye/face wash unit.

1) Capacity: Not less than 3.0 gpm (11.4 L/min.) for at least 15 minutes.
2) Drench Hose: Hand-held spray head with squeeze-handle actuator and hose.
3) Mounting: Bracket on shower pedestal.

E. Freeze-Protected, Plumbed Emergency Shower with Eyewash Combination Units:
1. Piping: Galvanized steel.

a. Unit Supply: As directed, NPS 1-1/4 (DN 32) minimum or NPS 1-1/2 (DN 40) from bottom.

2. Heating System: As directed, Electric, 120 or 240 V ac; insulation enclosed in a protective jacket with thermometer.

a. Heating Capacity: 10 deg F (6 deg C) minimum above ambient temperature.
b. Design Ambient Temperature: As directed.

3. Shower:

    a. Shower Capacity: Not less than 20 gpm (76 L/min.) for at least 15 minutes.
    b. Supply Piping: NPS 1 (DN 25) with flow regulator and stay-open control valve.
    c. Control-Valve Actuator: Pull rod.
    d. Shower Head: As directed, 8-inch (200-mm) minimum diameter, chrome-plated brass or stainless steel or plastic.
    e. Mounting: Pedestal.

4. Eyewash Unit:

    a. Capacity: Not less than 0.4 gpm (1.5 L/min.) for at least 15 minutes.
    b. Supply Piping: NPS 1/2 (DN 15) with flow regulator and stay-open control valve.
    c. Control-Valve Actuator: Paddle.

5. Eye/Face Wash Unit:

    a. Capacity: Not less than 3 gpm (11.4 L/min.) for at least 15 minutes.
    b. Control-Valve Actuator: Paddle.

6. Appurtenances:

    a. As directed.

2.6 WATER-TEMPERING EQUIPMENT

A. Hot- and Cold-Water, Water-Tempering Equipment:
    1. Description: Factory-fabricated equipment with thermostatic mixing valve.

        a. Thermostatic Mixing Valve: Designed to provide 85 deg F (29 deg C) tepid, potable water at emergency plumbing fixtures, to maintain temperature at plus or minus 5 deg F (3 deg C) throughout required 15-minute test period, and in case of unit failure to continue cold-water flow, with union connections, controls, metal piping, and corrosion-resistant enclosure.
        b. Supply Connections: For hot and cold water.

2.7 SOURCE QUALITY CONTROL

A. Certify performance of emergency plumbing fixtures by independent testing organization acceptable to authorities having jurisdiction.

    1. Exception: As directed.

PART 3 - EXECUTION

3.1 INSTALLATION OF EMERGENCY PLUMBING FIXTURE

A. Assemble emergency plumbing fixture piping, fittings, control valves, and other components.

B. Install fixtures level and plumb.

C. Fasten fixtures to substrate.

D. Install shutoff valves in water-supply piping to fixtures, to facilitate maintenance of the equipment. Use ball or gate valve if specific type valve is not indicated. Install valves chained or locked in open position if permitted. Install valves in locations where they can easily be reached for operation. Comply with requirements for valves specified in Section 220523.12 "Ball Valves for Plumbing Piping" and Section 220523.15 "Gate Valves for Plumbing Piping."

1. Exception: Omit shutoff valve on supply to group of plumbing fixtures that includes emergency equipment.
2. Exception: Omit shutoff valve on supply to emergency equipment if prohibited by authorities having jurisdiction.

E. Install dielectric fitting in supply piping to emergency equipment if piping and equipment connections are made of different metals. Comply with requirements for dielectric fittings specified in Section 221116 "Domestic Water Piping."

F. Install thermometers in supply and outlet piping connections to water-tempering equipment. Comply with requirements for thermometers specified in Section 220519 "Meters and Gages for Plumbing Piping."

G. Install trap and waste piping on drain outlet of emergency equipment receptors that are indicated to be directly connected to drainage system. Comply with requirements for waste piping specified in Section 221316 "Sanitary Waste and Vent Piping."

H. Install indirect waste piping on drain outlet of emergency equipment receptors that are indicated to be indirectly connected to drainage system. Comply with requirements for waste piping specified in Section 221316 "Sanitary Waste and Vent Piping."

I. Install escutcheons on piping wall and ceiling penetrations in exposed, finished locations. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

J. Fill self-contained fixtures with flushing fluid.

3.2 CONNECTIONS

A. Connect cold-water-supply piping to plumbed emergency plumbing fixtures not having water-tempering equipment. Comply with requirements for cold-water piping specified in Section 221116 "Domestic Water Piping."

B. Connect hot- and cold-water-supply piping to hot- and cold-water, water-tempering equipment. Connect output from water-tempering equipment to emergency plumbing fixtures. Comply with requirements for hot- and cold-water piping specified in Section 221116 "Domestic Water Piping."

C. Directly connect emergency plumbing fixture receptors with trapped drain outlet to sanitary waste and vent piping. Comply with requirements for waste piping specified in Section 221316 "Sanitary Waste and Vent Piping."

D. Indirectly connect emergency plumbing fixture receptors without trapped drain outlet to sanitary waste or storm drainage piping.

E. Where installing piping adjacent to emergency plumbing fixtures, allow space for service and maintenance of fixtures.

3.3 IDENTIFICATION

A. Install equipment nameplates or equipment markers on emergency plumbing fixtures and equipment and equipment signs on water-tempering equipment. Comply with requirements for identification materials specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

A. Mechanical-Component Testing: After plumbing connections have been made, test for compliance with requirements. Verify ability to achieve indicated capacities.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Emergency plumbing fixtures and water-tempering equipment will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust or replace fixture flow regulators for proper flow.

B. Adjust equipment temperature settings.

END OF SECTION 224500

SECTION 224600 - SECURITY PLUMBING FIXTURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Combination units.
2. Water closets.
3. Urinals.
4. Lavatories.
5. Drinking fountains.
6. Showers.
7. Service sinks.

1.2 DEFINITIONS

A. Accessible Service Space: Service area in secure space behind wall-mounted fixtures.

B. Back-Access Fixture: Security plumbing fixture designed to mount on wall sleeve built into wall or on wall, so installation and removal of fixture, piping, and other components are accessible only from service space behind wall.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance data.

PART 2 - PRODUCTS

2.1 COMBINATION UNITS

A. Combination Units: As directed, Back access, off or on floor, cabinet, with water closet and lavatory.
   1. Material: 0.078-inch (2.0-mm) minimum-thick stainless steel; corrosion-resistant metal for internal piping and bracing.
   2. Finish: ASTM A480/A480M, No. 4 polished finish on exposed surfaces.

3. Cabinet: As directed, rectangular apron, five-sided apron with two angled sides, four-sided apron with angled left side or Four-sided apron with angled right side, with backsplash.

    a. Water-Closet Bowl Location: As directed, centered on front, Left of center on front, right of center on front, on angled left side or on angled right side of apron.
    b. Toilet-Paper Holder: Recessed; stainless steel located above water closet and centered in front, in front, right of center in front, left of center in front, in angled right side, in angled left side, in right side or in left side of apron.

4. Accessories:

    a. Toothbrush Holders: As directed, one on each, left or right side of backsplash.
    b. Towel Hooks: As directed, one or two on each, left or right side of fixture.
    c. Bubbler: As directed, on backsplash or deck.

5. Mounting: Bolts through wall sleeve into accessible service space.
6. Water Closet:

    a. Standard: IAPMO PS 61.
    b. Bowl:

        1) Type: As directed, Elongated, with back inlet, integral trap, and blowout or siphon-jet design with back outlet and contoured seat.
        2) Seat Surface: ASTM A480/A480M, No. 7 polished finish.
        3) Punching: Two holes for installation of separate toilet seat.
        4) Outlet Connection: As directed, NPS 3 (DN 80) or NPS 4 (DN 100), horizontal with cleanout and slip joint.

7. Flushometer Valve: As directed.
8. Toilet Seat: As directed.
9. Lavatory:

    a. Standard: ASME A 112.19.3/CSA B45.4.
    b. Location: In top of cabinet.
    c. Receptor: Oval or rectangular bowl with integral soap depression.
    d. Hot- and Cold-Water and Bubbler Supply Valves: Mechanical-metering type with push-button actuation and individual check stops complying with ASME A112.18.1/CSA B125.1.
    e. Filler Spout: Backsplash or deck mounted.
    f. Drain: Integral punched grid with NPS 1-1/4 (DN 32) minimum waste and trap complying with ASME A112.18.2/CSA B125.2.

10. Wall Sleeve: Galvanized-steel frame of dimensions required to match fixture. Include steel bars or other design to prevent escape if fixture is removed.

2.2 STAINLESS-STEEL WATER CLOSETS

A. Water Closets: As directed, back access, on, off, floor, back or floor outlet, cabinet.

1. Material: 0.078-inch (2.0-mm) minimum-thick stainless steel; corrosion-resistant metal for internal piping and bracing.
2. Finish: ASTM A480/A480M, No. 4 polished finish on exposed surfaces.
3. Cabinet: As directed, rectangular apron, five-sided apron with two angled sides, four-sided apron with angled left side or four-sided apron with angled right side, with backsplash.

    a. Water-Closet Bowl Location: Centered on front, left of center on front, right of center on front, on angled left side or on angled right side of apron.
    b. Toilet-Paper Holder: Recessed; stainless steel located above water closet and centered in front, in front, right of center in front, left of center in front, in angled right side, in angled left side, in right side or in left side of apron.

4. Mounting: Bolts through wall sleeve into accessible service space.
5. Water Closet:

    a. Standard: IAPMO PS 61.
    b. Bowl:

        1) Type: As directed, Elongated with back inlet, integral trap, and blowout or siphon-jet design with back outlet and contoured seat.
        2) Type: Elongated, with back inlet, integral trap, and siphon-jet design with bottom outlet and contoured seat.
        3) Back-Outlet Connection: As directed, NPS 3 (DN 80) or NPS 4 (DN 100), horizontal with cleanout and slip joint.
        4) Bottom-Outlet Connection: NPS 3 (DN 80) or NPS 4 (DN 100), vertical.
        5) Seat Surface: ASTM A480/A480M, No. 7 polished finish.
        6) Punching: Two holes for installation of separate toilet seat.

6. Flushometer Valve: As directed.
7. Toilet Seat: As directed.
8. Wall Sleeve: Galvanized-steel frame of dimensions required to match fixture. Include steel bars or other design to prevent escape if fixture is removed.

    a. Configuration: Modify wall sleeve for water-closet mounting height according to ICC A117.1.

B. Water Closets: Back access, off, on, floor, back or floor outlet, extended bowl.
1. Standard: IAPMO PS 61.
2. Material: 0.078-inch- (2.0-mm-) minimum-thick stainless steel; corrosion-resistant metal for internal piping and bracing.
3. Finish: ASTM A480/A480M, No. 4 polished finish on exposed surfaces.
4. Bowl:

    a. Type: As directed, elongated, with back inlet, integral trap, and blowout or siphon-jet design with back outlet and contoured seat.
    b. Type: Elongated, with back inlet, integral trap, and siphon-jet design with bottom outlet and contoured seat.
    c. Length to Wall: Minimum of 25 inches (635 mm).
    d. Back-Outlet Connection: As directed, NPS 3 (DN 80) or NPS 4 (DN 100), horizontal with cleanout and slip joint.

e. Bottom-Outlet Connection: As directed, NPS 3 (DN 80) or NPS 4 (DN 100), vertical.
f. Seat Surface: ASTM A480/A480M, No. 7 polished finish.
g. Punching: Two holes for installation of separate toilet seat.

5. Mounting: Bolts through wall sleeve into accessible pipe space.
6. Flushometer Valve: As directed.
7. Toilet Seat: As directed.
8. Wall Sleeve: Galvanized-steel frame of dimensions required to match fixture. Include steel bars or other design to prevent escape if fixture is removed.

a. Configuration: Modify wall sleeve for water-closet mounting height according to ICC A117.1.

2.3 FLUSHOMETER VALVES

A. Flushometer Valves: As directed Lever handle or Push button, diaphragm.
1. Standard: ASSE 1037.
2. Minimum Pressure Rating: 125 psig (860 kPa).
3. Features: Integral check stops and backflow-prevention device.
4. Material: Brass body with corrosion-resistant components.
5. Exposed Flushometer-Valve Finish: Chrome plated.
6. Panel Finish: Chrome plated or stainless steel.
7. Style: As directed, Concealed or Exposed.
8. Consumption: As directed, 3.5 gal. (13.2 L), 1.6 gal. (6 L), 1.5 gal. (5.7 L), 1.0 gal. (3.8 L) or 0.5 gal. (1.9 L) per flush.
9. Minimum Inlet: NPS 1 (DN 25).
10. Minimum Outlet: NPS 1-1/4 (DN 32).

2.4 TOILET SEATS

A. Toilet Seats:
1. Standard: IAPMO Z124.5.
2. Material: Plastic.

B. Type: As directed, Commercial standard or heavy duty.

1. Shape: As directed, elongated rim, open or closed front.
2. Hinge: Check.
3. Hinge Material: Noncorroding metal.
4. Seat Cover: As directed, Required or Not required.
5. Color: As directed White or Black.

2.5 URINALS

A. Urinals: Back access, back outlet, single.
1. Fixture:

a. Standard: IAPMO PS 61.
b. Material: 0.078-inch (2.0-mm) minimum-thick stainless steel; corrosion-resistant metal for internal piping and bracing.
c. Finish: ASTM A480/A480M, No. 4 polished finish on exposed surfaces.
d. Type and Configuration: As directed, Blowout, Washout, with back or top inlet.
e. Drain: Strainer with NPS 2 (DN 50) tailpiece and trap.

2. Mounting: Bolts through wall sleeve into accessible service space.
3. Flushometer Valve: As directed.
4. Wall Sleeve: Galvanized-steel frame of dimensions required to match fixture.

2.6 STAINLESS-STEEL LAVATORIES

A. Lavatories: Back access.
1. Fixture:

a. Standard: ASME A112.19.3/CSA B45.4.
b. Material: 0.078-inch (2.0-mm) minimum-thick stainless steel; corrosion-resistant metal for internal piping and bracing.
c. Finish: ASTM A480/A480M, No. 4 polished finish on exposed surfaces.
d. Receptor: As directed, Oval or rectangular bowl with integral soap depression and backsplash.
e. Hot- and Cold-Water and Bubbler Supply Valves: Mechanical-metering type with push-button actuation, individual check stops, and backsplash- or deck-mounted filler spouts complying with ASME A112.18.1/CSA B125.1.
f. Drain: Integral punched grid with NPS 1-1/4 (DN 32) minimum horizontal waste and trap complying with ASME A112.18.2/CSA B125.2.

2. Accessories:

a. Toothbrush Holders: As directed, One on each, left or right side of backsplash.
b. Towel Hooks: As directed, One or Two on each, left or right side of fixture.
c. Bubbler Location: As directed, on backsplash or deck.

3. Mounting: Bolts through wall into accessible service space.

2.7 DRINKING FOUNTAINS

A. Drinking Fountains: Back access.
1. Fixture:

a. Standard: ASME A112.19.3/CSA B45.4.
b. Material: 0.078-inch (2.0-mm) minimum-thick stainless steel; corrosion-resistant metal for internal piping and bracing.
c. Finish: ASTM A480/A480M, No. 4 polished finish on exposed surfaces.
d. Receptor: Bowl with backsplash.
e. Bubbler Supply Valve: Push-button actuation and backsplash- or deck-mounted filler spouts complying with ASME A112.18.1/CSA B125.1.
f. Drain: Integral punched grid with NPS 1-1/4 (DN 32) tailpiece.

2. Waste Fittings: NPS 1-1/4 (DN 32) minimum waste and trap complying with ASME A112.18.2/CSA B125.2.
3. Mounting: Bolts through wall into accessible service space.
4. Wall Sleeve: Galvanized-steel frame of dimensions required to match fixture.

2.8 SHOWERS

A. Showers: Back access, recessed.
   1. Fixture:

      a. Standard: ASME A112.19.3/CSA B45.4.
      b. Material: 0.078-inch (2.0-mm) minimum-thick stainless steel; corrosion-resistant metal for internal piping and bracing.
      c. Finish: ASTM A480/A480M, No. 4 polished finish on exposed surfaces.
      d. Type and Configuration: Wall, with showerhead and soap dish.
      e. Tempered or Hot- and Cold-Water Supply Valves As directed: Mechanical-metering type with individual check stops complying with ASME A112.18.1/CSA B125.1.
      f. Shower: As directed, Hose with vandal-resistant, hand-held, Vandal-resistant, fixed-type or Vandal-resistant, swivel-type head.
      g. Soap Dish: Recessed, stainless steel.

   2. Mounting: Bolts through wall sleeve into accessible service space.
   3. Wall Sleeve: Galvanized-steel frame of dimensions required to match fixture.

B. Showers: Back access, accessible, cabinet.
   1. Fixture:

      a. Standard: ASME A112.19.3/CSA B45.4.
      b. Material: 0.078-inch (2.0-mm) minimum-thick stainless steel; corrosion-resistant metal for internal piping and bracing.
      c. Finish: ASTM A480/A480M, No. 4 polished finish on exposed surfaces.
      d. Type and Configuration: As directed, Cabinet 42 or 44 by 36 inches (1065 or 1120 by 915 mm) or 48 by 36 inches (1220 by 915 mm) with floor and top, and with stainless-steel soap dish, towel hook, drain, seat, and grab bar.
      e. As directed Tempered or Hot- and Cold-Water Supply Valves: Mechanical-metering type with individual check stops complying with ASME A112.18.1/CSA B125.1.
      f. Shower: Hose with vandal-resistant, hand-held head.
      g. Drain: Grid with NPS 2 (DN 50) outlet.

   2. Waste Fittings: NPS 2 (DN 50) waste to wall; trap complying with ASME A112.18.2/CSA B125.2.
   3. Mounting: Bolts through wall into accessible service space.

2.9 SERVICE SINKS

A. Service Sinks: Back access, off or on floor as directed.
   1. Fixture:

a. Standard: ASME A112.19.3/CSA B45.4.
b. Material: 0.078-inch (2.0-mm) minimum-thick stainless steel; corrosion-resistant metal for internal piping and bracing.
c. Finish: ASTM A480/A480M, No. 4 polished finish on exposed surfaces.
d. Receptor: Rectangular bowl with high backsplash.
e. Nominal Size: As directed, 20 by 19 inches (508 by 483 mm) or 24 by 19 inches (610 by 483 mm).
f. Hot- and Cold-Water Supply Valves: As directed, Push-button actuation and backsplash-mounted filler spout with hose or plain end complying with ASME A112.18.1/CSA B125.1.
g. Drain: Grid with NPS 2 (DN 50) outlet.

2. Waste Fittings: NPS 2 (DN 50) elbow waste complying with ASME A112.18.2/CSA B125.2.
3. Mounting: Bolts through wall into accessible service space.
4. Wall Sleeve: Galvanized-steel frame of dimensions required to match fixture.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install security plumbing fixtures level and plumb according to roughing-in drawings.

B. Install back-access, stainless-steel fixtures as follows:

1. Install wall sleeve in wall if indicated.
2. Install fixture on wall sleeve or wall, as indicated, with access from accessible service space.
3. Extend supply piping from service space to fixture.
4. Install soil and waste piping from fixture and extend into service space.
5. Install fixture trap in service space instead of below fixture drain.

C. Install fixture outlets with gasket seals.

D. Install fixtures designated "accessible" according to ICC A117.1 for heights, dimensions, and clearances.

E. Install toilet seats on water closets and combination units if seats are indicated.

F. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible fixtures. Comply with requirements in Section 220719 "Plumbing Piping Insulation."

G. Seal joints between fixtures, floors, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

H. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

I. Operate and adjust flushometer valves and flow-control valves on fixtures.

J. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

K. Comply with requirements for water piping specified in Section 221116 "Domestic Water Piping."

L. Comply with requirements for soil and waste drainage piping specified in Section 221316 "Sanitary Waste and Vent Piping."

3.2 CLEANING AND PROTECTION

A. After installing fixtures, inspect and repair damaged finishes.

B. Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.

C. Provide protective covering for installed fixtures and fittings.

D. Do not allow use of fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 224600

SECTION 224713 - DRINKING FOUNTAINS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes drinking fountains and related components.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of drinking fountains.

B. Sustainable Design Submittals: As directed.

1.3 CLOSEOUT SUBMITTALS

A. Maintenance Data: For drinking fountains to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 DRINKING FOUNTAINS

A. Drinking Fountains: Concrete, Painted cast iron or steel, pedestal or wheelchair accessible.

1. Concrete Drinking Fountains:

2. Cast-Iron or Steel Drinking Fountains:

3. Standards: Comply with ICC A117.1 and NSF 61 Annex G.
4. Pedestal: As directed Rectangular, Round, with offset to receptor or with side receptor(s).
5. Receptor(s):

    a. Number: As directed, One, Two or Three.
    b. Material: As directed, Bronze or Chrome-plated brass or stainless steel.
    c. Shape: As directed, Rectangular, Round or Rounded front.
    d. Bubbler: One for each receptor, with adjustable stream regulator.
    e. Drain: Grid type with NPS 1-1/4 (DN 32) tailpiece.

6. Maximum water flow: As directed, 0.15 or 0.5 gpm.
7. Controls: As directed, Foot pedal, Push bar or Push button.
8. Access to Internal Components: Panel in pedestal.
9. Supply Piping: As directed, NPS 3/8 (DN 10) or NPS 1/2 (DN 15) with shutoff valve.
10. Drain Piping: As directed, NPS 1-1/4 (DN 32) or NPS 1-1/2 (DN 40) minimum trap and waste.

B. Drinking Fountains: As directed, Bronze or Stainless steel, wall mounted.

1. Bronze Drinking Fountains:

2. Stainless-Steel Drinking Fountains:

3. Standards:

a. Comply with ASME A112.19.3/CSA B45.4.
b. Comply with NSF 61 Annex G.

4. Type Receptor: As directed, Slab, with back or on horizontal support.
5. Receptor Shape: As directed, rectangular or round.
6. Back Panel: Stainless-steel wall plate behind drinking fountain.
7. Bubblers: As directed, one, two or three, with adjustable stream regulator, located on deck.
8. Maximum water flow: As directed 0.15 or 0.5 gpm.
9. Control: As directed, Push button or Push bar.
10. Drain: Grid type with NPS 1-1/4 (DN 32) tailpiece.
11. Supply Piping: NPS 3/8 (DN 10) with shutoff valve.
12. Drain Piping: ASME A112.18.2/CSA B125.2, NPS 1-1/4 (DN 32) chrome-plated brass P-trap and waste.
13. Support: As directed Type I Water Cooler Carrier or Type II Water Cooler Carrier.
14. Drinking Fountain Mounting Height: As directed Standard, Child or Handicapped/elderly according to ICC A117.1.

2.2 SUPPORTS

A. Type I Water Cooler Carrier:

1. Standard: ASME A112.6.1M.

B. Type II Water Cooler Carrier:

1. Standard: ASME A112.6.1M.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for water-supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before fixture installation.

B. Examine walls and floors for suitable conditions where fixtures will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install fixtures level and plumb according to roughing-in drawings. For fixtures indicated for children, install at height required by authorities having jurisdiction.

B. Set pedestal drinking fountains on floor.

C. Install off-the-floor carrier supports, affixed to building substrate, for wall-mounted fixtures.

D. Install water-supply piping with shutoff valve on supply to each fixture to be connected to domestic-water distribution piping. Use ball or gate valve. Install valves in locations where they can be easily reached for operation. Valves are specified in Section 220523.12 "Ball Valves for Plumbing Piping" and Section 220523.15 "Gate Valves for Plumbing Piping."

E. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.

F. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons where required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

G. Seal joints between fixtures and walls using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

H. Adjust fixture flow regulators for proper flow and stream height.

3.3 CONNECTIONS

A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Install ball or gate shutoff valve on water supply to each fixture. Comply with valve requirements specified in Section 220523.12 "Ball Valves for Plumbing Piping" and Section 220523.15 "Gate Valves for Plumbing Piping."

D. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.4 CLEANING

A. After installation, inspect unit. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. Clean fixtures, on completion of installation, according to manufacturer's written instructions.

C. Provide protective covering for installed fixtures.

D. Do not allow use of fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 224713

SECTION 224716 - PRESSURE WATER COOLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes pressure water coolers and related components.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of pressure water cooler.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.3 CLOSEOUT SUBMITTALS

A. Maintenance Data: For pressure water coolers to include in maintenance manuals.

1.4 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filter Cartridges: Equal to percent as directed of quantity installed for each type and size indicated, but no fewer than number of each as directed.

PART 2 - PRODUCTS

2.1 PRESSURE WATER COOLERS

A. Pressure Water Coolers: As directed Freestanding or Flush to wall.
1. Standards:

a. Comply with NSF 61 Annex G.
b. Comply with ASHRAE 34, "Designation and Safety Classification of Refrigerants," for water coolers. Provide HFC 134a (tetrafluoroethane) refrigerant unless otherwise indicated.

2. Cabinet: As directed All stainless steel, Steel with powder-coat finish or Vinyl-covered steel with stainless-steel top.
3. Bubbler: One, with adjustable stream regulator, located on deck.
4. Control: As directed Push button or Foot pedal.

5. Drain: Grid with NPS 1-1/4 (DN 32) tailpiece.
6. Supply: NPS 3/8 (DN 10) with shutoff valve.
7. Waste Fitting: ASME A112.18.2/CSA B125.2, NPS 1-1/4 (DN 32) brass P-trap.
8. Filter: One or more water filters complying with NSF 42 and NSF 53 for cyst and lead reduction to below EPA standards; with capacity sized for unit peak flow rate.
9. Cooling System: Electric, with precooler, hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.

    a. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

10. Capacities and Characteristics:

    a. Cooled Water: As directed, 5 gph (0.0053 L/s), 8 gph (0.0084 L/s), 10 gph (0.0105 L/s) or 14 gph (0.0147 L/s).
    b. Ambient-Air Temperature: 90 deg F (32 deg C).
    c. Inlet-Water Temperature: 80 deg F (27 deg C.)
    d. Cooled-Water Temperature: 50 deg F (10 deg C).
    e. Cooled-Water Storage: As directed.
    f. Electrical Characteristics:

        1) Motor Horsepower: As directed 1/6, 1/5 or 1/4.
        2) Volts: 120-V ac.
        3) Phase: Single.
        4) Hertz: 60.
        5) Full-Load Amperes: As directed.
        6) Minimum Circuit Ampacity: As directed.
        7) Maximum Overcurrent Protection: As directed.

B. Pressure Water Coolers: As directed Wall mounted, standard, wheelchair accessible.
    1. Standards:

        a. Comply with NSF 61 Annex G.
        b. Comply with ASHRAE 34, "Designation and Safety Classification of Refrigerants," for water coolers. Provide HFC 134a (tetrafluoroethane) refrigerant unless otherwise indicated.

    2. Cabinet: As directed, Single, Bi-level with two attached cabinets, Bi-level with two attached cabinets and with a bi-level skirt kit, all stainless steel or vinyl-covered steel with stainless-steel top.
    3. Bubbler: One, with adjustable stream regulator, located on each cabinet deck.
    4. Control: As directed, Push button or Push bar.
    5. Drain: Grid with NPS 1-1/4 (DN 32) tailpiece.
    6. Supply: NPS 3/8 (DN 10) with shutoff valve.
    7. Waste Fitting: ASME A112.18.2/CSA B125.2, NPS 1-1/4 (DN 32) brass P-trap.
    8. Filter: One or more water filters complying with NSF 42 and NSF 53 for cyst and lead reduction to below EPA standards; with capacity sized for unit peak flow rate.

9. Cooling System: Electric, with hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.

    a. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

10. Capacities and Characteristics:

    a. Cooled Water: As directed, 5 gph (0.0053 L/s) or 8 gph (0.0084 L/s).
    b. Ambient-Air Temperature: 90 deg F (32 deg C).
    c. Inlet-Water Temperature: 80 deg F (27 deg C).
    d. Cooled-Water Temperature: 50 deg F (10 deg C).
    e. Cooled-Water Storage: As directed.
    f. Electrical Characteristics:

        1) Motor Horsepower: As directed 1/6, 1/5, ¼ or 1/3.
        2) Volts: 120-V ac.
        3) Phase: Single.
        4) Hertz: 60.
        5) Full-Load Amperes: As directed.
        6) Minimum Circuit Ampacity: As directed.
        7) Maximum Overcurrent Protection: As directed.

11. Support: As directed Type I water cooler carrier or Type II water cooler carrier.
12. Water Cooler Mounting Height: As directed Standard, Child or Handicapped/elderly according to ICC A117.1.

2.2 SUPPORTS

A. Type I Water Cooler Carrier:
    1. Standard: ASME A112.6.1M.

B. Type II Water Cooler Carrier:
    1. Standard: ASME A112.6.1M.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for water-supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before fixture installation.

B. Examine walls and floors for suitable conditions where fixtures will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install fixtures level and plumb according to roughing-in drawings. For fixtures indicated for children, install at height required by authorities having jurisdiction.

B. Set freestanding pressure water coolers on floor.

C. Install off-the-floor carrier supports, affixed to building substrate, for wall-mounted fixtures.

D. Install water-supply piping with shutoff valve on supply to each fixture to be connected to domestic-water distribution piping. Use ball or gate valve. Install valves in locations where they can be easily reached for operation. Valves are specified in Section 220523.12 "Ball Valves for Plumbing Piping" and Section 220523.15 "Gate Valves for Plumbing Piping."

E. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.

F. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons where required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

G. Seal joints between fixtures and walls using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

3.3 CONNECTIONS

A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Install ball or gate shutoff valve on water supply to each fixture. Install valve upstream from filter for water cooler. Comply with valve requirements specified in Section 220523.12 "Ball Valves for Plumbing Piping" and Section 220523.15 "Gate Valves for Plumbing Piping."

D. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.4 ADJUSTING

A. Adjust fixture flow regulators for proper flow and stream height.

B. Adjust pressure water-cooler temperature settings.

3.5 CLEANING

A. After installing fixture, inspect unit. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. Clean fixtures, on completion of installation, according to manufacturer's written instructions.

C. Provide protective covering for installed fixtures.

D. Do not allow use of fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 224716

SECTION 224723 - REMOTE WATER COOLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes remote water coolers and related components.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of remote water cooler.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.3 CLOSEOUT SUBMITTALS

A. Maintenance Data: For remote water coolers to include in maintenance manuals.

1.4 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filter Cartridges: Equal to number percent as directed of quantity installed for each type and size indicated, but no fewer than number of each as directed.

PART 2 - PRODUCTS

2.1 REMOTE WATER COOLERS

A. Remote Water Coolers: Remote chiller equipment.
1. Standards:

a. Comply with NSF 61 Annex G.
b. Comply with UL 1951.
c. Comply with ASHRAE 34, "Designation and Safety Classification of Refrigerants," for water coolers. Provide HFC 134a (tetrafluoroethane) refrigerant unless otherwise indicated.

2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

3. Chassis: Galvanized or corrosion-resistant-coated steel.
4. Chiller: Hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, and refrigerant.
5. Storage Tank: As directed 0.5 gal. (1.9 L) or 4 gal. (15.1 L), stainless steel.
6. Controls: Adjustable thermostat.
7. Capacities and Characteristics:

    a. Cooled Water: As directed 5 gph (0.0053 L/s), 8 gph (0.0084 L/s) or 14 gph (0.0147 L/s).
    b. Ambient-Air Temperature: 90 deg F (32 deg C).
    c. Inlet-Water Temperature: 80 deg F (27 deg C.)
    d. Cooled-Water Temperature: 50 deg F (10 deg C).
    e. Cooled-Water Storage: As directed.
    f. Electrical Characteristics:

        1) Motor Horsepower: As directed 1/5, ¼ or 1/3.
        2) Volts: 120-V ac.
        3) Phase: Single.
        4) Hertz: 60.
        5) Full-Load Amperes: As directed.
        6) Minimum Circuit Ampacity: As directed.
        7) Maximum Overcurrent Protection: As directed.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for water-supply and sanitary drainage piping systems to verify actual locations of piping connections before fixture installation.

B. Examine walls and floors for suitable conditions where remote water coolers will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install remote water coolers level and plumb according to roughing-in drawings.

B. Install water-supply piping with shutoff valve on supply to each remote water cooler to be connected to domestic-water distribution piping. Use ball or gate valve. Install valves in locations where they can be easily reached for operation. Valves are specified in Section 220523.12 "Ball Valves for Plumbing Piping" and Section 220523.15 "Gate Valves for Plumbing Piping,"

C. Set remote water coolers on floor unless otherwise indicated.

D. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons where required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

E. Adjust water-cooler temperature settings.

3.3 CONNECTIONS

A. Connect fixtures with water supplies. Use size fittings required to match fixtures.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Install ball or gate shutoff valve on water supply to each fixture. Comply with valve requirements specified in Section 220523.12 "Ball Valves for Plumbing Piping" and Section 220523.15 "Gate Valves for Plumbing Piping."

D. Install ball or gate valves with valved bypass on water connections to remote water coolers. Comply with valve requirements specified in Section 220523.12 "Ball Valves for Plumbing Piping" and Section 220523.15 "Gate Valves for Plumbing Piping."

3.4 CLEANING

A. After installing remote water cooler, inspect unit. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

END OF SECTION 224723

SECTION 226113 - COMPRESSED-AIR PIPING FOR LABORATORY AND HEALTHCARE FACILITIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Medical compressed-air piping, designated "medical air."
2. Gas-powered-tool compressed-air piping, designated "instrument air."

B. Related Requirements:

1. Section 221513 "General-Service Compressed-Air Piping" for general-service compressed-air piping and specialties.
2. Section 226119 "Compressed-Air Equipment for Laboratory and Healthcare Facilities" for air compressors and specialties.
3. Section 226400 "Medical Gas Alarms" for combined medical air, vacuum, and gas alarms.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer and testing agency.

B. Material Certificates: Signed by Installer certifying that medical compressed-air piping materials comply with requirements in NFPA 99 for positive-pressure medical gas systems.

C. Retain "Field Quality-Control Reports" Paragraph below if Contractor is retaining "Brazing" Paragraph in "Quality Assurance" Article.

D. Field quality-control reports: Brazing certificates.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For compressed-air piping specialties to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Installer Qualifications:

1. Medical Air Piping Systems for Healthcare Facilities: According to ASSE Standard #6010 for medical-gas-system installers.
2. Shape-Memory-Metal Coupling Joints: An authorized representative who is trained and approved by manufacturer.

B. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the vacuum piping testing indicated, that is a member of the Medical Gas Professional Healthcare Organization or is an NRTL, and that is acceptable to authorities having jurisdiction.

1. Qualify testing personnel according to ASSE Standard #6020 for medical-gas-system inspectors and ASSE Standard #6030 for medical-gas-system verifiers.

C. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code, Section IX, "Welding and Brazing Qualifications"; or AWS B2.2, "Standard for Brazing Procedure and Performance Qualification."

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Medical air operating at 50 to 55 psig (345 to 380 kPa).

B. Instrument air operating at 175 psig (1200 kPa).

2.2 PIPES, TUBES, AND FITTINGS

A. Comply with NFPA 99.

1. For medical air, all positive pressure compressed air piping, tubing, and fittings shall have been manufacturer cleaned, purged, and sealed as for oxygen service, according to CGA G-4.1.

a. Each length of tubing shall be delivered plugged or capped by the manufacturer and kept sealed until prepared for installation.
b. Fittings and other components shall be delivered manufacturer sealed and labeled and kept sealed until prepared for installation.

B. Copper Medical Gas Tube: ASTM B819, Type K and Type L, seamless, drawn temper. Include standard color marking "MED" or "OXY/MED" in green for Type K tube and in blue for Type L tube.

C. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type.

D. Copper Unions: ASME B16.22 or MSS SP-123, wrought-copper or cast-copper alloy.

E. Cast-Copper-Alloy Flanges: ASME B16.24, Class 150.

1. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch (3.2-mm) maximum thickness, full-face type.
2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel.

F. Shape-Memory-Metal Couplings:
1. Description: Cryogenic compression fitting made of nickel-titanium, shape-memory alloy.

G. Flexible Pipe Connectors:
1. Description: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.

a. Working-Pressure Rating: As directed, 200 psig (1380 kPa) or 250 psig (1725 kPa minimum.
b. End Connections: Plain-end copper tube.

2.3 JOINING MATERIALS

A. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys.

B. Threaded-Joint Tape: PTFE.

2.4 VALVES

A. Zone-Valve Box Assemblies: Box with medical gas valves, tube extensions, and gages.

1. Steel Box with Aluminum Cover:
a. Description: Formed steel box with cover, anchors for recessed mounting, holes with grommets in box sides for tubing extension protection, and of size for single or multiple valves with pressure gages and in sizes required to permit manual operation of valves. Medical air tubing, valves, and gages may be incorporated in zone valve boxes for medical gases.

1) Positive pressure compressed air valves shall have been manufacturer cleaned, purged, and sealed as for oxygen service, according to CGA G-4.1.

a) Valves shall be delivered sealed and labeled and kept sealed until prepared for installation.

b. Interior Finish: Factory-applied white enamel.

c. Cover Plate: Aluminum with frangible or removable windows.
d. Valve-Box Windows: Clear or tinted transparent plastic with labeling that includes rooms served, according to NFPA 99.

2. Steel Box with Stainless-Steel Cover:
   a. Description: Formed steel box with cover, anchors for recessed mounting, holes with grommets in box sides for tubing extension protection, and of size for single or multiple valves with pressure gages and in sizes required to permit manual operation of valves. Medical air and medical vacuum tubing, valves, and gages may be incorporated in zone valve boxes for medical gases.

      1) Positive pressure compressed air valves shall have been manufacturer cleaned, purged, and sealed as for oxygen service, according to CGA G-4.1.

         a) Valves shall be delivered sealed and labeled and kept sealed until prepared for installation.

   b. Interior Finish: Factory-applied white enamel.
   c. Cover Plate: Stainless-steel with frangible or removable windows.
   d. Valve-Box Windows: Clear or tinted transparent plastic with labeling that includes rooms served, according to NFPA 99.

B. Ball Valves:
1. Standard: MSS SP-110.
2. Description: Three-piece body, brass or bronze.
3. Pressure Rating: 300 psig (2070 kPa) minimum.
4. Ball: Full-port, chrome-plated brass.
5. Seats: PTFE or TFE.
6. Handle: Lever type with locking device.
7. Stem: Blowout proof with PTFE or TFE seal.
8. Ends: Manufacturer-installed ASTM B819, copper-tube extensions and manufacturer-installed ASTM B819, copper-tube extensions with pressure gage on one copper-tube extension.
9. Positive pressure medical air valves shall have been manufacturer cleaned, purged, and sealed as for oxygen service, according to CGA G-4.1.

   a. Valves shall be delivered sealed and labeled and kept sealed until prepared for installation.

C. Check Valves:
1. Description: In-line pattern, bronze.
2. Pressure Rating: 300 psig (2070 kPa) minimum.
3. Operation: Spring loaded.
4. Ends: Manufacturer-installed ASTM B819, copper-tube extensions.
5. Positive pressure compressed air valves shall have been manufacturer cleaned, purged, and sealed as for oxygen service, according to CGA G-4.1.

   a. Valves shall be delivered sealed and labeled and kept sealed until prepared for installation.

D. Medical Gas Safety Valves:

1. Bronze body.
2. ASME-construction, poppet, pressure-relief type.
3. Settings to match system requirements.
4. Positive pressure compressed air valves shall have been manufacturer cleaned, purged, and sealed as for oxygen service, according to CGA G-4.1.

    a. Valves shall be delivered sealed and labeled and kept sealed until prepared for installation.

E. Pressure Regulators:

1. Bronze body and trim.
2. Spring-loaded, diaphragm-operated, relieving type.
3. Manual pressure-setting adjustment.
4. Rated for 250-psig (1725-kPa) minimum inlet pressure.
5. Capable of controlling delivered air pressure within 0.5 psig for each 10-psig (5.0 kPa for each 100-kPa) inlet pressure.
6. Positive pressure medical air regulators shall have been manufacturer cleaned, purged, and sealed as for oxygen service, according to CGA G-4.1.

    a. Valves shall be delivered sealed and labeled and kept sealed until prepared for installation.

2.5 MEDICAL COMPRESSED-AIR SERVICE CONNECTIONS

A. General Requirements for Medical Compressed-Air Service Connections:

1. All positive pressure compressed air service connections shall be manufacturer cleaned, purged, and sealed as for oxygen service, according to CGA G-4.
2. Suitable for specific medical air pressure and service listed.
3. Include roughing-in assemblies, finishing assemblies, and cover plates.
4. Individual cover plates are not required if service connection is in multiple unit or assembly with cover plate.
5. Recessed-type units made for concealed piping unless otherwise indicated.

B. Roughing-in Assembly:

1. Steel outlet box for recessed mounting and concealed piping.
2. Brass-body outlet block with secondary check valve that will prevent gas flow when primary valve is removed.
3. Double seals that will prevent air leakage.
4. ASTM B819, NPS 3/8 (DN 10) copper outlet tube brazed to valve with service marking and tube-end dust cap.

C. Finishing Assembly:

1. Brass housing with primary check valve.
2. Double seals that will prevent air leakage.
3. Cover plate with gas-service label.

D. Quick-Coupler Pressure Service Connections:

1. Outlets for medical air and instrument air with noninterchangeable keyed indexing to prevent interchange between services.
2. Constructed to permit one-handed connection and removal of equipment.
3. With positive-locking ring that retains equipment stem in valve during use.

E. D.I.S.S. Pressure Service Connections: Outlets, complying with CGA V-5, with threaded indexing to prevent interchange between services, constructed to permit one-handed connection and removal of equipment.

1. Medical Air: D.I.S.S. No. 1160.
2. Instrument Air: D.I.S.S. No. 1160.

F. Cover Plates:

1. One piece.
2. Aluminum or stainless steel.
3. Permanent, color-coded, identifying label matching corresponding service.

2.6 MEDICAL COMPRESSED-AIR PRESSURE CONTROL PANELS

A. Description: Steel box and support brackets for recessed roughing-in with stainless-steel or anodized-aluminum cover plate with printed operating instructions.

B. Manufacturer cleaned, purged, and sealed as for oxygen service, according to CGA G-4.1.

C. Manifold: Assembly consisting of inlet supply valve, inlet supply pressure gage, line-pressure control regulator, outlet supply pressure gage, D.I.S.S. service connection, and piping outlet for remote service connection.

D. Minimum Working Pressure: 200 psig (1380 kPa).

E. Line-Pressure Control Regulator: Self-relieving diaphragm type with precision manual adjustment.

F. Pressure Gages: 0 to 300 psig (0 to 2070 kPa).

G. Service Connection: CGA V-5, D.I.S.S. No. 1160, instrument air outlet.

H. Before final assembly, provide temporary dust shield and U-tube for testing.

I. Label cover plate "Air Pressure Control."

2.7 NITROGEN

A. Comply with USP 32 - NF 27 for oil-free dry nitrogen.

PART 3 - EXECUTION

3.1 PREPARATION

A. Cleaning of Medical Gas Tubing: If manufacturer-cleaned and -capped fittings or tubing is not available or if precleaned fittings or tubing must be recleaned because of exposure, have supplier or separate agency acceptable to authorities having jurisdiction perform the following procedures:

1. Clean medical gas tube and fittings, valves, gages, and other components of oil, grease, and other readily oxidizable materials as required for oxygen service according to CGA G-4.1.
2. Wash medical gas tubing and components in hot, alkaline-cleaner-water solution of sodium carbonate or trisodium phosphate in proportion of 1 lb (0.453 kg) of chemical to 3 gal. (11.3 L) of water.

    a. Scrub to ensure complete cleaning.
    b. Rinse with clean, hot water to remove cleaning solution.

3.2 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of compressed-air piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, air-compressor sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Comply with NFPA 99 for installation of compressed-air piping.

C. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and coordinate with other services occupying that space.

F. Install piping adjacent to equipment and specialties to allow service and maintenance.

G. Install compressed-air piping with 1 percent slope downward in direction of flow.

H. Install nipples, unions, special fittings, and valves with pressure ratings same as or higher than system pressure rating used in applications specified in "Piping Schedule" Article unless otherwise indicated.

I. Install eccentric reducers, if available, where compressed-air piping is reduced in direction of flow, with bottoms of both pipes and reducer fitting flush.

J. Install branch connections to compressed-air mains from top of main. Provide drain leg and drain trap at end of each main and branch and at low points.

K. Install thermometer and pressure gage on discharge piping from each air compressor and on each receiver. Comply with requirements in Section 220519 "Meters and Gages for Plumbing Piping."

L. Install piping to permit valve servicing.

M. Install piping free of sags and bends.

N. Install fittings for changes in direction and for branch connections.

O. Install medical air piping to medical air service connections specified in this Section, to medical air service connections in equipment specified in Section 226313 "Gas Piping for Laboratory and Healthcare Facilities," and to equipment specified in other Sections requiring medical air service.

P. Piping Restraint Installation: Install seismic restraints on compressed-air piping. Seismic-restraint devices are specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

Q. Install compressed-air service connections recessed in walls. Attach roughing-in assembly to substrate; attach finishing assembly to roughing-in assembly.

R. Connect compressed-air piping to air compressors and to compressed-air outlets and equipment requiring compressed-air service.

S. Install unions in copper compressed-air tubing adjacent to each valve and at final connection to each machine, specialty, and piece of equipment.

T. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

U. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 VALVE INSTALLATION

A. Install shutoff valve at each connection to and from compressed-air equipment and specialties.

B. Install check valves to maintain correct direction of compressed-air flow from compressed-air equipment.

C. Install valve boxes recessed in wall and anchored to substrate. Single boxes may be used for multiple valves that serve same area or function.

D. Install zone valves and gages in valve boxes. Rotate valves to angle that prevents closure of cover when valve is in closed position.

E. Install pressure regulators on compressed-air piping where reduced pressure is required.

F. Install flexible pipe connectors in discharge piping and in inlet air piping from remote air-inlet filter of each air compressor.

3.4 JOINT CONSTRUCTION

A. Remove scale, slag, dirt, and debris from outside of cleaned tubing and fittings before assembly.

B. Threaded Joints: Apply appropriate tape to external pipe threads.

C. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" chapter. Continuously purge joint with oil-free dry nitrogen during brazing.

D. Flanged Joints: Install flange on copper tubes. Use pipe-flange gasket between flanges. Join flanges with gasket and bolts according to ASME B31.9 for bolting procedure.

E. Shape-Memory-Metal Coupling Joints: Join new copper tube to existing tube according to procedures developed by fitting manufacturer for installation of shape-memory-metal coupling joints.

3.5 COMPRESSED-AIR SERVICE COMPONENT INSTALLATION

A. Install compressed-air pressure control panel in walls. Attach to substrate.

3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.

B. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices.

C. Vertical Piping: MSS Type 8 or Type 42, clamps.

D. Individual, Straight, Horizontal Piping Runs:

1. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel, clevis hangers.
2. Longer Than 100 Feet (30 m): MSS Type 43, adjustable, roller hangers.

E. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for trapeze hangers.

F. Base of Vertical Piping: MSS Type 52, spring hangers.

G. Support horizontal piping within 12 inches (300 mm) of each fitting and coupling.

H. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch- (10-mm-) minimum rods.

I. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1/4 (DN 8): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
2. NPS 3/8 and NPS 1/2 (DN 10 and DN 15): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
3. NPS 3/4 (DN 20): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
4. NPS 1 (DN 25): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
5. NPS 1-1/4 (DN 32): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
6. NPS 1-1/2 (DN 40): 10 feet (3 m) with 3/8-inch (10-mm) rod.
7. NPS 2 (DN 50): 11 feet (3.4 m) with 3/8-inch (10-mm) rod.
8. NPS 2-1/2 (DN 65): 13 feet (4 m) with 1/2-inch (13-mm) rod.
9. NPS 3 (DN 80): 14 feet (4.3 m) with 1/2-inch (13-mm) rod.
10. NPS 3-1/2 (DN 90): 15 feet (4.6 m) with 1/2-inch (13-mm) rod.
11. NPS 4 (DN 100): 16 feet (4.9 m) with 1/2-inch (13-mm) rod.
12. NPS 5 (DN 125): 18 feet (5.5 m) with 1/2-inch (13-mm) rod.
13. NPS 6 (DN 150): 20 feet (6 m) with 5/8-inch (16-mm) rod.
14. NPS 8 (DN 200): 23 feet (7 m) with 3/4-inch (19-mm) rod.

J. Install supports for vertical copper tubing every 10 feet (3 m).

3.7 IDENTIFICATION

A. Install identifying labels and devices for nonmedical laboratory compressed-air piping, valves, and specialties. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment."

B. Install identifying labels and devices for medical compressed-air piping systems according to NFPA 99. Use the following or similar captions and color-coding for piping products where required by NFPA 99:

1. Medical Air: Black letters on yellow background.
2. Dental Air: Black letters on yellow background.
3. Instrument Air: White letters on red background.
4. Medical Laboratory Air: Black letters on yellow-and-white checkerboard background.

3.8 FIELD QUALITY CONTROL FOR MEDICAL COMPRESSED-AIR PIPING IN HEALTHCARE FACILITIES

A. Testing Agency: As directed Owner will engage or Engage a qualified testing agency to perform tests and inspections of medical compressed-air piping in healthcare facilities and to prepare test and inspection reports.

B. Tests and Inspections:

1. Medical Compressed-Air Testing Coordination: Perform tests, inspections, verifications, and certification of medical compressed-air piping systems concurrently with tests, inspections, and certification of medical gas piping and medical vacuum piping systems.

2. Preparation: Perform the following Installer tests according to requirements in NFPA 99 and ASSE Standard #6010:

    a. Initial blowdown.
    b. Initial pressure test.
    c. Cross-connection test.
    d. Piping purge test.
    e. Standing pressure test for positive-pressure medical compressed-air piping.
    f. Repair leaks and retest until no leaks exist.

3. System Verification: Perform the following tests and inspections according to NFPA 99, ASSE Standard #6020, and ASSE Standard #6030:

    a. Standing pressure test.
    b. Individual-pressurization or pressure-differential cross-connection test.
    c. Valve test.
    d. Master and area alarm tests.
    e. Piping purge test.
    f. Piping particulate test.
    g. Piping purity test.
    h. Final tie-in test.
    i. Operational pressure test.
    j. Medical air purity test.
    k. Verify correct labeling of equipment and components.

4. Testing Certification: Certify that specified tests, inspections, and procedures have been performed and certify report results. Include the following:

    a. Inspections performed.
    b. Procedures, materials, and gases used.
    c. Test methods used.
    d. Results of tests.

C. Remove and replace components that do not pass tests and inspections and retest as specified above.

3.9 PIPING SCHEDULE

A. Connect new tubing to existing tubing with memory-metal couplings.

B. Flanges may be used where connection to flanged equipment is required.

C. Medical Air Piping except Instrument Air Piping Larger Than NPS 3 (DN 80) and Operating at More Than 185 psig (1275 kPa): Type L, copper medical gas tube; wrought-copper fittings; and brazed joints.

D. Instrument Air Piping Larger Than NPS 3 (DN 80) and Operating at More Than 185 psig (1275 kPa): Type K, copper tube; wrought-copper fittings; and brazed joints.

E. Laboratory Air Piping except Laboratory Air Piping Larger Than NPS 3 (DN 80) and Operating at More Than 185 psig (1275 kPa): Type L, copper medical gas tube; wrought-copper fittings; and brazed joints.

F. Laboratory Air Piping Larger Than NPS 3 (DN 80) and Operating at More Than 185 psig (1275 kPa): Type K, copper medical gas tube; wrought-copper fittings; and brazed joints.

3.10 VALVE SCHEDULE

A. Shutoff Valves: Ball valve with manufacturer-installed ASTM B819, copper-tube extensions.

B. Zone Valves: Ball valve with manufacturer-installed ASTM B819, copper-tube extensions with pressure gage on one copper-tube extension.

END OF SECTION 226113

SECTION 226119 - COMPRESSED-AIR EQUIPMENT FOR LABORATORY AND HEALTHCARE FACILITIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Oilless, reciprocating air compressors.
2. Liquid-ring air compressors.
3. Scroll air compressors.
4. Inlet-air filters.
5. Refrigerant compressed-air dryers.
6. Compressed-air filter assemblies.

B. See Section 226400 "Medical Gas Alarms" for compressed-air equipment local alarms.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For air compressors and compressed-air dryers.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
4. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For air compressors, accessories, and components from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the compressed-air equipment testing indicated, that is a member of the Medical Gas Professional Healthcare Organization or is an NRTL and that is acceptable to authorities having jurisdiction.

1. Qualify testing personnel according to ASSE 6020 for inspectors and ASSE 6030 for verifiers.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design compressed-air equipment mounting.

B. Seismic Performance: Air compressors and accessories shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the air compressor and receiver will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: As directed 1.5 or 1.0.

2.2 GENERAL REQUIREMENTS FOR AIR COMPRESSORS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 99, "Health Care Facilities," for compressed-air equipment and accessories for medical compressed-air systems.

C. Comply with UL 544, "Medical and Dental Equipment," for medical compressed-air equipment.

D. Description: Factory-assembled, -wired, -piped, and -tested; electric-motor-driven; air-cooled; continuous-duty air compressors and receivers that deliver air of quality equal to intake air.

E. Control Panels: Automatic control station with load control and protection functions. Comply with NEMA ICS 2 and UL 508.

1. Enclosure: NEMA ICS 6, Type 12 control panel unless otherwise indicated.

2. Motor Controllers: Full-voltage, combination-magnetic type with undervoltage release feature and motor-circuit-protector-type disconnecting means and short-circuit protective device.
3. Control Voltage: 120-V ac or less, using integral control power transformer.
4. Motor Overload Protection: Overload relay in each phase.
5. Starting Devices: Hand-off-automatic selector switch in cover of control panel, plus pilot device for automatic control.
6. Automatic control switches to alternate lead-lag air compressors for duplex and sequence lead-lag air compressors for multiplex air compressors.
7. Instrumentation: Include discharge-air and receiver pressure gages, air-filter maintenance indicator, hour meter, air-compressor discharge-air and coolant temperature gages, and control transformer.
8. Alarm Signal Device: For connection to alarm system to indicate when backup air compressor is operating.

F. Receivers: Steel tank constructed according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

1. Pressure Rating: At least as high as highest discharge pressure of connected air compressors and bearing appropriate code symbols.
2. Interior Finish: Corrosion-resistant coating.
3. Accessories: Include safety valve, pressure gage, automatic drain, and pressure regulator.

G. Mounting Frame: Fabricate base and attachment to air compressor and components with reinforcement strong enough to resist movement during a seismic event when base is anchored to building structure.

2.3 RECIPROCATING AIR COMPRESSORS

A. Oilless, Reciprocating Air Compressors:
1. Description: Packaged unit.
2. Air Compressor(s): Single or two-stage, oilless (nonlubricated), reciprocating-piston type, with sealed oil-free bearings, that will deliver air of quality equal to intake air.

a. High discharge-air temperature switch.
b. Belt guard totally enclosing pulleys and belts.
c. Intercooler between stages of two-stage units.

3. Receiver and accessories.

B. Capacities and Characteristics:

1. Compressed-Air Service: As directed Medical, Dental, Instrument, Medical laboratory or Nonmedical laboratory air.
2. Air Compressor(s): As directed One, Two or Three.
3. Standard-Air Capacity of Each Air Compressor: As directed free air.
4. Actual-Air Capacity of Each Air Compressor: As directed delivered.
5. Discharge-Air Pressure: As directed 80 psig (550 kPa), 125 psig (860 kPa) or 75 psig (1200 kPa).
6. Intake-Air Temperature: As directed.

7. Discharge-Air Temperature: As directed.
8. Mounting: As directed Freestanding or Tank mounted.
9. Motor (Each Air Compressor):

    a. Horsepower: As directed.
    b. Speed: As directed 1750 or 3400 rpm.

10. Electrical Characteristics:

    a. Volts: As directed.
    b. Phase(s): As directed Single or Three.
    c. Hertz: 60.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed.
    f. Maximum Overcurrent Protection: As directed.

11. Receiver:

    a. Orientation: As directed Horizontal or Vertical arrangement.
    b. Capacity: As directed.
    c. Interior Finish: As directed Epoxy, Epoxy or galvanized or Galvanized.
    d. Pressure Rating: As directed 100 psig (690 kPa), 125 psig (860 kPa), 150 psig (1035 kPa) or 200 psig (1380 kPa) minimum.
    e. Pressure Regulator Setting: As directed.
    f. Pressure Relief Valve Setting: As directed.
    g. Drain: As directed Automatic or Manual valve.

2.4 LIQUID-RING AIR COMPRESSORS

A. Liquid-Ring Air Compressors:
    1. Description: Packaged unit.
    2. Air Compressor(s): Nonpulsating, rotary, liquid-ring type.

        a. Construction: As directed Cast-iron body with bronze rotor, Bronze body and rotor or Cast-iron or bronze body and bronze rotor.
        b. Coupling: Nonlubricated, flexible type.
        c. Sealing Fluid: Potable water. Water circulation is prohibited.

B. Capacities and Characteristics:

    1. Compressed-Air Service: As directed Medical, Medical laboratory or Nonmedical laboratory air.
    2. Air Compressor(s): As directed One, Two or Three.
    3. Standard-Air Capacity of Each Air Compressor: free air.
    4. Actual-Air Capacity of Each Air Compressor: Delivered As directed.
    5. Discharge-Air Pressure: As directed 80 psig (550 kPa) or 100 psig (690 kPa).
    6. Intake-Air Temperature: As directed.
    7. Discharge-Air Temperature: As directed.
    8. Mounting: As directed Freestanding or Tank mounted.
    9. Motor (Each Air Compressor):

a. Horsepower: As directed.
b. Speed: As directed, 1750 or 3400 rpm.

10. Electrical Characteristics:

a. Volts: As directed.
b. Phase(s): As directed, Single or Three.
c. Hertz: 60.
d. Full-Load Amperes: As directed.
e. Minimum Circuit Ampacity: As directed.
f. Maximum Overcurrent Protection: As directed.

11. Receiver: ASME construction steel tank.

a. Orientations: As directed, Horizontal or Vertical arrangement.
b. Capacity: As directed.
c. Interior Finish: As directed, Epoxy, Epoxy or galvanized or Galvanized.
d. Pressure Rating: As directed, 100 psig (690 kPa), 125 psig (860 kPa) or 150 psig (1035 kPa) minimum.
e. Pressure Regulator Setting: As directed.
f. Pressure Relief Valve Setting: As directed.
g. Drain: As directed, Automatic or Manual valve.

2.5 SCROLL AIR COMPRESSORS

A. Scroll Air Compressors As directed:
1. Description: Packaged unit.
2. Air Compressor(s): Single-stage, oil-free, rotary, ocillating-volute type of construction that prohibits oil from entering compression chamber.

a. Mounting: Freestanding.

B. Capacities and Characteristics:

1. Compressed-Air Service: As directed, Medical, Dental, Instrument, Medical laboratory or Nonmedical laboratory air.
2. Air Compressor(s): As directed, One or Two.
3. Standard-Air Capacity of Each Air Compressor: Free air, as directed.
4. Actual-Air Capacity of Each Air Compressor: Delivered, as directed.
5. Discharge-Air Pressure: As directed 80 psig (550 kPa) or 110 psig (760 kPa).
6. Intake-Air Temperature: As directed.
7. Discharge-Air Temperature: As directed.
8. Motor (Each Air Compressor):

a. Horsepower: As directed.
b. Speed: As directed 1750 or 3400 rpm.

9. Electrical Characteristics:

a. Volts: As directed.

b. Phase(s): As directed, Single or Three.
c. Hertz: 60.
d. Full-Load Amperes: As directed.
e. Minimum Circuit Ampacity: As directed.
f. Maximum Overcurrent Protection: As directed.

10. Receiver: ASME construction steel tank.

a. Orientation: As directed, Horizontal or Vertical arrangement.
b. Capacity: As directed.
c. Interior Finish: As directed, Epoxy, Epoxy or galvanized or Galvanized.
d. Pressure Rating: As directed, 100 psig (690 kPa), 125 psig (860 kPa) or 150 psig (1035 kPa) minimum.
e. Pressure Regulator Setting: As directed.
f. Pressure Relief Valve Setting: As directed.
g. Drain: As directed, Automatic or Manual valve.

2.6 INLET-AIR FILTERS

A. Description: Combination inlet-air filter-silencer, suitable for remote installation, for each air compressor.

1. Construction: Weatherproof housing for replaceable, dry-type filter element, with silencer tubes or other method of sound reduction.
2. Capacity: Match capacity of air compressor, with collection efficiency of 99 percent retention of particles larger than 10 micrometers.

2.7 COMPRESSED-AIR DRYERS

A. Refrigerant Compressed-Air Dryers:
1. Description: Noncycling, air-cooled, electric-motor-driven unit with steel enclosure and capability to deliver 35 deg F (2 deg C), 100-psig (690-kPa) air at dew point. Include automatic ejection of condensate from airstream, step-down transformers, disconnect switches, inlet and outlet pressure gages, thermometers, automatic controls, and filters.

B. Capacities and Characteristics:

1. Standard-Air Capacity of Each Compressed-Air Dryer: free air.
2. Pressure: As directed.
3. Entering-Air Temperature: As directed.
4. Leaving-Air Temperature: As directed.
5. Leaving-Air Pressure Dew Point: As directed.
6. Ambient-Air Temperature: As directed.
7. Maximum Air-Pressure Drop: As directed.
8. Inlet Filter: 5 micrometers.
9. Outlet Filter: 1 micrometer(s).
10. Motor Horsepower: As directed.
11. Electrical Characteristics:

a. Volts: As directed.
b. Phase(s): As directed, Single or Three.
c. Hertz: 60.
d. Full-Load Amperes: As directed.
e. Minimum Circuit Ampacity: As directed.
f. Maximum Overcurrent Protection: As directed.

2.8 COMPRESSED-AIR FILTER ASSEMBLIES

A. Compressed-Air Filter Assemblies:
1. Description: Filter assemblies suitable for compressed air, in parallel duplex arrangement. Size each assembly for maximum capacity of connected equipment and operating pressure of compressed-air system. Include automatic ejection of condensate from airstream, inlet and outlet pressure gages, and shutoff valves.

a. Option: Factory-fabricated filter system consisting of three air filters equivalent to those specified, pipe, fittings, valves, differential pressure switch, and enclosure; and with additional automatic drain traps and gages.

2. Size filter assemblies for 5-psig (34.5-kPa) maximum air-pressure drop when filters are new and clean, at system rated capacity, and at 100-psig (690-kPa) pressure.
3. Differential Pressure Switch: Adjustable, diaphragm type, with electrical connections for alarm system, to indicate when air-pressure drop through filters rises to more than 2 psig (13.8 kPa) greater than when new and clean.
4. Particulate Filters: Collection efficiency of 98 percent retention of particles 1 micrometer and larger.
5. Odor and Taste Filters: Vapor-absorbing, activated charcoal.
6. Coalescing Filters: Collection efficiency of 99.9 percent retention of particles 0.3 micrometer and smaller.
7. Include automatic drain trap for each filter.

2.9 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 220513 "Common Motor Requirements for Plumbing Equipment."

1. Enclosure: As directed, open, dripproof, totally enclosed, fan cooled, totally enclosed, air over, open, externally ventilated, totally enclosed, nonventilated, severe duty, explosion proof or dust-ignition-proof machine.
2. Enclosure Materials: As directed, cast iron, cast aluminum or rolled steel.
3. Motor Bearings: As directed.
4. Unusual Service Conditions:

a. Ambient Temperature: As directed.
b. Altitude: Feet (m) above sea level as directed.
c. High humidity.

5. Efficiency: Premium efficient.

6. NEMA Design: As directed.
7. Service Factor: As directed.
8. Electrical Characteristics:

    a. Horsepower: As directed.
    b. Volts: As directed ,120, 208, 230 or 460.
    c. Phase: As directed Single or Poly.
    d. Hertz: 60.
    e. Full-Load Amperes: As directed.
    f. Minimum Circuit Ampacity: As directed.
    g. Maximum Overcurrent Protection: As directed.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean compressed-air equipment, accessories, and components that have not been cleaned for oxygen service and sealed or that are furnished unsuitable for laboratory air and medical air applications, according to CGA G-4.1, "Cleaning Equipment for Oxygen Service."

3.2 COMPRESSED-AIR EQUIPMENT INSTALLATION

A. General Requirements for Compressed-Air Equipment Installation:

1. Install compressed-air equipment to allow maximum headroom unless specific mounting heights are indicated.
2. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces unless otherwise indicated.
3. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
4. Install equipment to allow right of way for piping installed at required slope.
5. Install the following devices on compressed-air equipment:

    a. Thermometer, Pressure Gage, and Safety Valve: Install on each compressed-air receiver.
    b. Pressure Regulators: Install downstream from air compressors, dryers, purification units, and filter assemblies.
    c. Drain Valves: Install on aftercoolers, receivers, and dryers. Discharge condensate over nearest floor drain.

B. Nonmedical Laboratory Compressed-Air Equipment Installation:

1. Install compressed-air equipment, except wall-mounted equipment, on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" As directed.

2. Comply with requirements for vibration isolation and seismic control devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment"
3. Comply with requirements for vibration isolation devices specified in Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."

C. Medical Compressed-Air Equipment Installation:

1. Install according to ASSE 6010 and NFPA 99.
2. Install compressed-air equipment, except wall-mounted equipment, on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" As directed.
3. Comply with requirements for vibration isolation and seismic control devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment"
4. Comply with requirements for vibration isolation devices specified in Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."

3.3 CONNECTIONS

A. Comply with requirements for water-supply piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Comply with requirements for drain piping specified in Section 221316 "Sanitary Waste and Vent Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

C. Comply with requirements for compressed-air piping specified in Section 226113 "Compressed-Air Piping for Laboratory and Healthcare Facilities." Drawings indicate general arrangement of piping, fittings, and specialties.

D. Where installing piping adjacent to equipment, allow space for service and maintenance.

E. Connect compressed-air piping to compressed-air equipment, accessories, and specialties with shutoff valve and union or flanged connection.

F. Connect water supply to compressed-air equipment that requires water. Include backflow preventer. Backflow preventers are specified in Section 221119 "Domestic Water Piping Specialties."

3.4 IDENTIFICATION

A. Identify nonmedical laboratory compressed-air equipment system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

B. Identify medical compressed-air equipment system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment." and with NFPA 99.

3.5 FIELD QUALITY CONTROL FOR HEALTHCARE-FACILITY MEDICAL COMPRESSED-AIR EQUIPMENT

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative.

1. Medical Compressed-Air Equipment Testing Coordination: Perform tests, inspections, verifications, and certification of medical compressed-air equipment concurrently with tests, inspections, and certification of medical vacuum equipment, medical vacuum piping, medical compressed-air piping and medical gas piping systems.
2. Preparation: Perform medical compressed-air equipment tests according to requirements in NFPA 99 for the following:

    a. Air-quality purity test.
    b. System operation test.

3. Equipment Verification: Comply with requirements in ASSE 6020, ASSE 6030, and NFPA 99 for verification of medical compressed-air equipment.
4. Replace damaged and malfunctioning controls and equipment.
5. Testing Certification: Certify that specified tests, inspections, and procedures have been performed and certify report results. Include the following:

    a. Inspections performed.
    b. Procedures, materials, and gases used.
    c. Test methods used.
    d. Results of tests.

B. Components will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. As directed Engage a factory-authorized service representative to perform or Perform As directed startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Check for lubricating oil in lubricated-type equipment.
3. Check belt drives for proper tension.
4. Verify that air-compressor inlet filters and piping are clear.
5. Check for equipment vibration-control supports and flexible pipe connectors and verify that equipment is properly attached to substrate.
6. Check safety valves for correct settings. Ensure that settings are higher than air-compressor discharge pressure, but not higher than rating of system components.
7. Check for proper seismic restraints.
8. Drain receiver tank(s).
9. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
10. Test and adjust controls and safeties.

B. Prepare written report documenting testing procedures and results.

END OF SECTION 226119

SECTION 226213 - VACUUM PIPING FOR LABORATORY AND HEALTHCARE FACILITIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Medical-surgical vacuum piping, designated "medical vacuum."
2. Waste anesthetic gas disposal piping, designated "WAGD."

B. Related Requirements:

1. Section 226219 "Vacuum Equipment for Laboratory and Healthcare Facilities" for vacuum producers and accessories.
2. Section 226400 "Medical Gas Alarms" for vacuum piping alarms.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer and testing agency.

B. Material Certificates: Signed by Installer certifying that medical vacuum piping materials comply with requirements in NFPA 99.

C. Brazing certificates.

D. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Installer Qualifications:

1. Medical Vacuum Piping Systems for Healthcare Facilities: According to ASSE Standard #6010 for medical-gas-system installers.
2. Shape-Memory-Metal Coupling Joints: An authorized representative who is trained and approved by manufacturer.

B. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the vacuum piping testing indicated, that is a member of the Medical Gas Professional Healthcare Organization or is an NRTL, and that is acceptable to authorities having jurisdiction.

1. Qualify testing personnel according to ASSE Standard #6020 for medical-gas-system inspectors and ASSE Standard #6030 for medical-gas-system verifiers.

C. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code, Section IX, "Welding and Brazing Qualifications"; or AWS B2.2, "Standard for Brazing Procedure and Performance Qualification."

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. As directed Medical vacuum operating at 15 in. Hg (380 mm Hg), 20 in. Hg (510 mm Hg) or 30 in. Hg (760 mm Hg).

B. As directed WAGD operating at 14 in. Hg (355 mm Hg) or 15 in. Hg (380 mm Hg).

2.2 PIPES, TUBES, AND FITTINGS

A. Comply with NFPA 99 for medical vacuum piping materials.

B. Copper Medical Gas Tube: ASTM B819, Type L, seamless, drawn temper that has been manufacturer cleaned, purged, and sealed for medical gas service or according to CGA G-4.1 for oxygen service. Include standard color marking "OXY," "MED," "OXY/MED," "OXY/ACR," or "ACR/MED" in blue.

C. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type that has been manufacturer cleaned, purged, and sealed for medical gas service or according to CGA G-4.1 for oxygen service.

D. Copper Unions: ASME B16.22 or MSS SP-123, wrought-copper or cast-copper alloy.

E. Cast-Copper-Alloy Flanges: ASME B16.24, Class 150.

1. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness, full-face type.
2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel.

F. Shape-Memory-Metal Couplings:
1. Description: Cryogenic compression fitting made of nickel-titanium, shape-memory alloy, and that has been manufacturer cleaned, purged, and sealed for oxygen service according to CGA G-4.1.

G. Flexible Pipe Connectors:

1. Description: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.

    a. Working-Pressure Rating: As directed 200 psig (1380 kPa) or 250 psig (1725 kPa) minimum.
    b. End Connections: Plain-end copper tube.

2.3 JOINING MATERIALS

A. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys.

B. Threaded-Joint Tape: PTFE.

2.4 VALVES

A. General Requirements for Valves: Manufacturer cleaned, purged, and bagged according to CGA G-4.1 for oxygen service.

1. Exception: Factory cleaning and bagging are not required for valves for WAGD service.

B. Zone-Valve Box Assemblies: Box with medical gas valves, tube extensions, and gages.

1. Zone-Valve Boxes:

    a. Steel Box with Aluminum Cover: As directed.

    b. Steel Box with Stainless-Steel Cover: As directed.

    c. Description: Formed steel box with cover, anchors for recessed mounting, holes with grommets in box sides for tubing extension protection, and of size for single or multiple valves with pressure gages and in sizes required to permit manual operation of valves. Medical air and medical vacuum tubing, valves, and gages may be incorporated in zone valve boxes for medical gases.

        1) Interior Finish: Factory-applied white enamel.
        2) Cover Plate: Aluminum or stainless-steel with frangible or removable windows.
        3) Valve-Box Windows: Clear or tinted transparent plastic with labeling that includes rooms served, according to NFPA 99.

C. Copper-Alloy Ball Valves:
1. Standard: MSS SP-110.
2. Description: Three-piece body, brass or bronze.
3. Pressure Rating: 300 psig (2070 kPa) minimum.
4. Ball: Full-port, chrome-plated brass.
5. Seats: PTFE or TFE.
6. Handle: Lever type with locking device.
7. Stem: Blowout proof with PTFE or TFE seal.

8. Ends: Manufacturer-installed ASTM B819, copper-tube extensions and manufacturer-installed ASTM B819, copper-tube extensions with pressure gage on one copper-tube extension.

D. Check Valves:
1. Description: In-line pattern, bronze.
2. Pressure Rating: 300 psig (2070 kPa) minimum.
3. Operation: Spring loaded.
4. Ends: Manufacturer-installed ASTM B819, copper-tube extensions.

2.5 MEDICAL VACUUM SERVICE CONNECTIONS

A. General Requirements for Medical Vacuum Service Connections:

1. Suitable for specific medical vacuum service listed.
2. Include roughing-in assemblies, finishing assemblies, and cover plates.
3. Individual cover plates are not required if service connection is in multiple unit or assembly with cover plate.
4. Recessed-type units made for concealed piping unless otherwise indicated.

B. Roughing-in Assembly:

1. Steel outlet box for recessed mounting and concealed piping.
2. Brass-body inlet block.
3. Seals that will prevent vacuum leakage.
4. ASTM B819, NPS 3/8 (DN 10) copper outlet tube brazed to valve with service marking and tube-end dust cap.

C. Finishing Assembly:

1. Brass housing with primary check valve.
2. Seals that will prevent vacuum leakage.
3. Cover plate with gas-service label.

D. Quick-Coupler Suction Service Connections:

1. Inlets for medical vacuum and WAGD with noninterchangeable keyed indexing to prevent interchange between services.
2. Constructed to permit one-handed connection and removal of equipment.
3. With positive-locking ring that retains equipment stem in valve during use.

E. D.I.S.S. Suction Service Connections:

1. Inlets complying with CGA V-5.
2. Threaded indexing to prevent interchange between services.
3. Constructed to permit one-handed connection and removal of equipment.
4. Medical Vacuum: CGA V-5, D.I.S.S. No. 1220.
5. WAGD: CGA V-5, D.I.S.S. No. 2220.

F. Vacuum Bottle Brackets: One piece, with pattern and finish matching corresponding service cover plate.

G. Cover Plates:

1. One piece.
2. Aluminum or stainless steel.
3. Permanent, color-coded, identifying label matching corresponding service.

2.6 NITROGEN

A. Comply with USP 32 - NF 27 for oil-free dry nitrogen.

PART 3 - EXECUTION

3.1 PREPARATION

A. Cleaning of Medical Gas Tubing: If manufacturer-cleaned and -capped fittings or tubing is not available or if precleaned fittings or tubing must be recleaned because of exposure, have supplier or separate agency acceptable to authorities having jurisdiction perform the following procedures:

1. Clean medical gas tube and fittings, valves, gages, and other components of oil, grease, and other readily oxidizable materials as required for oxygen service according to CGA G-4.1.
2. Wash medical gas tubing and components in hot, alkaline-cleaner-water solution of sodium carbonate or trisodium phosphate in proportion of 1 lb (0.453 kg) of chemical to 3 gal. (11.3 L) of water.

a. Scrub to ensure complete cleaning.
b. Rinse with clean, hot water to remove cleaning solution.

3.2 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of vacuum piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, vacuum producer sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Comply with NFPA 99 for installation of vacuum piping.

C. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and coordinate with other services occupying that space.

F. Install piping adjacent to equipment and specialties to allow service and maintenance.

G. Install vacuum piping with 1 percent slope downward in direction of flow.

H. Install nipples, unions, special fittings, and valves with pressure ratings same as or higher than piping pressure rating used in applications specified in "Piping Schedule" Article unless otherwise indicated.

I. Install eccentric reducers, if available, where vacuum piping is reduced in direction of flow, with bottoms of both pipes and reducer fitting flush.

J. Provide drain leg and drain trap at end of each main and branch and at low points.

K. Install thermometer and vacuum gage on inlet piping to each vacuum producer and on each receiver and separator. Comply with requirements in Section 220519 "Meters and Gages for Plumbing Piping."

L. Install piping to permit valve servicing.

M. Install piping free of sags and bends.

N. Install fittings for changes in direction and for branch connections.

O. Install medical vacuum piping from medical vacuum service connections specified in this Section, to equipment specified in Section 226219 "Vacuum Equipment for Laboratory and Healthcare Facilities," and to equipment specified in other Sections requiring medical vacuum service.

P. Piping Restraint Installation: Install seismic restraints on vacuum piping. Seismic-restraint devices are specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

Q. Install medical vacuum service connections recessed in walls. Attach roughing-in assembly to substrate; attach finishing assembly to roughing-in assembly.

R. Install medical vacuum bottle bracket adjacent to each wall-mounted medical vacuum service connection suction inlet.

S. Connect vacuum piping to vacuum producers and to equipment requiring vacuum service.

T. Install unions in copper vacuum tubing adjacent to each valve and at final connection to each machine, specialty, and piece of equipment.

U. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

V. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 VALVE INSTALLATION

A. Install shutoff valve at each connection to and from vacuum equipment and specialties.

B. Install check valves to maintain correct direction of vacuum flow to vacuum-producing equipment.

C. Install valve boxes recessed in wall and anchored to substrate. Single boxes may be used for multiple valves that serve same area or function.

D. Install zone valves and gages in valve boxes. Rotate valves to angle that prevents closure of cover when valve is in closed position.

E. Install flexible pipe connectors in suction inlet piping to each vacuum producer.

3.4 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from outside of cleaned tubing and fittings before assembly.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Threaded Joints: Apply appropriate tape to external pipe threads.

E. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" chapter. Do not use flux. Continuously purge joint with oil-free dry nitrogen during brazing.

F. Flanged Joints:

1. Copper Tubing: Install flange on copper tubes. Use pipe-flange gasket between flanges. Join flanges with gasket and bolts according to ASME B31.9 for bolting procedure.

G. Shape-Memory-Metal Coupling Joints: Join new copper tube to existing tube according to procedures developed by fitting manufacturer for installation of shape-memory-metal coupling joints.

3.5 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.

B. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices.

C. Vertical Piping: MSS Type 8 or Type 42, clamps.

D. Individual, Straight, Horizontal Piping Runs:

1. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel, clevis hangers.
2. Longer Than 100 Feet (30 m): MSS Type 43, adjustable, roller hangers.

E. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for trapeze hangers.

F. Base of Vertical Piping: MSS Type 52, spring hangers.

G. Support horizontal piping within 12 inches (300 mm) of each fitting and coupling.

H. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch- (10-mm-) minimum rods.

I. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1/4 (DN 8): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
2. NPS 3/8 and NPS 1/2 (DN 10 and DN 15): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
3. NPS 3/4 (DN 20): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
4. NPS 1 (DN 25): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
5. NPS 1-1/4 (DN 32): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
6. NPS 1-1/2 (DN 40): 10 feet (3 m) with 3/8-inch (10-mm) rod.
7. NPS 2 (DN 50): 11 feet (3.4 m) with 3/8-inch (10-mm) rod.
8. NPS 2-1/2 (DN 65): 13 feet (4 m) with 1/2-inch (13-mm) rod.
9. NPS 3 (DN 80): 14 feet (4.3 m) with 1/2-inch (13-mm) rod.
10. NPS 3-1/2 (DN 90): 15 feet (4.6 m) with 1/2-inch (13-mm) rod.
11. NPS 4 (DN 100): 16 feet (4.9 m) with 1/2-inch (13-mm) rod.
12. NPS 5 (DN 125): 18 feet (5.5 m) with 1/2-inch (13-mm) rod.

J. Install supports for vertical copper tubing every 10 feet (3 m).

3.6 IDENTIFICATION

A. Install identifying labels and devices for valves and specialties. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment."

B. Install identifying labels and devices for medical vacuum piping systems according to NFPA 99. Use the following or similar captions and color-coding for piping products where required by NFPA 99:

1. Medical Vacuum: Black letters on white background.
2. WAGD: White letters on violet background.

3.7 FIELD QUALITY CONTROL FOR HEALTHCARE FACILITY MEDICAL VACUUM PIPING

A. Testing Agency: As directed Owner will engage or Engage a qualified testing agency to perform tests and inspections of medical vacuum piping systems in healthcare facilities and to prepare test and inspection reports.

B. Tests and Inspections:

1. Medical Vacuum Testing Coordination: Perform tests, inspections, verifications, and certification of medical vacuum piping systems concurrently with tests, inspections, and certification of medical compressed-air piping and medical gas piping systems.
2. Preparation: Perform the following Installer tests according to requirements in NFPA 99 and ASSE Standard #6010:

    a. Initial blowdown.
    b. Initial pressure test.
    c. Cross-connection test.
    d. Piping purge test.
    e. Standing pressure test for vacuum systems.
    f. Repair leaks and retest until no leaks exist.

3. System Verification: Perform the following tests and inspections according to NFPA 99, ASSE Standard #6020, and ASSE Standard #6030:

    a. Standing pressure test.
    b. Individual-pressurization or pressure-differential cross-connection test.
    c. Valve test.
    d. Master and area alarm tests.
    e. Piping purge test.
    f. Final tie-in test.
    g. Operational vacuum test.
    h. Verify correct labeling of equipment and components.

4. Testing Certification: Certify that specified tests, inspections, and procedures have been performed and certify report results. Include the following:

    a. Inspections performed.
    b. Procedures, materials, and gases used.
    c. Test methods used.
    d. Results of tests.

C. Remove and replace components that do not pass tests and inspections and retest as specified above.

3.8 PROTECTION

A. Protect tubing from damage.

B. Retain sealing plugs in tubing, fittings, and specialties until installation.

C. Clean tubing not properly sealed, and where sealing is damaged, according to "Preparation" Article.

3.9 PIPING SCHEDULE

A. Connect new copper tubing to existing copper tubing with memory-metal couplings.

B. Flanges may be used where connection to flanged equipment is required.

C. Medical Vacuum Piping: As directed Use copper medical gas or water tube, wrought-copper fittings, and brazed joints.

D. WAGD Piping: As directed Use copper medical gas or water tube, wrought-copper fittings, and brazed joints.

3.10 VALVE SCHEDULE

A. Shutoff Valves:

1. Copper Tubing: Copper-alloy ball valve with manufacturer-installed ASTM B819, copper-tube extensions.

B. Zone Valves: Copper-alloy ball valve with manufacturer-installed ASTM B819, copper-tube extensions with pressure gage on one copper-tube extension.

END OF SECTION 226213

SECTION 226219 - VACUUM EQUIPMENT FOR LABORATORY AND HEALTHCARE FACILITIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Reciprocating vacuum pumps.
2. Liquid-ring vacuum pumps.
3. Oil-sealed, rotary-screw vacuum pumps.

B. See Section 226400 "Medical Gas Alarms" for vacuum equipment local alarms.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For vacuum producers.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
4. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For vacuum producers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vacuum equipment mounting.

B. Seismic Performance: Vacuum producers and accessories shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the vacuum producer and receiver or separator will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: As directed 1.5 or 1.0.

2.2 GENERAL REQUIREMENTS FOR VACUUM PUMPS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 99, "Health Care Facilities," for vacuum equipment and accessories for medical vacuum systems.

C. Comply with UL 544, "Medical and Dental Equipment," for medical vacuum equipment.

D. Description: Factory-assembled, -wired, -piped, and -tested; electric-motor-driven; air-cooled; continuous-duty vacuum pumps and receivers.

E. Control Panels: Automatic control station with load control and protection functions. Comply with NEMA ICS 2 and UL 508.

1. Enclosure: NEMA ICS 6, Type 12 control panel unless otherwise indicated.
2. Motor Controllers: Full-voltage, combination-magnetic type with undervoltage release feature and motor-circuit-protector-type disconnecting means and short-circuit protective device.
3. Control Voltage: 120-V ac or less, using integral control power transformer.
4. Motor Overload Protection: Overload relay in each phase.
5. Starting Devices: Hand-off-automatic selector switch in cover of control panel, plus pilot device for automatic control.
6. Automatic control switches to alternate lead-lag vacuum pumps for duplex and sequence lead-lag vacuum pumps for multiplex vacuum pumps.

7. Instrumentation: Include vacuum pump inlet and receiver vacuum gages, hour meter, vacuum pump discharge-air and coolant temperature gages, and control transformer.
8. Alarm Signal Devices: For connection to alarm system to indicate when backup vacuum pump is operating.

F. Receivers: Steel tank constructed according to ASME Boiler and Pressure Vessel Code, Section VIII, Division 1; bearing appropriate code symbols.

1. Interior Finish: Corrosion-resistant coating.
2. Accessories: Include vacuum relief valve, vacuum gage, and drain.

G. Mounting Frames: Fabricate base and attachment to vacuum pump and components with reinforcement strong enough to resist movement during a seismic event when base is anchored to building structure.

2.3 RECIPROCATING VACUUM PUMPS

A. Reciprocating Vacuum Pumps:
1. Description: Packaged unit.
2. Vacuum Pump(s): Lubricated, reciprocating-piston type.

a. Inlet filters.
b. Low-lubrication oil pressure switches, submerged gear-type oil pumps, and oil filters.
c. Belt guards totally enclosing pulleys and belts.

3. Receiver: ASME construction steel tank with vacuum relief valve.
4. Outlet silencers and oil-mist separators on discharge piping.

B. Capacities and Characteristics:

1. Vacuum Service: As directed, Medical, WAGD, Dental, Medical laboratory or Nonmedical laboratory vacuum.
2. Vacuum Pump(s): As directed, One, Two or Three.
3. Standard-Air Capacity of Each Vacuum Pump: Free air, as directed.
4. Actual-Air Capacity of Each Vacuum Pump: Expanded air delivered, as directed.
5. Vacuum Required: As directed, 20 in. Hg (510 mm Hg) or 26 in. Hg (660 mm Hg).
6. Mounting: As directed, Freestanding or Tank mounted.
7. Motor (Each Vacuum Pump):

a. Horsepower: As directed.
b. Speed: As directed 1750 or 3400 rpm.

8. Electrical Characteristics:

a. Volts: As directed.
b. Phase(s): As directed Single or Three.
c. Hertz: 60.
d. Full-Load Amperes: As directed.

e. Minimum Circuit Ampacity: As directed.
f. Maximum Overcurrent Protection: As directed.

9. Receiver:

a. Orientation: As directed Horizontal or Vertical arrangement.
b. Capacity: Insert gal. (L).
c. Pressure Rating: 100 psig (690 kPa minimum.
d. Interior Finish: As directed, Epoxy, Epoxy or galvanized or Galvanized.
e. Drain: As directed Automatic or Manual valve.

2.4 LIQUID-RING VACUUM PUMPS

A. Liquid-Ring Vacuum Pumps:
1. Description: Packaged unit.
2. Vacuum Pump(s): Non-pulsating, rotary, liquid-ring type.

a. Construction: As directed, Cast-iron body and Cast-iron body with bronze or Bronze body and rotor.
b. Coupling: Nonlubricated, flexible type.
c. Sealing Fluid: Potable water with up to 90 percent recirculation.

3. Receiver: ASME construction steel tank with vacuum relief valve.
4. Outlet silencers and water-vapor separators on discharge connections.

B. Capacities and Characteristics:

1. Vacuum Service: As directed, Medical, WAGD, Dental, Medical laboratory or Nonmedical laboratory vacuum.
2. Vacuum Pump(s): As directed, One, Two or Three.
3. Standard-Air Capacity of Each Vacuum Pump: Free air, as directed.
4. Actual-Air Capacity of Each Vacuum Pump: Expanded air delivered, as directed.
5. Vacuum Required: As directed 8 in. Hg (205 mm Hg), 10 in. Hg (255 mm Hg) or 12 in. Hg (305 mm Hg).
6. Mounting: As directed, Freestanding or Tank mounted.
7. Motor (Each Vacuum Pump):

a. Horsepower: As directed.
b. Speed: As directed 1750 or 3400 rpm.

8. Electrical Characteristics:

a. Volts: As directed.
b. Phase(s): As directed Single or Three.
c. Hertz: 60.
d. Full-Load Amperes: As directed.
e. Minimum Circuit Ampacity: As directed.
f. Maximum Overcurrent Protection: As directed.

9. Receiver:

a. Orientation: As directed, Horizontal or Vertical arrangement.
b. Capacity: As directed.
c. Pressure Rating: 100 psig (690 kPa) minimum.
d. Interior Finish: As directed, Epoxy, Epoxy or galvanized or Galvanized.
e. Drain: As directed Automatic or Manual valve.

2.5 ROTARY, SLIDING-VANE VACUUM PUMPS

A. Oil-Sealed, Rotary, Sliding-Vane Vacuum Pumps:
1. Description: Packaged unit.
2. Vacuum Pumps: Non-pulsating, oil-sealed, rotary, sliding-vane type.

a. Cleanable inlet screens.
b. Outlet silencers and oil-mist separators on discharge connections.

3. Receiver: ASME construction steel tank with vacuum relief valve.

B. Capacities and Characteristics:

1. Vacuum Service: Medical, WAGD, Dental, Medical laboratory or Nonmedical laboratory vacuum.
2. Vacuum Pump(s): As directed, One, Two or Three.
3. Standard-Air Capacity of Each Vacuum Pump: Free air, as directed.
4. Actual-Air Capacity of Each Vacuum Pump: Expanded air delivered, as directed.
5. Vacuum Required: As directed, 20 in. Hg (510 mm Hg) or 26 in. Hg (660 mm Hg).
6. Mounting: As directed, Freestanding or Tank mounted.
7. Motor (Each Vacuum Pump):

a. Horsepower: As directed.
b. Speed: As directed 1750 or 3400 rpm.

8. Electrical Characteristics:

a. Volts: As directed.
b. Phase(s): As directed, Single or Three.
c. Hertz: 60.
d. Full-Load Amperes: As directed.
e. Minimum Circuit Ampacity: As directed.
f. Maximum Overcurrent Protection: As directed.

9. Receiver:

a. Orientation: As directed, Horizontal or Vertical arrangement.
b. Capacity: As directed.
c. Pressure Rating: 100 psig (690 kPa) minimum.
d. Interior Finish: As directed, Epoxy, Epoxy or galvanized or Galvanized.
e. Drain: As directed, Automatic or Manual valve.

2.6 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 220513 "Common Motor Requirements for Plumbing Equipment."

1. Enclosure: As directed, Open, dripproof, totally enclosed, fan cooled, totally enclosed, air over, open, externally ventilated, totally enclosed, nonventilated or severe duty, Explosion proof or Dust-ignition-proof machine.
2. Enclosure Materials: As directed, cast iron, cast aluminum or rolled steel.
3. Motor Bearings: As directed.
4. Unusual Service Conditions:

    a. Ambient Temperature: As directed.
    b. Altitude: Feet (m) above sea level, as directed.
    c. High humidity.

5. Efficiency: Premium efficient.
6. NEMA Design: As directed.
7. Service Factor: As directed.
8. Electrical Characteristics:

    a. Horsepower: As directed.
    b. Volts: As directed 120, 208, 230 or 460.
    c. Phase: As directed Single or Poly.
    d. Hertz: 60.
    e. Full-Load Amperes: As directed.
    f. Minimum Circuit Ampacity: As directed.
    g. Maximum Overcurrent Protection: As directed.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean vacuum equipment, accessories, and components that have not been cleaned for oxygen service and sealed or that are furnished unsuitable for laboratory vacuum and medical vacuum applications, according to CGA G4.1, "Cleaning Equipment for Oxygen Service."

3.2 VACUUM EQUIPMENT INSTALLATION

A. Install vacuum equipment for healthcare facilities according to ASSE 6010 and NFPA 99.

B. Equipment Mounting:

1. Install vacuum producers or vacuum producers, except diaphragm vacuum pumps, on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" As directed

2. Comply with requirements for vibration isolation and seismic control devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment"
3. Comply with requirements for vibration isolation devices specified in Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."

C. Install vacuum equipment anchored to substrate.

D. Orient equipment so controls and devices are accessible for servicing.

E. Maintain manufacturer's recommended clearances for service and maintenance.

F. Install the following devices on vacuum equipment:

1. Thermometer, Vacuum Gage, and Pressure Relief Valve: Install on each vacuum pump receiver.
2. Drain Valves: Install on receivers. Discharge receiver condensate over nearest floor drain.

3.3 CONNECTIONS

A. Comply with requirements for water-supply piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Comply with requirements for drain piping specified in Section 221316 "Sanitary Waste and Vent Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

C. Comply with requirements for vacuum piping specified in Section 226213 "Vacuum Piping for Laboratory and Healthcare Facilities." Drawings indicate general arrangement of piping, fittings, and specialties.

D. Where installing piping adjacent to equipment, allow space for service and maintenance.

E. Connect vacuum piping to vacuum equipment, accessories, and specialties with shutoff valve and union or flanged connection.

F. Connect water supply to vacuum equipment that requires water. Include backflow preventer. Backflow preventers are specified in Section 221119 "Domestic Water Piping Specialties."

3.4 IDENTIFICATION

A. Identify nonmedical laboratory vacuum equipment system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

B. Identify medical vacuum equipment system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment." and with NFPA 99.

3.5 FIELD QUALITY CONTROL FOR HEALTHCARE-FACILITY MEDICAL VACUUM EQUIPMENT

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Medical Vacuum Equipment Testing Coordination: Perform tests, inspections, verifications, and certification of medical vacuum equipment concurrently with tests, inspections, and certification of medical compressed-air equipment, medical compressed-air piping, medical vacuum piping and medical gas piping systems As directed.
2. Preparation: Perform medical vacuum equipment tests according to requirements in NFPA 99 for the following:

    a. System operation test.

3. Equipment Verification: Comply with requirements in ASSE 6020, ASSE 6030, and NFPA 99 for verification of medical vacuum equipment.
4. Replace damaged and malfunctioning controls and equipment.
5. Testing Certification: Certify that specified tests, inspections, and procedures have been performed and certify report results. Include the following:

    a. Inspections performed.
    b. Procedures and materials used.
    c. Test methods used.
    d. Results of tests.

B. Components will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. As directed Engage a factory-authorized service representative to perform or Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Check for lubricating oil in lubricated-type equipment.
3. Check belt drives for proper tension.
4. Verify that vacuum producer outlet piping is clear.
5. Check for equipment vibration-control supports and flexible pipe connectors and verify that equipment is properly attached to substrate.
6. Check safety valves for correct settings.
7. Check for proper seismic restraints.
8. Drain separator tank(s).
9. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
10. Test and adjust controls and safeties.

B. Verify that vacuum equipment is installed and connected according to the Contract Documents.

C. Verify that electrical wiring installation complies with manufacturer's submittal and written installation requirements in electrical Sections.

D. Prepare written report documenting testing procedures and results.

END OF SECTION 226219

SECTION 226313 - GAS PIPING FOR LABORATORY AND HEALTHCARE FACILITIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Nitrogen piping, designated "medical nitrogen."
2. Nitrous oxide piping, designated "medical nitrous oxide."
3. Oxygen piping, designated "medical oxygen."
4. Owner will furnish gases for medical gas concentration testing specified in this Section.

B. Related Requirements:

1. Section 226400 "Medical Gas Alarms" for combined medical air, vacuum, and gas alarms.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer and testing agency.

B. Seismic Qualification Data: Certificates, for gas manifolds, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Material Certificates: Signed by Installer certifying that medical gas piping materials comply with requirements in NFPA 99 for positive-pressure medical gas systems.

D. Field Quality Control Reports: Brazing certificates.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For medical gas piping specialties to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Installer Qualifications:

1. Medical Gas Piping Systems for Healthcare Facilities: According to ASSE Standard #6010 for medical-gas-system installers.
2. Shape-Memory-Metal Coupling Joints: An authorized representative who is trained and approved by manufacturer.

B. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the medical gas piping testing indicated, that is a member of the Medical Gas Professional Healthcare Organization or is an NRTL, and that is acceptable to authorities having jurisdiction.

1. Qualify testing personnel according to ASSE Standard #6020 for medical-gas-system inspectors and ASSE Standard #6030 for medical-gas-system verifiers.

C. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code, Section IX, "Welding and Brazing Qualifications"; or AWS B2.2, "Standard for Brazing Procedure and Performance Qualification."

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. As directed, Medical nitrogen operating at 160 to 185 psig (1100 to 1275 kPa) or higher than 200 psig (1380 kPa).

B. Medical nitrous oxide operating at 50 to 55 psig (345 to 380 kPa).

C. Medical oxygen operating at 50 to 55 psig (345 to 380 kPa).

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Medical gas manifolds shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the medical gas manifolds will remain in place without separation of any parts when subjected to the seismic forces specified and the manifolds will be fully operational after the seismic event."
2. Component Importance Factor is 1.5 or 1.0 As directed.

2.3 PIPES, TUBES, AND FITTINGS

A. Comply with NFPA 99.

B. For all medical gases, all positive pressure medical gas piping, tubing, and fittings shall have been manufacturer cleaned, purged, and sealed for oxygen service, according to CGA G-4.1.

1. Each length of tubing shall be delivered plugged or capped by the manufacturer and kept sealed until prepared for installation.
2. Fittings and other components shall be delivered manufacturer sealed and labeled, and kept sealed until prepared for installation.

C. Copper Medical Gas Tube: ASTM B819, Type K and Type L, seamless, drawn temper. Include standard color marking "OXY," "MED," "OXY/MED," "OXY/ACR," or "ACR/MED" in green for Type K tube and blue for Type L tube.

D. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type.

E. Copper Unions: ASME B16.22 or MSS SP-123, wrought-copper or cast-copper alloy.

F. Cast-Copper-Alloy Flanges: ASME B16.24, Class 150.

1. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness, full-face type.
2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel.

G. Shape-Memory-Metal Couplings:
1. Description: Cryogenic compression fitting made of nickel-titanium, shape-memory alloy.

2.4 JOINING MATERIALS

A. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys.

B. Threaded-Joint Tape: PTFE.

2.5 VALVES

A. Zone-Valve Box Assemblies: Box with medical gas valves, tube extensions, and gages.

1. Zone-Valve Boxes:

a. Steel Box with Aluminum Cover:

b. Description: Formed steel box with cover, anchors for recessed mounting, holes with grommets in box sides for tubing extension protection, and of size for single or multiple valves with pressure gages and in sizes required to permit manual operation of valves. Medical air and medical vacuum tubing, valves, and gages may be incorporated in zone valve boxes for medical gases.

1) Interior Finish: Factory-applied white enamel.
2) Cover Plate: Aluminum with frangible or removable windows.
3) Valve-Box Windows: Clear or tinted transparent plastic with labeling that includes rooms served, according to NFPA 99.

2. Positive pressure medical gas valves, for all medical gas types, shall have been manufacturer cleaned, purged, and sealed for oxygen service, according to CGA G-4.1.

a. Valves shall be delivered sealed and labeled and kept sealed until prepared for installation.
b. Steel Box with Stainless-Steel Cover:

c. Description: Formed steel box with cover, anchors for recessed mounting, holes with grommets in box sides for tubing extension protection, and of size for single or multiple valves with pressure gages and in sizes required to permit manual operation of valves. Medical air and medical vacuum tubing, valves, and gages may be incorporated in zone valve boxes for medical gases.

1) Interior Finish: Factory-applied white enamel.
2) Cover Plate: Stainless steel with frangible or removable windows.
3) Valve-Box Windows: Clear or tinted transparent plastic with labeling that includes rooms served, according to NFPA 99.

d. Positive pressure medical gas valves, for all medical gas types, shall have been manufacturer cleaned, purged, and sealed for oxygen service, according to CGA G-4.1.

1) Valves shall be delivered sealed and labeled and kept sealed until prepared for installation.

B. Ball Valves:
1. Standard: MSS SP-110.
2. Description: Three-piece body, brass or bronze.
3. Pressure Rating: 300 psig (2070 kPa) minimum.
4. Ball: Full-port, chrome-plated brass.
5. Seats: PTFE or TFE.
6. Handle: Lever type with locking device.
7. Stem: Blowout proof with PTFE or TFE seal.
8. Ends: Manufacturer-installed ASTM B819, copper-tube extensions and manufacturer-installed ASTM B819, copper-tube extensions with pressure gage on one copper-tube extension.
9. Positive pressure medical gas valves, for all medical gas types, shall have been manufacturer cleaned, purged, and sealed for oxygen service, according to CGA G-4.1.

a. Valves shall be delivered sealed and labeled and kept sealed until prepared for installation.

C. Check Valves:
1. Description: In-line pattern, bronze.
2. Pressure Rating: 300 psig (2070 kPa) minimum.

3. Operation: Spring loaded.
4. Ends: Manufacturer-installed ASTM B819, copper-tube extensions.
5. Positive pressure medical gas valves, for all medical gas types, shall have been manufacturer cleaned, purged, and sealed for oxygen service, according to CGA G-4.1.

    a. Valves shall be delivered sealed and labeled and kept sealed until prepared for installation.

2.6 MEDICAL GAS SERVICE CONNECTIONS

A. All medical gas service connections shall be manufacturer cleaned, purge, and sealed for medical gas service or according to CGA G4.1 for oxygen service.

B. General Requirements for Medical Gas Service Connections: For specific medical gas pressure and suction service listed. Include roughing-in assemblies, finishing assemblies, and cover plates. Individual cover plates are not required if service connection is in multiple unit or assembly with cover plate. Furnish recessed-type units made for concealed piping unless otherwise indicated.

1. All positive pressure medical gas service connections, for all medical gas type, shall be manufacturer cleaned, purged, and sealed as for oxygen service in accordance with CGA G-4.

C. Roughing-in Assembly:

1. Steel outlet box for recessed mounting and concealed piping.
2. Brass-body outlet block with secondary check valve that will prevent gas flow when primary valve is removed. Suction inlets to be without secondary valve.
3. Double seals that will prevent gas leakage.
4. ASTM B819, NPS 3/8 (DN 10) copper outlet tube brazed to valve with service marking and tube-end dust cap.

D. Finishing Assembly:

1. Brass housing with primary check valve.
2. Double seals that will prevent gas leakage.
3. Cover plate with gas-service label.

E. Quick-Coupler Pressure Service Connections: Outlets for nitrous oxide and oxygen with noninterchangeable keyed indexing to prevent interchange between services, constructed to permit one-handed connection and removal of equipment, and with positive-locking ring that retains equipment stem in valve during use.

F. D.I.S.S. Pressure Service Connections: Outlets, complying with CGA V-5, with threaded indexing to prevent interchange between services, constructed to permit one-handed connection and removal of equipment.

1. Medical Nitrogen: D.I.S.S. No. 1120.
2. Medical Nitrous Oxide: D.I.S.S. No. 1040.
3. Medical Oxygen: D.I.S.S. No. 1240.

G. Cover Plates: One piece, aluminum or stainless steel and permanent, color-coded, identifying label matching corresponding service.

2.7 MEDICAL NITROGEN PRESSURE CONTROL PANELS

A. Manufacturer cleaned, purge, and sealed for medical gas service or according to CGA G4.1 for oxygen service.

B. Description: Steel box and support brackets for recessed roughing-in with stainless-steel or anodized-aluminum cover plate with printed operating instructions. Include manifold assembly consisting of inlet supply valve, inlet supply pressure gage, line-pressure control regulator, outlet supply pressure gage, D.I.S.S. service connection, and piping outlet for remote service connection.

C. Minimum Working Pressure: 200 psig (1380 kPa).

D. Line-Pressure Control Regulator: Self-relieving diaphragm type with precision manual adjustment.

E. Pressure Gages: 0 to 300 psig (0 to 2070 kPa).

F. Service Connection: CGA V-5, D.I.S.S. No. 1120, nitrogen outlet.

G. Before final assembly, provide temporary dust shield and U-tube for testing.

H. Label cover plate "Nitrogen Pressure Control."

I. Manufacturer cleaned, purged, and sealed, for all medical gas type, for oxygen service in accordance with CGA G-4.1.

2.8 MEDICAL GAS MANIFOLDS

A. Manufacturer cleaned, purged, and sealed, for all medical gas type, for oxygen service in accordance with CGA G-4.1.

B. Comply with NFPA 99 for high-pressure medical gas cylinders.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Central Control-Panel Unit: Weatherproof cabinet, supply and delivery pressure gages, electrical alarm-system connections and transformer, indicator lights or devices, manifold connection, pressure changeover switch, line-pressure regulator, shutoff valves, and safety valve.

E. Manifold and Headers: Duplex, nonferrous-metal header for number of cylinders indicated, divided into two equal banks. Units include design for 2000-psig (13.8-MPa) minimum inlet pressure. Include cylinder-bank headers with inlet (pigtail) connections complying with CGA V-1, individual inlet check valves, shutoff valve, pressure regulator, check valve, and pressure gage.

F. Operation: Automatic, pressure-switch-activated changeover from one cylinder bank to the other when first bank becomes exhausted, without line-pressure fluctuation or resetting of regulators and without supply interruption by shutoff of either cylinder-bank header.

G. Mounting: As directed, Wall with mounting brackets for manifold control cabinet and headers or Floor with support legs for manifold control cabinet.

H. Label manifold control unit with permanent label identifying medical gas type and system operating pressure.

I. Medical Nitrogen Manifolds: As directed For eight or 12 cylinders and 180-psig (1240-kPa) or higher than 200-psig (1380-kPa) line pressure.

J. Medical Nitrous Oxide Manifolds: For eight or 12 cylinders and 55-psig (380-kPa) line pressure, with electric heater or orifice design that will prevent freezing during high demand.

K. Medical Oxygen Manifolds: For 12 or 20 cylinders and 55-psig (380-kPa) line pressure.

L. Medical Gas Cylinders: As directed, Furnished by Owner or Number and type of medical gas cylinders required for complete manifold systems.

2.9 NITROGEN

A. Comply with USP 32 - NF 27 for oil-free dry nitrogen.

PART 3 - EXECUTION

3.1 PREPARATION

A. Cleaning of Medical Gas Tubing: If manufacturer-cleaned and -capped fittings or tubing are not available or if precleaned fittings or tubing must be recleaned because of exposure, have supplier or separate agency acceptable to authorities having jurisdiction, perform the following procedures:

1. Clean medical gas tube and fittings, valves, gages, and other components of oil, grease, and other readily oxidizable materials as required for oxygen service according to CGA G-4.1.
2. Wash medical gas tubing and components in hot, alkaline-cleaner-water solution of sodium carbonate or trisodium phosphate in proportion of 1 lb (0.453 kg) of chemical to 3 gal. (11.3 L) of water.

    a. Scrub to ensure complete cleaning.
    b. Rinse with clean, hot water to remove cleaning solution.

3.2 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of gas piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

B. Comply with NFPA 99 for installation of medical gas piping.

C. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and coordinate with other services occupying that space.

F. Install piping adjacent to equipment and specialties to allow service and maintenance.

G. Install nipples, unions, special fittings, and valves with pressure ratings same as or higher than system pressure rating used in applications specified in "Piping Schedule" Article unless otherwise indicated.

H. Install piping to permit valve servicing.

I. Install piping free of sags and bends.

J. Install fittings for changes in direction and for branch connections.

K. Install medical gas piping to medical gas service connections specified in this Section, to medical gas service connections in equipment specified in this Section, and to equipment specified in other Sections requiring medical gas service.

L. Piping Restraint Installation: Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

M. Install medical gas service connections recessed in walls. Attach roughing-in assembly to substrate; attach finishing assembly to roughing-in assembly.

N. Connect gas piping to gas sources and to gas outlets and equipment requiring gas service.

O. Install unions in copper tubing adjacent to each valve and at final connection to each specialty and piece of equipment.

P. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

Q. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 VALVE INSTALLATION

A. Install shutoff valve at each connection to gas laboratory and healthcare equipment and specialties.

B. Install check valves to maintain correct direction of gas flow from laboratory and healthcare gas supplies.

C. Install valve boxes recessed in wall and anchored to substrate. Single boxes may be used for multiple valves that serve same area or function.

D. Install zone valves and gages in valve boxes. Arrange valves so largest valve is lowest. Rotate valves to angle that prevents closure of cover when valve is in closed position.

E. Install pressure regulators on gas piping where reduced pressure is required.

3.4 JOINT CONSTRUCTION

A. Remove scale, slag, dirt, and debris from outside of cleaned tubing and fittings before assembly.

B. Threaded Joints: Apply appropriate tape to external pipe threads.

C. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" chapter. Continuously purge joint with oil-free, dry nitrogen during brazing.

D. Shape-Memory-Metal Coupling Joints: Join new copper tube to existing tube according to procedures developed by fitting manufacturer for installation of shape-memory-metal coupling joints.

3.5 GAS SERVICE COMPONENT INSTALLATION

A. Install nitrogen pressure-control panels in walls. Attach to substrate.

B. Install gas manifolds on concrete base anchored to substrate.

C. Install gas cylinders and connect to manifold piping.

D. Install gas manifolds with seismic restraints.

3.6 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.

B. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices.

C. Vertical Piping: MSS Type 8 or Type 42, clamps.

D. Individual, Straight, Horizontal Piping Runs:

1. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel, clevis hangers.
2. Longer Than 100 Feet (30 m): MSS Type 43, adjustable, roller hangers.

E. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for trapeze hangers.

F. Base of Vertical Piping: MSS Type 52, spring hangers.

G. Support horizontal piping within 12 inches (300 mm) of each fitting and coupling.

H. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch- (10-mm-) minimum rods.

I. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1/4 (DN 8): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
2. NPS 3/8 and NPS 1/2 (DN 10 and DN 15): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
3. NPS 3/4 (DN 20): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
4. NPS 1 (DN 25): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
5. NPS 1-1/4 (DN 32): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
6. NPS 1-1/2 (DN 40): 10 feet (3 m) with 3/8-inch (10-mm) rod.
7. NPS 2 (DN 50): 11 feet (3.4 m) with 3/8-inch (10-mm) rod.
8. NPS 2-1/2 (DN 65): 13 feet (4 m) with 1/2-inch (13-mm) rod.
9. NPS 3 (DN 80): 14 feet (4.3 m) with 1/2-inch (13-mm) rod.
10. NPS 3-1/2 (DN 90): 15 feet (4.6 m) with 1/2-inch (13-mm) rod.
11. NPS 4 (DN 100): 16 feet (4.9 m) with 1/2-inch (13-mm) rod.

J. Install supports for vertical copper tubing every 10 feet (3 m).

3.7 IDENTIFICATION

A. Install identifying labels and devices for healthcare medical gas piping systems according to NFPA 99. Use the following or similar captions and color-coding for piping products where required by NFPA 99:

1. Nitrogen: White letters on black background.
2. Nitrous Oxide: White letters on blue background.
3. Oxygen: White letters on green background or green letters on white background.

3.8 FIELD QUALITY CONTROL FOR HEALTHCARE FACILITY MEDICAL GAS

A. Testing Agency: As directed Owner will engage or Engage a qualified testing agency to perform tests and inspections.

B. Tests and Inspections:

1. Medical Gas Piping Testing Coordination: Perform tests, inspections, verifications, and certification of medical gas piping systems concurrently with tests, inspections, and certification of medical compressed-air piping and medical vacuum piping systems.
2. Preparation: Perform the following Installer tests according to requirements in NFPA 99 and ASSE Standard #6010:

    a. Initial blow down.
    b. Initial pressure test.
    c. Cross-connection test.
    d. Piping purge test.
    e. Standing pressure test for positive-pressure medical gas piping.
    f. Standing pressure test for vacuum systems.
    g. Repair leaks and retest until no leaks exist.

3. System Verification: Perform the following tests and inspections according to NFPA 99, ASSE Standard #6020, and ASSE Standard #6030:

    a. Standing pressure test.
    b. Individual-pressurization or pressure-differential cross-connection test.
    c. Valve test.
    d. Master and area alarm tests.
    e. Piping purge test.
    f. Piping particulate test.
    g. Piping purity test.
    h. Final tie-in test.
    i. Operational pressure test.
    j. Medical gas concentration test.
    k. Medical air purity test.
    l. Verify correct labeling of equipment and components.
    m. Verify medical gas supply sources.

4. Testing Certification: Certify that specified tests, inspections, and procedures have been performed and certify report results. Include the following:

    a. Inspections performed.
    b. Procedures, materials, and gases used.
    c. Test methods used.
    d. Results of tests.

C. Remove and replace components that do not pass tests and inspections and retest as specified above.

D. Prepare test and inspection reports.

3.9 PROTECTION

A. Protect tubing from damage.

B. Retain sealing plugs in tubing, fittings, and specialties until installation.

C. Clean tubing not properly sealed, and where sealing is damaged, according to "Preparation" Article.

3.10 PIPING SCHEDULE

A. Connect new tubing to existing tubing with memory-metal couplings.

B. Medical Gas Piping except Medical Nitrogen Piping Larger Than NPS 3 (DN 80) and Operating at More Than 185 psig (1275 kPa): Type L, copper tube; wrought-copper fittings; and brazed joints.

C. Medical Nitrogen Piping Larger Than NPS 3 (DN 80) and Operating at More Than 185 psig (1275 kPa): Type K, copper tube; wrought-copper fittings; and brazed joints.

3.11 VALVE SCHEDULE

A. Shutoff Valves: Ball valve with manufacturer-installed ASTM B819, copper-tube extensions.

B. Zone Valves: Ball valve with manufacturer-installed ASTM B819, copper-tube extensions with pressure gage on one copper-tube extension.

END OF SECTION 226313

SECTION 226400 - MEDICAL GAS ALARMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Master alarm panels.
2. Anesthetizing-area alarm panels.
3. Area alarm panels.
4. Local alarm panels.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Product test reports.

B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Qualify Installers for air, vacuum, and gas piping systems for healthcare facilities according to ASSE Standard #6010 for medical-gas-system installers.

B. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the air, vacuum, and gas piping testing indicated, that is a member of the Medical Gas Professional Healthcare Organization or is an NRTL, and that is acceptable to authorities having jurisdiction.

1. Qualify testing personnel for air, vacuum, and gas piping systems for healthcare facilities according to ASSE Standard #6020 for medical-gas-system inspectors and ASSE Standard #6030 for medical-gas-system verifiers.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Gas and Vacuum Systems Monitored:

1. Gas-powered-tool compressed air, designated "instrument air."
2. Medical compressed air, designated "medical air."
3. Medical-surgical vacuum, designated "medical vacuum."
4. Nitrogen, designated "medical nitrogen."
5. Nitrous oxide, designated "medical nitrous oxide."
6. Oxygen, designated "medical oxygen."
7. Waste anesthetic gas disposal, designated "WAGD."

2.2 MANUFACTURERS

A. Source Limitations: Obtain medical alarm systems and components from single manufacturer.

2.3 GENERAL REQUIREMENTS FOR ALARM PANELS

A. Description: Factory wired with audible and color-coded visible signals to indicate specified functions.

1. Mounting: As directed, exposed, surface or recessed installation.
2. Enclosures: Fabricated from minimum 0.047-inch (1.2-mm) thick steel or minimum 0.05-inch (1.27-mm) thick aluminum, with knockouts for electrical and piping connections.

B. Components: As directed, designed for continuous service and to operate on power supplied from 120, 240 or 277-V ac power source to alarm panels and with connections for low-voltage wiring to remote sensing devices. Include step-down transformers if required.

C. Dew Point Monitors: Continuous line monitoring, having panel with gage or digital display, pipeline sensing element, electrical connections for alarm system, factory- or field-installed valved bypass, and visual and cancelable audio signal for dryer site and master alarm panels. Alarm signals when pressure dew point rises above 39 deg F (4 deg C) at 55 psig (380 kPa).

1. Operation: Chilled-mirror method or hygrometer moisture analyzer with sensor probe.

D. Pressure Switches or Transducer Sensors: Continuous line monitoring with electrical connections for alarm system.

1. Low-Pressure Operating Range: 0 to 100 psig (0 to 690 kPa).
2. High-Pressure Operating Range: Up to 250 psig (1725 kPa).

E. Carbon-Monoxide Monitors: Panel with gage or digital display, pipeline sensing element, electrical connections for alarm system, and factory- or field-installed valved bypass. Alarm signals when carbon-monoxide level rises above 10 ppm.

F. Vacuum Switches or Pressure Transducer Sensors: Continuous line monitoring with electrical connections for alarm system.

1. Vacuum Operating Range: 0 to 30 in. Hg (0 to 760 mm Hg).

2.4 MASTER ALARM PANELS

A. Master Alarm Panels: Separate trouble alarm signals and indicators for each system.

1. Standards: Comply with NFPA 99 and UL 544.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Include alarm signals when the following conditions exist:

a. Medical Air: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa), backup air compressor is in operation, pressure drop across filter assembly increases more than 2 psig (13.8 kPa), dew point rises above 39 deg F (4 deg C) at 55 psig (380 kPa), carbon-monoxide level rises above 10 ppm, and high water level is reached in receiver for liquid-ring, medical air compressor systems.
b. Instrument Air: Pressure drops below 165 psig (1140 kPa) or rises above 185 psig (1275 kPa).
c. Medical Vacuum: Vacuum drops below 12 in. Hg (305 mm Hg) and backup vacuum pump is in operation.
d. WAGD: Vacuum drops below 12 in. Hg (305 mm Hg).
e. Medical Nitrogen: Pressure drops below 145 psig (1000 kPa) or rises above 200 psig (1380 kPa) and changeover is made to alternate bank.
f. Medical Nitrous Oxide: Liquid level is low, pressure downstream from main shutoff valve drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa), changeover is made to reserve, reserve is in use, and reserve level is low.
g. Medical Nitrous Oxide: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa) and changeover is made to alternate bank.
h. Medical Oxygen: Liquid level is low, pressure downstream from main shutoff valve drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa), changeover is made to reserve, reserve is in use, reserve level is low, and reserve pressure is low.
i. Medical Oxygen: Pressure downstream from main shutoff valve drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa) and changeover is made to alternate bank.

2.5 ANESTHETIZING-AREA ALARM PANELS

A. Anesthetizing-Area Alarm Panels: Separate trouble alarm signals and indicators for each system.

1. Standards: Comply with NFPA 99 and UL 544.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

3. Include alarm signals when the following conditions exist:

    a. Medical Air: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa).
    b. Instrument Air: Pressure drops below 165 psig (1140 kPa) or rises above 185 psig (1275 kPa).
    c. Medical Vacuum: Vacuum drops below 12 in. Hg (305 mm Hg).
    d. WAGD: Vacuum drops below 12 in. Hg (305 mm Hg).
    e. Medical Nitrogen: Pressure drops below 145 psig (1000 kPa) or rises above 200 psig (1380 kPa).
    f. Medical Nitrous Oxide: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa).
    g. Medical Oxygen: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa).

2.6 AREA ALARM PANELS

A. Area Alarm Panels: Separate trouble alarm signals and indicators for each system.

1. Standards: Comply with NFPA 99 and UL 544.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Include alarm signals when the following condition exists:

    a. Medical Air: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa).
    b. Medical Vacuum: Vacuum drops below 12 in. Hg (305 mm Hg).
    c. Medical Oxygen: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa).

2.7 LOCAL ALARM PANELS

A. Local Alarm Panels: Separate trouble alarm signals and indicators for each system.

1. Standards: Comply with NFPA 99 and UL 544.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Include alarm signals when the following conditions exist:

    a. Medical Air: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa), backup air compressor is in operation, pressure drop across filter assembly increases more than 2 psig (13.8 kPa), dew point rises above 39 deg F (3.9 deg C) at 55 psig (380 kPa), carbon-monoxide level rises above 10 ppm, and the following:

        1) As directed, Oil-Free, Oilless or Oil-Free, Rotary-Screw Air Compressor: High discharge-air temperature and high water level in receiver.

2) Liquid-Ring Air Compressor: High water level in receiver and high water level in separator.

b. Instrument Air: Pressure drops below 165 psig (1140 kPa) or rises above 185 psig (1275 kPa), backup air compressor is in operation, pressure drop across filter assembly increases more than 2 psig (13.8 kPa), dew point rises above 39 deg F (3.9 deg C) at 55 psig (380 kPa), and high water level is in receiver.
c. Medical Vacuum: Vacuum drops below 12 in. Hg (305 mm Hg), backup vacuum producer is in operation, and high water level is in receiver.
d. WAGD: Vacuum drops below 12 in. Hg (305 mm Hg), backup vacuum producer is in operation, and high water level is in receiver.

PART 3 - EXECUTION

3.1 ALARM-PANEL INSTALLATION

A. Install alarm panels in locations required by and according to NFPA 99.

B. As directed, engage a factory-authorized service representative to perform or Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

C. Adjust initial alarm panel pressure and vacuum set points.

3.2 CONNECTIONS

A. Comply with requirements for piping specified in Section 226113 "Compressed-Air Piping for Laboratory and Healthcare Facilities," Section 226213 "Vacuum Piping for Laboratory and Healthcare Facilities," and Section 226313 "Gas Piping for Laboratory and Healthcare Facilities." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to alarm panels, allow space for service and maintenance.

3.3 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment" and according to NFPA 99.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: As directed, Owner will engage or Engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform each visual and mechanical inspection.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning panels and equipment.

C. Alarm panels will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain alarm panels.

END OF SECTION 226400

SECTION 226600 - CHEMICAL-WASTE SYSTEMS FOR LABORATORY AND HEALTHCARE FACILITIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Single-wall piping.
2. Piping specialties.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Delegated-Design Submittal: For seismic restraints of aboveground piping.

1. Include design calculations for selecting seismic restraints.

1.3 INFORMATIONAL SUBMITTALS

A. Profile Drawings for Outdoor Underground Piping: Show system piping in elevation. Draw profiles at horizontal scale of not less than 1-inch equals 50 feet (1:500) and vertical scale of not less than 1-inch equals 5 feet (1:50). Indicate underground structures and pipes. Show types, sizes, materials, and elevations of other utilities crossing system piping.

B. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, and coordinated with each other, using input from installers of the items involved:

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Single-Wall Piping Pressure Rating: 5-psig (34.5-kPa) air test pressure.

B. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design seismic restraints for aboveground piping.

2.2 SINGLE-WALL PIPE AND FITTINGS

A. PE Drainage Pipe and Fittings: Comply with ASTM D4976.

1. Pipe: ASTM F1412, Schedule 40.
2. Fittings: ASTM F1412, Schedule 40, socket-fusion, drainage pattern complying with ASTM D3311.

B. PP Drainage Pipe and Fittings: ASTM F1412 pipe extruded and drainage-pattern fittings molded, with Schedule 40 dimensions and with fire-retardant additive complying with ASTM D4101; As directed with fusion, fusion- and mechanical or mechanical-joint ends.

1. Exception: Pipe and fittings made from PP resin without fire-retardant additive may be used for underground installation.

C. PVC Drainage Pipe and Fittings: ASTM D2665 pipe and drainage-pattern fittings: As directed.

D. CPVC Drainage Pipe and Fittings: ASTM F2618 pipe and drainage-pattern fittings As directed.

E. PVDF Drainage Pipe and Fittings: ASTM F1673, Schedule 40, pipe and drainage-pattern fittings. Include fittings with fusion, fusion- and mechanical or mechanical-joint ends.

F. High-Silicon-Iron, Hub-and-Plain-End Pipe and Fittings: ASTM A861 pipe and drainage-pattern fittings, acid-resistant packing, and lead calking materials.

G. High-Silicon-Iron, Mechanical-Joint Pipe and Fittings: ASTM A861 pipe and drainage-pattern fittings, and stainless-steel clamps with TFE inner sleeve and chlorosulfonated polyethylene synthetic rubber outer sleeve.

H. Borosilicate Glass Pipe and Fittings: ASTM C1053, pipe and drainage-pattern fittings; with manufacturer's standard couplings.

1. Covering: Factory-applied polystyrene for pipe installed underground.

I. Adapters and Transition Fittings: Assemblies with combinations of clamps, couplings, adapters, and gaskets; compatible with piping and system liquid; made for joining different piping materials.

2.3 JOINING MATERIALS

A. Couplings: Assemblies with combinations of clamps, gaskets, sleeves, and threaded or flanged parts; compatible with piping and system liquid; and made by piping manufacturer for joining system piping.

B. Adapters and Transition Fittings: Assemblies with combinations of clamps, couplings, adapters, gaskets, and threaded or flanged parts; compatible with piping and system liquid; and made for joining different piping materials.

C. Flanges: Assemblies of companion flanges and gaskets complying with ASME B16.21 and compatible with system liquid, and bolts and nuts.

D. Solvent Cement for Joining PVC Piping: ASTM D2564. Include primer according to ASTM F656.

E. Solvent Cement for Joining CPVC Piping: ASTM F493. Include primer according to ASTM F656.

2.4 PIPING SPECIALTIES

A. Plastic Dilution Traps:

1. Material: Corrosion-resistant PP, with removable base.
2. End Connections: Mechanical joint.
3. Dilution Tanks: 1-gal. (3.8-L) capacity, with clear base unless colored base is indicated; with two NPS 1-1/2 (DN 40) top inlets and one NPS 1-1/2 (DN 40) side outlet.
4. Small Dilution Jars: 1-pint (0.5-L) capacity, with clear base unless colored base is indicated; with NPS 1-1/2 (DN 40) top inlet and NPS 1-1/2 (DN 40) side outlet.
5. Large Dilution Jars: 1-quart (1-L) capacity; with NPS 1-1/2 (DN 40) top inlet and NPS 1-1/2 (DN 40) side outlet.

B. High-Silicon-Iron Dilution Traps:

1. Standard: ASTM A861.
2. Size: NPS 1-1/2 or NPS 2 (DN 40 or DN 50) as required for fixture and waste.
3. End Connections: Mechanical.

C. Glass, Drain-Line, Interceptor Traps:

1. Standard: ASTM C1053.
2. Type: Drum trap.
3. Size: NPS 1-1/2 (DN 40), NPS 2 by NPS 1-1/2 (DN 50 by DN 40), or NPS 2 (DN 50), as required to match connecting piping.

D. Corrosion-Resistant Traps:

1. Type: P-trap or drum trap.
2. Size: NPS 1-1/2 or NPS 2 (DN 40 or DN 50), as required to match connected piping.
3. High-Silicon Iron: ASTM A861, with horizontal outlet and hub-and-plain or plain ends to match connecting piping.
4. PP: ASTM D4101, with mechanical-joint pipe connections.
5. PVDF: ASTM D3222, with mechanical-joint pipe connections.
6. Glass: ASTM C1053, with coupling pipe connections.

E. High-Silicon-Iron Floor Drains:

1. Standard: ASTM A861.
2. Body: With integral flashing flange and weep holes; and with flashing ring and stainless-steel strip, sediment basin and funnel attachment.
3. Top: 8-3/4-inch (222-mm) diameter with grate.
4. Size: NPS 2, NPS 3, NPS 4, or NPS 6 (DN 50, DN 80, DN 100, or DN 150) outlet as indicated.

F. Stainless-Steel Floor Drains:

1. Standard: ASME A112.3.1, ASTM A666, Type 316L.
2. Body: With 8.5-by-8.5-inch (215-by-215-mm) or 12.4-by-12.4-inch (315-by-315-mm) top with grate.
3. Outlet: Bottom, of size indicated.

G. PP Floor Drains:

1. Body: With 7- to 9-inch (178- to 230-mm) top diameter, with flashing flange and weep holes; and with flashing clamp, basket strainer, funnel attachment and trap-primer connection, as directed.
2. Outlet: Bottom, to match connecting pipe, with NPS 2, NPS 3, NPS 4, or NPS 6 (DN 50, DN 80, DN 100, or DN 150) outlet as indicated.

H. High-Silicon-Iron Cleanouts:

1. Standard: ASTM A861 fitting with PTFE gasket and closure plug, of design appropriate for piping application.

I. Stainless-Steel Cleanouts:

1. Standard: ASME A112.3.1, ASTM A666, Type 316L stainless steel.
2. Aboveground Piping: Cleanout tee of size matching piping.
3. Underground and Underslab Piping: Floor access cleanout of size matching piping.

J. High-Silicon-Iron Backwater Valves:

1. Description: Body: Hub-and-plain end with swing-check valve; and with high-silicon-iron pipe extension of length to reach floor surface, and high-silicon-iron closure plug.

2. Standard: ASTM A861.

K. Plastic Backwater Valves:

1. Description: Full-port NPS 3 (DN 80) check valve, PP or PVDF, matching or compatible with system piping and compatible with system liquid, with EPDM seals and flanged ends.

    a. Exception: PVC material for use with PVC piping systems.

L. High-Silicon-Iron Sink Outlets:

1. Description: NPS 1-1/2 (DN 40), with clamping device and 4-, 6-, or 8-inch- (100-, 150-, or 200-mm-) high overflow fitting, as indicated.

2. Standard: ASTM A861 high-silicon iron.

M. PP Sink Outlets:

1. Description: NPS 1-1/2 (DN 40), with clamping device, stopper, and 7-inch- (178-mm-) high overflow fitting.

N. Glass Sink Outlets: As directed.

O. Description: NPS 1-1/2 (DN 40); with sink assembly of outlet, strainer, gasket, and locknut; overflow fitting of length indicated; and tailpiece assembly of borosilicate glass and locknut.

1. Standard: ASTM C1053 components for field assembly.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING INSTALLATION

A. Chemical-Waste Sewerage Outside the Building:

1. Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground chemical-waste sewerage piping. Location and arrangement of piping layout take design considerations into account. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.
2. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for using lubricants, cements, and other installation requirements.
3. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.
4. Tunneling: Install pipe under streets or other obstructions that cannot be disturbed by tunneling, jacking, or combination of both.
5. Install drainage piping pitched down in direction of flow, at minimum slope of 1 or 2 percent unless otherwise indicated.
6. As directed Install drainage piping with 36-inch (900-mm), 48-inch (1200-mm), 60-inch (1500-mm) or 72-inch (1800-mm) minimum cover.
7. Install PE drainage piping according to ASTM D2321 and ASTM F1668.
8. Install PVC drainage piping according to ASTM D2321 and ASTM F1668.
9. Install CPVC drainage piping according to ASTM D2321 and ASTM F1668.
10. Install PVDF drainage piping according to ASTM D2321 and ASTM F1668.

11. Clear interior of piping and structures of dirt and superfluous material as work progresses. Maintain a swab or drag inside piping and pull past each joint as it is completed. Place plug in end of incomplete piping at end of day and when work stops.

B. Chemical-Waste Piping Inside the Building:

1. Install piping next to equipment, accessories, and specialties to allow service and maintenance.
2. Transition and special fittings with pressure ratings at least equal to piping pressure rating may be used unless otherwise indicated.
3. Flanges may be used on aboveground piping unless otherwise indicated.
4. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
5. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
6. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
7. Install piping at indicated slopes.
8. Install piping free of sags and bends.
9. Install fittings for changes in direction and branch connections.
10. Verify final equipment locations for roughing-in.
11. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
12. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
13. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 PIPING SPECIALTY INSTALLATION

A. Embed floor drains in 4-inch (100-mm) minimum depth of concrete around bottom and sides. Comply with requirements in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" for concrete As directed.

B. Fasten grates to drains if indicated.

C. Set floor drains with tops flush with pavement surface.

D. Install cleanouts and riser extension from sewer pipe to cleanout at grade. Use fittings of same material as sewer pipe at branches for cleanouts and riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in pipe.

1. Set cleanout bodies in earth in cast-in-place concrete block, 18 by 18 by 12 inches (450 by 450 by 300 mm) deep. Set with tops 1 inch (25 mm) above surrounding grade. Set cleanout plugs in concrete pavement, with tops flush with pavement surface. Comply

with requirements in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" for formwork, reinforcement, and concrete requirements, as directed.

E. Install backwater valves in horizontal position. Include riser to cleanout at grade.

3.4 JOINT CONSTRUCTION

A. Chemical-Waste Sewerage Outside the Building:

1. Plastic-Piping Fusion Joints: Make PP drainage-piping joints according to ASTM F1290.
2. Join dissimilar pipe materials with adapters compatible with pipe materials being joined.
3. Join high-silicon-iron, hub-and-plain-end piping with calked joints using acid-resistant packing and lead.
4. Join high-silicon-iron, mechanical-joint piping with coupled joints using clamps and sleeves.
5. PVC Non-pressure Piping Joints: Join piping according to ASTM D2665.

B. Chemical-Waste Piping Inside the Building:

1. Plastic-Piping Fusion Joints: Make PP drainage-piping joints according to ASTM F1290.
2. Dissimilar-Material Piping Joints: Make joints using adapters compatible with both system materials.
3. Join high-silicon-iron, hub-and-plain-end piping with calked joints, using acid-resistant packing and lead.
4. Join high-silicon-iron, mechanical-joint piping with coupled joints, using clamps and sleeves.
5. PVC Non-pressure Piping Joints: Join piping according to ASTM D2665.

3.5 HANGER AND SUPPORT INSTALLATION

A. Pipe sizes in this article refer to aboveground single-wall piping and carrier piping of containment piping.

B. Comply with requirements in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.

C. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices. Install the following:

1. Vertical Piping: MSS Type 8 or MSS Type 42 riser clamps.
2. Individual, Straight, Horizontal Piping Runs:

    a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
    b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
    c. Longer Than 100 Feet (30 m), if Indicated: MSS Type 49, spring cushion rolls.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.

4. Base of Vertical Piping: MSS Type 52 spring hangers.

D. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for installation of supports.

E. Support horizontal piping and tubing within 12 inches (300 mm) of each fitting and coupling.

F. Support vertical piping and tubing at base and at each floor.

G. Rod diameter may be reduced one size for double-rod hangers, to minimum of 3/8 inch (10 mm).

H. Install vinyl-coated hangers for PP piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 2 (DN 50): 33 inches (840 mm) with 3/8-inch (10-mm) rod.
2. NPS 2-1/2 and NPS 3 (DN 65 and DN 80): 42 inches (1067 mm) with 1/2-inch (13-mm) rod.
3. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1220 mm) with 5/8-inch (16-mm) rod.
4. NPS 6 (DN 150): 48 inches (1220 mm) with 3/4-inch (19-mm) rod.
5. NPS 8 (DN 200): 48 inches (1220 mm) with 7/8-inch (22-mm) rod.

I. Install supports for vertical PP piping every 72 inches (1830 mm).

J. Install vinyl-coated hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4 (DN 32): 36 inches (910 mm) with 3/8-inch (10-mm) rod.
2. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 42 inches (1070 mm) with 3/8-inch (10-mm) rod.
3. NPS 2-1/2 and NPS 3 (DN 65 and DN 80): 42 inches (1070 mm) with 1/2-inch (13-mm) rod.
4. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1220 mm) with 5/8-inch (16-mm) rod.
5. NPS 6 (DN 150): 48 inches (1220 mm) with 3/4-inch (19-mm) rod.
6. NPS 8 to NPS 12 (DN 200 to DN 300): 48 inches (1220 mm) with 7/8-inch (22-mm) rod.

K. Install supports for vertical PVC piping every 48 inches (1220 mm).

L. Install vinyl-coated hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 36 inches (910 mm) with 3/8-inch (10-mm) rod.
2. NPS 2-1/2 and NPS 3 (DN 65 and DN 80): 42 inches (1070 mm) with 1/2-inch (13-mm) rod.
3. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1220 mm) with 5/8-inch (16-mm) rod.
4. NPS 6 (DN 150): 48 inches (1220 mm) with 3/4-inch (19-mm) rod.
5. NPS 8 to NPS 12 (DN 200 to DN 300): 48 inches (1220 mm) with 7/8-inch (22-mm) rod.

M. Install supports for vertical PVC piping every 48 inches (1220 mm).

N. Install supports for vertical CPVC piping every 48 inches (1220 mm).

O. Install vinyl-coated hangers for PVDF piping with the following maximum horizontal spacing and minimum rod diameters:

1. All Sizes: Install continuous support for piping with liquid waste at temperatures above 140 deg F (60 deg C).
2. NPS 1/2 (DN 15) and Smaller: 30 inches (760 mm) with 3/8-inch (10-mm) rod.
3. NPS 3/4 to NPS 1-1/2 (DN 20 to DN 40): 36 inches (910 mm) with 3/8-inch (10-mm) rod.
4. NPS 2 (DN 50): 36 inches (910 mm) with 3/8-inch (10-mm) rod.
5. NPS 2-1/2 and NPS 3 (DN 65 and DN 80): 42 inches (1070 mm) with 1/2-inch (13-mm) rod.
6. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1220 mm) with 5/8-inch (16-mm) rod.
7. NPS 6 (DN 150): 48 inches (1220 mm) with 3/4-inch (19-mm) rod.

P. Install supports for vertical PVDF piping NPS 1-1/2 (DN 40) every 48 inches (1220 mm) and NPS 2 (DN 50) and larger every 72 inches (1830 mm).

Q. Install hangers for high-silicon-iron piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 60 inches (1520 mm) with 3/8-inch (10-mm) rod.
2. NPS 3 (DN 80): 60 inches (1520 mm) with 1/2-inch (13-mm) rod.
3. NPS 4 and NPS 5 (DN 100 and DN 125): 60 inches (1520 mm) with 5/8-inch (16-mm) rod.
4. NPS 6 (DN 150): 60 inches (1520 mm) with 3/4-inch (19-mm) rod.
5. NPS 8 to NPS 12 (DN 200 to DN 300): 60 inches (1520 mm) with 7/8-inch (22-mm) rod.
6. NPS 15 (DN 375): 60 inches (1520 mm) with 1-inch (25-mm) rod.
7. Spacing for horizontal pipe in 84-inch (2130-mm) lengths may be increased to 84 inches (2130 mm). Spacing for fittings is limited to 60 inches (1520 mm).

R. Install supports for vertical high-silicon-iron piping every 15 feet (4.5 m).

S. Install vinyl-coated hangers for glass piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1 and NPS 1-1/4 (DN 25 and DN 32): 72 inches (1830 mm) with 3/8-inch (10-mm) rod.
2. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2440 mm) with 3/8-inch (10-mm) rod.
3. NPS 3 (DN 80): 96 inches (2440 mm) with 1/2-inch (13-mm) rod.
4. NPS 4 and NPS 6 (DN 100 and DN 150): 96 inches (2440 mm) with 5/8-inch (16-mm) rod.

T. Install supports for vertical glass piping every 96 inches (2440 mm).

U. Support piping and tubing not listed above according to MSS SP-58.

3.6 CONCRETE PLACEMENT

A. Comply with requirements in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" for concrete supports As directed.

B. Place cast-in-place concrete according to ACI 318/318R.

3.7 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Make connections to existing piping, so finished Work complies as nearly as practical with requirements specified for new Work.

C. Use commercially manufactured wye fittings for sewerage piping branch connections. Remove section of existing pipe; install wye fitting into existing piping; and encase entire wye fitting plus 6-inch (150-mm) overlap, with not less than 6 inches (150 mm) of concrete with 28-day compressive strength of 3000 psi (20.7 MPa).

D. Protect existing piping to prevent concrete or debris from entering while making connections. Remove debris or other extraneous material that may accumulate.

E. Install piping adjacent to equipment to allow service and maintenance.

3.8 LABELING AND IDENTIFICATION

A. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment" for labeling of equipment and piping.

1. Use warning tape or detectable warning tape over ferrous piping.
2. Use detectable warning tape over nonferrous piping and over edges of underground structures.

3.9 FIELD QUALITY CONTROL

A. Inspect interior of sewerage piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches (610 mm) of backfill is in place and again at completion of Project.

1. Defects requiring correction include the following:

a. Alignment: Less than full diameter of inside of pipe is visible between inspection points.
b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
c. Crushed, broken, cracked, or otherwise damaged piping.

d. Hydrostatic Tests for Drainage Piping:

1) Allowable leakage is a maximum of 50 gal./inch of nominal pipe size per mile (4.6 L/mm of nominal pipe size per kilometer) of pipe during 24-hour period.
2) Close openings in system and fill with water.
3) Purge air and refill with water.
4) Disconnect water supply.
5) Test and inspect joints for leaks.

e. Air Tests for Drainage Piping: Comply with UNI-B-6.

2. Leaks and loss in test pressure constitute defects that must be repaired.
3. Submit separate reports for each test.

B. Replace leaking sewerage piping using new materials, and repeat testing until leakage is within allowances specified.

C. Chemical-waste piping will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.10 CLEANING

A. Use procedures prescribed by authorities having jurisdiction or, if not prescribed, use procedures described below:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Clean piping by flushing with potable water.

3.11 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping pressure rating may be used in applications below unless otherwise indicated.

B. Single-Wall, Chemical-Waste Sewerage Piping: Use any of the following piping materials for each size range:

1. NPS 2 to NPS 4 (DN 50 to DN 100): High-silicon-iron, hub-and-plain-end pipe and fittings and calked or High-silicon-iron, mechanical-joint pipe and fittings and coupled joints.
2. NPS 1-1/2 to NPS 4 (DN 40 to DN 100): PE drainage pipe and fittings and fusion joints.
3. NPS 1-1/2 to NPS 4 (DN 40 to DN 100): PP drainage pipe and fittings and fusion joints.
4. NPS 1-1/2 to NPS 4 (DN 40 to DN 100): PVC drainage pipe and fittings and solvent-cemented joints.
5. NPS 1-1/2 to NPS 4 (DN 40 to DN 100): CPVC drainage pipe and fittings and solvent-cemented joints.

6. NPS 1-1/2 to NPS 4 (DN 40 to DN 100): PVDF drainage pipe and fittings and fusion joints.
7. NPS 1-1/2 to NPS 4 (DN 40 to DN 100): Glass pipe and fittings and coupled joints.
8. NPS 6 (DN 150): High-silicon-iron, hub-and-plain-end pipe and fittings and calked or High-silicon-iron, mechanical-joint pipe and fittings and coupled joints.
9. NPS 6 (DN 150): PE drainage pipe and fittings and fusion joints.
10. NPS 6 (DN 150): PP drainage pipe and fittings and fusion joints.
11. NPS 6 (DN 150): PVC drainage pipe and fittings and solvent-cemented joints.
12. NPS 6 (DN 150): PVDF drainage pipe and fittings and fusion joints.
13. NPS 6 (DN 150): Glass pipe and fittings and coupled joints.

C. Aboveground Chemical-Waste Piping: Use any of the following piping materials for each size range:

1. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): PP drainage piping and fusion or mechanical joints As directed.
2. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): PVC drainage piping and solvent-cemented joints.
3. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): CPVC drainage piping and solvent-cemented joints.
4. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): PVDF drainage piping and fusion or mechanical joints As directed.
5. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): Use NPS 2 to NPS 6 (DN 50 to DN 150) high-silicon-iron piping with hub-and-plain ends and calked joints.
6. NPS 1-1/2 to NPS 4 (DN 40 to DN 100): High-silicon-iron piping with mechanical-joint ends, mechanical couplings, and coupled joints.
7. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): Borosilicate glass pipe and fittings, couplings, and coupled joints.

D. Under Slab-on-Grade, Indoor, Chemical-Waste Piping: Use any of the following piping materials for each size range:

1. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): PP drainage piping and fusion joints.
2. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): PVC drainage piping and solvent-cemented joints.
3. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): PVC drainage piping and solvent-cemented joints.
4. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): PVDF drainage piping and fusion joints.
5. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): NPS 2 to NPS 4 (DN 50 to DN 100) high-silicon-iron piping with hub-and-plain ends and calked joints.
6. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): Borosilicate glass piping with covering, couplings, and coupled joints.

END OF SECTION 226600

SECTION 226700 - PROCESSED WATER SYSTEMS FOR LABORATORY AND HEALTHCARE FACILITIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes reagent-water, deionized-water, distilled-water and reverse-osmosis-water piping, fittings, and valves.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: For water piping, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Detailed description of piping anchorage devices on which the certification is based and their installation requirements.

B. Welding certificates.

C. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. ASME Compliance: Comply with ASME B31.3 for piping conveying fluid at a pressure of 15 psig (105 kPa) or greater.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Minimum Working Pressure Ratings:

1. Reagent-Water Piping: As directed 20 psig (138 kPa), 40 psig (276 kPa), 50 psig (345 kPa) or 100 psig (690 kPa) unless otherwise indicated.
2. Deionized-Water Piping: 50 psig (345 kPa), 100 psig (690 kPa) or 150 psig (1035 kPa) unless otherwise indicated.
3. Distilled-Water Piping: 50 psig (345 kPa), 100 psig (690 kPa) or 150 psig (1035 kPa) unless otherwise indicated.
4. Reverse-Osmosis Water Piping: As directed 50 psig (345 kPa), 100 psig (690 kPa) or 150 psig (1035 kPa) unless otherwise indicated.

B. Seismic Performance: Water piping shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the piping system will remain in place without separation of any parts when subjected to the seismic forces specified and the piping system will be fully operational after the seismic event."
2. Component Importance Factor: As directed 1.5 or 1.0.

2.2 PLASTIC PIPE AND FITTINGS

A. Standards: Comply with NSF 14, NSF 61, and NSF 372.

B. CPVC Pipe and Fittings, Schedule 40: ASTM F441/F441M pipe; with plain ends for solvent-cemented joints and ASTM F438 socket-type fittings.

C. Solvent Cements for Joining CPVC Piping and Tubing: ASTM F493.
1.

D. PP Pipe and Fittings for Heat-Fusion Joints: Made from ASTM D4101, PP resin.

E. PP Pipe and Fittings, Schedule 40: Schedule 40 or SDR 11 dimensions; with socket- or butt-fusion fittings matching pipe dimensions.

F. PP Pipe and Fittings for Electro-Fusion Joints: Made from ASTM D4101, PP resin.
1. PP Pipe and Fittings, Schedule 80: Schedule 80 or SDR dimensions; with socket fittings matching pipe dimensions.
2. Electro-Fusion Fitting: Electrical-resistance heating coil for PP piping joints.

G. PVC Pipe and Fittings, Schedule 40: ASTM D1785 pipe; with plain ends for solvent-cemented joints and ASTM D2466, socket-type fittings.

H. Solvent Cements for Joining PVC Piping: ASTM D2564. Include primer according to ASTM F656.
1.

I. PVDF Pipe and Fittings: Made from ASTM D3222, PVDF resin.
1. PVDF Pipe and Fittings, Schedule 40: Schedule 40 or SDR 11 dimensions; with socket- or butt-fusion fittings matching pipe dimensions.

2.3 TRANSITION FITTINGS

A. Couplings, flanges, or other manufactured fittings; same size as, with pressure rating at least equal to, and ends compatible with piping to be joined.

2.4 CPVC VALVES

A. CPVC Ball Valves:
   1. Description:

      a. Standards: Comply with MSS SP-122 and ASTM F1970.
      b. Pressure Rating: 150 psig (1035 kPa) at 73 deg F (23 deg C).
      c. Body Material: ASTM D1784 CPVC compound.
      d. Body Design: Union type.
      e. End Connections: Detachable, socket.
      f. Ball: ASTM D1784 CPVC compound.
      g. Port: Full.
      h. Seats: PTFE.
      i. Stem: ASTM D1784 CPVC compound.
      j. Stem Seals: As directed EPDM or FKM-rubber O-rings.
      k. Handle: Tee shaped.

B. CPVC Ball-Check Valves:
   1. Description:

      a. Standard: Comply with ASTM F1970.
      b. Pressure Rating: 150 psig (1035 kPa) at 73 deg F (23 deg C).
      c. Body Material: ASTM D1784 CPVC compound.
      d. Body Design: Union type.
      e. End Connections: Detachable, socket.
      f. Ball: ASTM D1784 CPVC compound.
      g. Seat and Seals: EPDM or FKM-rubber O-rings.

2.5 PP VALVES

A. PP Ball Valves:
   1. Description:

      a. Standard: MSS SP-122.
      b. Pressure Rating: 150 psig (1035 kPa) at 73 deg F (23 deg C).
      c. Body Material: ASTM D4101 PP resin.
      d. Body Design: Union type.
      e. End Connections: Detachable, butt or socket.
      f. Ball: ASTM D4101 PP resin.
      g. Port: Full.
      h. Seats: PTFE.
      i. Stem: ASTM D4101 PP resin.
      j. Stem Seals: FKM-rubber O-rings.
      k. Handle: Tee shaped.

B. PP Ball-Check Valves:
1. Description:

a. Pressure Rating: 150 psig (1035 kPa) at 73 deg F (23 deg C).
b. Body Material: ASTM D4101 PP resin.
c. Body Design: Union type.
d. End Connections: Detachable, socket.
e. Ball: ASTM D4101 PP resin.
f. Seat and Seals: FKM-rubber O-rings.

2.6 PVC VALVES

A. PVC Ball Valves:
1. Description:

a. Standards: Comply with MSS SP-122 and ASTM F1970.
b. Pressure Rating: 150 psig (1035 kPa) at 73 deg F (23 deg C).
c. Body Material: ASTM D1784 PVC compound.
d. Body Design: Union type.
e. End Connections: Detachable, socket.
f. Ball: ASTM D1784 PVC compound.
g. Port: Full.
h. Seats: PTFE.
i. Stem: ASTM D1784 PVC compound.
j. Seals: As directed EPDM or FKM-rubber O-rings.
k. Handle: Tee shaped.

B. PVC Ball-Check Valves:
1. Description:

a. Standard: Comply with ASTM F1970.
b. Pressure Rating: 150 psig (1035 kPa) at 73 deg F (23 deg C).
c. Body Material: ASTM D1784 PVC compound.
d. Body Design: Union type.
e. End Connections: Detachable, socket.
f. Ball: ASTM D1784 PVC compound.
g. Seat and Seals: EPDM or FKM-rubber O-rings.

2.7 PVDF VALVES

A. PVDF Ball Valves:
1. Description:

a. Standard: MSS SP-122.
b. Pressure Rating: 150 psig (1035 kPa) at 73 deg F (23 deg C).
c. Body Material: ASTM D3222 PVDF resin.
d. Body Design: Union type.
e. End Connections: Detachable, butt or socket.
f. Ball: ASTM D3222 PVDF resin.

g. Port: Full.
h. Seats: PTFE.
i. Stem: ASTM D3222 PVDF resin.
j. Stem Seals: FKM-rubber O-rings.
k. Handle: Tee shaped.

B. PVDF Ball-Check Valves:
1. Description:

a. Pressure Rating: 150 psig (1035 kPa) at 73 deg F (23 deg C).
b. Body Material: ASTM D3222 PVDF resin.
c. Body Design: Union type.
d. End Connections: Detachable, socket.
e. Ball: ASTM D3222 PVDF resin.
f. Seat and Seals: FKM-rubber O-rings.

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPING

A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of water piping. Location and arrangement of piping layout take design considerations into account. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.

B. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

C. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for removal of ceiling panel, and coordinate with other services occupying that space.

F. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

G. Install piping to permit valve servicing.

H. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than system pressure ratings unless otherwise indicated.

I. Install piping free of sags and bends.

J. Install fittings for changes in direction and branch connections.

K. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

L. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

M. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.2 JOINT CONSTRUCTION

A. Where specific joint construction is not indicated, follow piping manufacturer's written instructions.

B. CPVC Piping Solvent-Cemented Joints: Comply with ASTM F402 for handling solvent cements, primers, and cleaners; make joints according to ASTM D2846/D2846M Appendix.

C. PP Piping Electro-Fusion Joints: Make according to ASTM F1290.

D. PP Piping Heat-Fusion Joints: Make according to ASTM D2657.

E. PVC Piping Solvent-Cemented Joints: Comply with ASTM F402 for handling solvent cements, primers, and cleaners; make joints according to ASTM D2672.

F. PVDF Piping Heat-Fusion Joints: Make according to ASTM D2657.

G. Join dissimilar pipe materials with transition fittings compatible with pipe materials being joined.

3.3 INSTALLATION OF VALVES

A. Install sectional valves close to mains on each branch and riser serving equipment.

B. Install shutoff valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

C. Locate valves for easy access and provide separate support where necessary.

D. Install valves of same size as the pipe or tube in which they are installed unless otherwise indicated.

E. Install plastic valves of the same material as the plastic pipe in which they are installed.

F. Install valves in horizontal piping with stem at or above center of pipe.

G. Install valves in position to allow full movement of stem and lever handle.

3.4 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Comply with requirements for pipe hanger and support devices and installation specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
2. Install stainless steel or fiberglass pipe hangers for horizontal piping in corrosive environments.
3. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
4. Install stainless steel pipe support clamps for vertical piping in corrosive environments.
5. Clamps for Vertical Piping: MSS Type 8 or Type 42.
6. Individual, Straight, Horizontal Piping Runs:

    a. 100 Feet (30 m) and Less: MSS Type 1 adjustable clevis hangers.
    b. Longer Than 100 Feet (30 m): MSS Type 43 adjustable roller hangers.
    c. Longer Than 100 Feet (30 m) if Indicated: MSS Type 49 spring cushion rolls.

7. Multiple, Straight, Horizontal Piping Runs, 100 Feet (30 m) or Longer: MSS Type 44 pipe rolls. Support pipe rolls on trapeze.
8. Base of Vertical Piping: MSS Type 52 spring hangers.

C. Support horizontal piping and tubing within 12 inches (300 mm) of each fitting, valve, and coupling.

D. Support vertical piping and tubing at base and at each floor.

E. Rod diameter may be reduced one size for double-rod hangers, to minimum 3/8 inch (10 mm).

F. Install padded hangers for CPVC piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1 (DN 25) and Smaller: 36 inches (900 mm) with 3/8-inch (10-mm) rod.
2. NPS 1-1/4 to NPS 2 (DN 32 to DN 50): 48 inches (1200 mm) with 3/8-inch (10-mm) rod.
3. NPS 2-1/2 and NPS 3 (DN 65 and DN 80): 48 inches (1200 mm) with 1/2-inch (13-mm) rod.

G. Install padded supports for vertical CPVC piping NPS 2-1/2 (DN 65) and larger every 120 inches (3000 mm) and midstory for NPS 2 (DN 50) and smaller.

H. Install padded hangers for PP piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1 (DN 25) and Smaller: 32 inches (813 mm) with 3/8-inch (10-mm) rod.
2. NPS 1-1/4 to NPS 2 (DN 32 to DN 50): 48 inches (1200 mm) with 3/8-inch (10-mm) rod.
3. NPS 2-1/2 and NPS 3 (DN 65 and DN 80): 48 inches (1200 mm) with 1/2-inch (13-mm) rod.

I. Install padded supports for vertical PP piping NPS 2-1/2 (DN 65) and larger every 120 inches (3000 mm) and midstory for NPS 2 (DN 50) and smaller.

J. Install padded hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 2 (DN 50) and Smaller: 48 inches (1200 mm) with 3/8-inch (10-mm) rod.
2. NPS 2-1/2 and NPS 3 (DN 65 and DN 80): 48 inches (1200 mm) with 1/2-inch (13-mm) rod.

K. Install padded supports for vertical PVC piping NPS 2-1/2 (DN 65) and larger every 120 inches (3000 mm) and midstory for NPS 2 (DN 50) and smaller.

L. Install padded hangers for PVDF piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1 (DN 25) and Smaller: 30 inches (750 mm) with 3/8-inch (10-mm) rod.
2. NPS 1-1/4 (DN 32): 33 inches (840 mm) with 3/8-inch (10-mm) rod.
3. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 36 inches (900 mm) with 3/8-inch (10-mm) rod.
4. NPS 2-1/2 and NPS 3 (DN 65 and DN 80): 48 inches (1200 mm) with 1/2-inch (13-mm) rod.

M. Install padded supports for vertical PVDF piping NPS 2-1/2 (DN 65) and larger every 120 inches (3000 mm) and midstory for NPS 2 (DN 50) and smaller.

N. Install padded hangers for glass piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1 and NPS 1-1/4 (DN 25 and DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
2. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
3. NPS 3 (DN 80): 96 inches (2400 mm) with 1/2-inch (13-mm) rod.

O. Install padded supports for vertical glass piping every 96 inches (2400 mm).

P. Install hangers for stainless steel tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1 and NPS 1-1/4 (DN 25 and DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
2. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
3. NPS 2-1/2 (DN 65): 108 inches (2700 mm) with 1/2-inch (13-mm) rod.
4. NPS 3 (DN 80): 10 feet (3 m) with 1/2-inch (13-mm) rod.

Q. Install supports for vertical stainless steel tubing every 10 feet (3 m).

R. Support piping and tubing not listed above according to MSS SP-58 and manufacturer's written instructions.

3.5 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

C. As directed Connect deionized-water, distilled-water and reverse-osmosis-water piping to equipment and service outlets with unions or flanges.

3.6 IDENTIFICATION

A. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Tests and Inspections:

1. Test new piping, and parts of existing piping that have been altered, extended, or repaired, for leaks and defects.
2. Schedule tests and their inspections by authorities having jurisdiction or Owner, with at least 24 hours' advance notice.
3. Do not cover piping or put into service before inspection and approval by the authorities having jurisdiction, engineer or Owner.
4. As directed Test completed piping according to authorities having jurisdiction or Owner. As directed If authorities having jurisdiction do or Owner does not have published procedures, perform tests as follows:

    a. Hydrostatic Tests: Test piping at pressure of not less than 1-1/2 times the maximum system operating pressure, but not less than 50 psig (345 kPa), 100 psig (690 kPa) or 150 psig (1035 kPa). As directed Hold test for two or four hours; pressure shall remain constant without pumping. Inspect system to determine visible leaks or significant pressure variations.

        1) Exception: Do not subject glass piping to pressure above manufacturer's pressure rating for size.

5. If piping does not pass the test, replace leaking joints with new materials and retest until no leaks exist.
6. Submit separate reports for each test.

E. Processed water system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.8 CLEANING OF PIPING SERVING HEALTHCARE

A. Use procedures prescribed by authorities having jurisdiction or Owner or, if not prescribed, use procedures described below:

1. Cleaning of system as indicated or according to AWWA-C601.
2. Before using, purge new piping and parts of existing piping that have been altered, extended, or repaired.
3. Remove flow indicators and flow-measuring devices before flushing. Replace after cleaning is completed.
4. As directed Clean piping by flushing at a sufficient velocity and quantity to dislodge sediment or dirt with reagent, deionized, distilled and reverse-osmosis water mixture throughout the system.
5. After flushing, introduce chlorine or chlorine compound into the system with a dosage sufficient to give an initial residual chlorine content of 50 ppm.
6. Open and close valves several times to collect samples from various fixtures throughout the system during introduction of chlorine, to assure uniform distribution.
7. After 12- or 24-hour contact period, flush chlorinated water from system.
8. As directed After flushing, provide evidence of effectiveness of disinfection by filing a report of bacteriological tests on samples taken from the system with the engineer, Owner or authorities having jurisdiction. The report shall include the number and locations of where the samples where taken.
9. If satisfaction is not achieved, repeat the above disinfection process until satisfactory results are obtained. And do not put the system online until this has been obtained.

3.9 CLEANING OF PIPING SERVING LABORATORIES

A. As directed Use procedures prescribed by authorities having jurisdiction or Owner or, if not prescribed, use procedures described below:

1. Before using, purge new piping and parts of existing piping that have been altered, extended, or repaired.
2. Remove flow indicators and flow-measuring devices before flushing. Replace after cleaning is completed.
3. Provide storage tank(s), heat exchanger(s) and pumping system(s) required for cleaning.
4. As directed Clean piping by pumping at a sufficient velocity and quantity to dislodge sediment or dirt with sodium hypochlorite and deionized, distilled and reverse-osmosis water mixture throughout the system.
5. As directed Open all taps until cleaning solution is detected, then close taps. Retain solution in the system at least three or four hours.

B. As directed At the end of the retention period, open all faucets and taps to thoroughly flush with clean reagent, deionized, distilled and reverse-osmosis water until solution is drained from the system.

3.10 PIPING APPLICATION

A. Transition and special fittings with pressure ratings at least equal to piping, and of same or compatible material, may be used in applications below.

B. Pipe fittings shall be the same material as the piping to which it is connected.

C. Reagent-Water Piping: Use any of the following piping materials for each pipe size range:

1. Pipe Sizes NPS 2 (DN 50) and Smaller: Schedule 40, CPVC pipe and fittings and solvent-cemented joints.
2. Pipe Sizes NPS 2 (DN 50) and Smaller: PP pipe and fittings and heat-fusion joints.
3. Pipe Sizes NPS 2 (DN 50) and Smaller: PP pipe and fittings and electro-fusion joints.
4. Pipe Sizes NPS 2 (DN 50) and Smaller: Schedule 40, PVC pipe and fittings and solvent-cemented joints.
5. Pipe Sizes NPS 2 (DN 50) and Smaller: PVDF pipe and fittings and heat-fusion joints.

D. Deionized-Water Piping: Use any of the following piping materials for each pipe size range:

1. NPS 2 (DN 50) and Smaller: PP pipe and fittings and heat-fusion joints.
2. NPS 2 (DN 50) and Smaller: PP pipe and fittings and electro-fusion joints.
3. NPS 2 (DN 50) and Smaller: PVDF pipe and fittings and heat-fusion joints.

E. Distilled-Water Piping: Use any of the following piping materials for each pipe size range:

1. NPS 2 (DN 50) and Smaller: PP pipe and fittings and heat-fusion joints.
2. NPS 2 (DN 50) and Smaller: PP pipe and fittings and electro-fusion joints.
3. NPS 2 (DN 50) and Smaller: PVDF pipe and fittings and heat-fusion joints.

F. Reverse-Osmosis-Water Piping: Use any of the following piping materials for each pipe size range:

1. NPS 2 (DN 50) and Smaller: PP pipe and fittings and heat-fusion joints.
2. NPS 2 (DN 50) and Smaller: PP pipe and fittings and electro-fusion joints.
3. NPS 3 (DN 80) and Smaller: PVDF pipe and fittings and heat-fusion joints.

3.11 VALVE SCHEDULE

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

1. Valves shall be the same material as the piping to which they are connected.
2. Shutoff Duty: Install ball valves in piping NPS 2 (DN 50) and smaller.
3. Throttling Duty: Install ball valves in piping NPS 2 (DN 50) and smaller.

END OF SECTION 226700

SECTION 230130.52 - EXISTING HVAC AIR DISTRIBUTION SYSTEM CLEANING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes cleaning existing HVAC air-distribution equipment, ducts, plenums, and system components.

1.2 DEFINITIONS

A. ACAC: American Council for Accredited Certification.

B. AIHA-LAP: American Industrial Hygiene Association Lab Accreditation Program

C. ASCS: Air systems cleaning specialist.

D. CESB: Council of Engineering and Scientific Specialty Boards.

E. CMI: Certified Microbial Investigator.

F. CMC: Certified Microbial Consultant.

G. CMR: Certified Microbial Remediator.

H. CMRS: Certified Microbial Remediation Supervisor.

I. EMLAP: Environmental Microbiology Laboratory Accreditation Program.

J. IEP: Indoor Environmental Professional.

K. IICRC: Institute of Inspection, Cleaning, and Restoration Certification.

L. NADCA: National Air Duct Cleaners Association.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. ASCS Qualifications: A certified member of NADCA.

1. Certification: Employ an ASCS certified by NADCA on a full-time basis.
2. Supervisor Qualifications: Certified as an ASCS by NADCA.

B. IEP Qualifications: CMI who is certified by ACAC and accredited by CESB.

C. IEP Qualifications: CMC who is certified by ACAC and accredited by CESB.

D. CMR Qualifications: Certified by ACAC and accredited by CESB.

E. CMRS Qualifications: Certified by ACAC and accredited by CESB.

PART 2 - PRODUCTS

2.1 HVAC CLEANING AGENTS

A. Description:

1. Formulated for each specific soiled coil condition that needs remedy.

2.2 ANTIMICROBIAL SURFACE TREATMENT

A. Description: Specific product selected shall be as recommended by the IEP based on the specific antimicrobial needs of the specific Project conditions.

1. Formulated to kill and inhibit growth of microorganisms.
2. EPA-registered for use in HVAC systems and for the specific application in which it will be used.
3. Have no residual action after drying, with zero VOC off-gassing.
4. OSHA compliant.
5. Treatment shall dry clear to allow continued visual observation of the treated surface.

PART 3 - EXECUTION

3.1 PREPARATION

A. Inspect HVAC air-distribution equipment, ducts, plenums, and system components to determine appropriate methods, tools, and equipment required for performance of the Work.

B. Cleaning Plan: Prepare a written plan for air-distribution system cleaning that includes strategies and step-by-step procedures.

C. Proceed with work only after conditions detrimental to performance of the Work have been corrected and cleaning plan has been approved.

D. Use the existing service openings, as required for proper cleaning, at various points of the HVAC system for physical and mechanical entry and for inspection.

E. Mark the position of manual volume dampers and air-directional mechanical devices inside the system prior to cleaning.

3.2 CLEANING

A. Comply with NADCA ACR.

B. Perform electrical lockout and tagout according to Owner's standards or authorities having jurisdiction.

C. Remove non-adhered substances and deposits from within the HVAC system.

D. Systems and Components to Be Cleaned: All air-moving and -distribution equipment.

E. Collect debris removed during cleaning. Ensure that debris is not dispersed outside the HVAC system during the cleaning process.

1. Particulate Collection: For particulate collection equipment, include adequate filtration to contain debris removed. Locate equipment downwind and away from all air intakes and other points of entry into the building.
2. HEPA filtration with 99.97 percent collection efficiency for particles sized 0.3 micrometer or larger shall be used where the particulate collection equipment is exhausting inside the building,

F. Control odors and mist vapors during the cleaning and restoration process.

G. Mark the position of manual volume dampers and air-directional mechanical devices inside the system prior to cleaning. Restore them to their marked position on completion of cleaning.

H. System components shall be cleaned so that all HVAC system components are visibly clean. On completion, all components must be returned to those settings recorded just prior to cleaning operations.

I. Clean all air-distribution devices, registers, grilles, and diffusers.

J. Clean non-adhered substance deposits according to NADCA ACR and the following:

1. Clean air-handling units, airstream surfaces, components, condensate collectors, and drains.
2. Ensure that a suitable operative drainage system is in place prior to beginning wash-down procedures.
3. Clean evaporator coils, reheat coils, and other airstream components.

K. Air-Distribution Systems:

1. Create service openings in the HVAC system as necessary to accommodate cleaning.

2. Mechanically clean air-distribution systems specified to remove all visible contaminants, so that the systems are capable of passing the HVAC System Cleanliness Tests (see NADCA ACR).

L. Debris removed from the HVAC system shall be disposed of according to applicable Federal, state, and local requirements.

M. Mechanical Cleaning Methodology:

1. Source-Removal Cleaning Methods: The HVAC system shall be cleaned using source-removal mechanical cleaning methods designed to extract contaminants from within the HVAC system and to safely remove these contaminants from the facility. No cleaning method, or combination of methods, shall be used that could potentially damage components of the HVAC system or negatively alter the integrity of the system.

    a. Use continuously operating vacuum-collection devices to keep each section being cleaned under negative pressure.
    b. Cleaning methods that require mechanical agitation devices to dislodge debris that is adhered to interior surfaces of HVAC system components shall be equipped to safely remove these devices. Cleaning methods shall not damage the integrity of HVAC system components or damage porous surface materials, such as duct and plenum liners.

2. Cleaning Mineral-Fiber Insulation Components:

    a. Fibrous-glass thermal or acoustical insulation elements present in equipment or ductwork shall be thoroughly cleaned with HEPA vacuuming equipment while the HVAC system is under constant negative pressure and shall not be permitted to get wet according to NADCA ACR.
    b. Cleaning methods used shall not cause damage to fibrous-glass components and will render the system capable of passing the HVAC System Cleanliness Tests (see NADCA ACR).
    c. Fibrous materials that become wet shall be discarded and replaced.

N. Coil Cleaning:

1. See NADCA ACR, "Coil Surface Cleaning" Section. Type 1, or Type 1 and Type 2, cleaning methods shall be used to render the coil visibly clean and capable of passing coil cleaning verification.
2. Coil drain pans shall be subject to NADCA ACR, "Non-Porous Surfaces Cleaning Verification." Ensure that condensate drain pans are operational.
3. Electric-resistance coils shall be de-energized, locked out, and tagged before cleaning.
4. Cleaning methods shall not cause any appreciable damage to, cause displacement of, inhibit heat transfer, or cause erosion of the coil surface or fins, and shall comply with coil manufacturer's written recommendations.
5. Rinse thoroughly with clean water to remove any latent residues.

O. Application of Antimicrobial Treatment:

1. Apply antimicrobial agents and coatings if active fungal growth is determined by the IEP to be at Condition 2 or Condition 3 status according to IICRC S520, as analyzed by a

laboratory accredited by AIHA-LAP with an EMLAP certificate, and with results interpreted by an IEP. Apply antimicrobial agents and coatings according to manufacturer's written recommendations and EPA registration listing after the removal of surface deposits and debris.

2. Apply antimicrobial treatments and coatings after the system is rendered clean.
3. Apply antimicrobial agents and coatings directly onto surfaces of interior ductwork.
4. Microbial remediation shall be performed by a qualified CMR and CMRS.

3.3 CLEANLINESS VERIFICATION

A. Verify cleanliness according to NADCA ACR, "Verification of HVAC System Cleanliness" Section.

B. Surface-Cleaning Verification: Perform visual inspection for cleanliness. If no contaminants are evident through visual inspection, the HVAC system shall be considered clean. If visible contaminants are evident through visual inspection, those portions of the system where contaminants are visible shall be re-cleaned and subjected to re-inspection for cleanliness.

C. Verification of Coil Cleaning: Coil will be considered clean if the coil is free of foreign matter and chemical residue, based on a thorough visual inspection.

D. Prepare a written cleanliness verification report.

3.4 RESTORATION

A. Restore and repair HVAC air-distribution equipment, ducts, plenums, and components according to NADCA ACR, "Restoration and Repair of Mechanical Systems" Section.

B. Restore service openings capable of future reopening. Comply with requirements in Section 233113 "Metal Ducts or Section 233116 "Nonmetal Ducts or as directed."

C. Reseal fibrous-glass ducts. Comply with requirements in Section 233116 "Nonmetal Ducts."

D. Replace fibrous-glass materials that cannot be restored by cleaning or resurfacing. Comply with requirements in Section 233113 "Metal Ducts" and Section 233116 "Nonmetal Ducts."

E. Replace damaged insulation according to Section 230713 "Duct Insulation."

F. Ensure that closures do not hinder or alter airflow.

G. New closure materials, including insulation, shall match opened materials and shall have removable closure panels fitted with gaskets and fasteners.

H. Restore manual volume dampers and air-directional mechanical devices inside the system to their marked position on completion of cleaning.

END OF SECTION 230130.52

SECTION 230513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on alternating-current power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.2 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.
4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet (1000 m) above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Premium efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.

1. For motors with 2:1 speed ratio, consequent pole, single winding.
2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Rotor: Random-wound, squirrel cage.

F. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

G. Temperature Rise: Match insulation rating.

H. Insulation: Class F.

I. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.

J. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 ADDITIONAL REQUIREMENTS FOR POLYPHASE MOTORS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable-Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width-modulated inverters.
2. Premium-Efficient Motors: Class B temperature rise; Class F insulation.
3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

2.5 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Split phase.
3. Capacitor start, inductor run.
4. Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 230513

SECTION 230516 - EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Slip-joint, packed expansion joints.
2. Metal, compensator packless expansion joints.
3. Rubber union connector packless expansion joints.
4. Flexible-hose packless expansion joints.
5. Externally pressurized metal-bellows packless expansion joints.
6. Alignment guides and anchors.
7. Pipe loops and swing connections.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Delegated-Design Submittal: For each anchor and alignment guide, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
3. Alignment Guide Details: Detail field assembly and attachment to building structure.
4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.

B. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

2.2 PACKED EXPANSION JOINTS

A. Slip-Joint Packed Expansion Joints SJ-01:
1. Standard: ASTM F1007.
2. Material: Carbon steel with asbestos-free PTFE packing.
3. Design: With internal guide and injection ports for repacking under full system pressure. Housing shall be furnished with drain ports and lifting ring. Include drip connection if used for steam piping.
4. Configuration: Single joint, Single joint with base, and double joint with base class(es), unless otherwise indicated.
5. Slip Tube for sizes NPS 1-1/2 (DN 40) through NPS 16 (DN 400): Schedule 80.
6. Sliding Surface: 2 mil thick chrome finish.
7. End Connections: Flanged or welded ends to match piping system.

2.3 PACKLESS EXPANSION JOINTS

A. Metal, Compensator Packless Expansion Joints MCEJ-01:
1. Minimum Pressure Rating: As directed.
2. Description: Totally enclosed, externally pressurized, multi-ply bellows isolated from fluid flow by an internal pipe sleeve and external housing.
3. Joint Axial Movement: 2 inches (50 mm) of compression and 1/2 inch (12 mm) of extension.
4. Configuration for Copper Tubing: Multi-ply, phosphor-bronze bellows with copper pipe ends.
    a. End Connections for Copper Tubing NPS 2 (DN 50) and Smaller: Solder joint or threaded as directed.
    b. End Connections for Copper Tubing NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Threaded.
5. Configuration for Steel Piping: Multi-ply, stainless-steel bellows; steel-pipe end connections; and carbon-steel shroud.
    a. End Connections for Steel Pipe NPS 2 (DN 50) and Smaller: Threaded.

b. End Connections for Steel Pipe NPS 2-1/2 to NPS 4 (DN 65 to DN 100): As directed.

B. Rubber Union Connector Expansion Joints RUEJ-01:
1. Material: Twin reinforced-rubber spheres with external restraining cables.
2. Minimum Pressure Rating: 150 psig at 170 deg F (1035 kPa at 77 deg C), unless otherwise indicated.
3. End Connections for NPS 2 (DN 50) and Smaller: Threaded.

C. Flexible-Hose Packless Expansion Joints FHEJ-01:
1. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.
2. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
3. Expansion Joints for Copper Tubing NPS 2 (DN 50) and Smaller: Copper-alloy fittings with solder-joint end connections.

a. Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F (3100 kPa at 21 deg C) and 340 psig at 450 deg F (2340 kPa at 232 deg C) ratings.

4. Expansion Joints for Copper Tubing NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Copper-alloy fittings with threaded end connections.

a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 psig at 70 deg F (2070 kPa at 21 deg C) and 225 psig at 450 deg F (1550 kPa at 232 deg C) ratings.

5. Expansion Joints for Steel Piping NPS 2 (DN 50) and Smaller: Carbon-steel fittings with threaded end connections.

a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 450 psig at 70 deg F (3100 kPa at 21 deg C) and 325 psig at 600 deg F (2250 kPa at 315 deg C) ratings.

6. Expansion Joints for Steel Piping NPS 2-1/2 to NPS 6 (DN 65 to DN 150): Carbon-steel fittings with flanged or welded end connections as directed.

a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 psig at 70 deg F (1380 kPa at 21 deg C) and 145 psig at 600 deg F (1000 kPa at 315 deg C) ratings.

D. Externally Pressurized Metal-Bellows Packless Expansion Joints EPEJ-01:
1. Minimum Pressure Rating: As directed.
2. Description:

a. Totally enclosed, externally pressurized, multi-ply, stainless-steel bellows isolated from fluid flow by an internal pipe sleeve.
b. Carbon-steel housing.
c. Drain plugs and lifting lug for the NPS 3 (DN 80) and larger.
d. Bellows shall have operating clearance between the internal pipe sleeves and the external shrouds.

e. Joints shall be supplied with a built-in scale to confirm the starting position and operating movement.
f. Joint Axial Movement: As directed.

3. Permanent Locking Bolts: Set locking bolts to maintain joint lengths during installation. Temporary welding tabs that are removed after installation in lieu of locking bolts are not acceptable.
4. End Connection Configuration: Flanged; one raised, fixed and one floating flange.

2.4 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides AG-01:

1. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding slider for bolting to pipe.

B. Anchor Materials:

1. Steel Shapes and Plates: ASTM A36/A36M.
2. Bolts and Nuts: ASME B18.10 or ASTM A183, steel hex head.
3. Washers: ASTM F844, steel, plain, flat washers.
4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.

a. Stud: Threaded, zinc-coated carbon steel.
b. Expansion Plug: Zinc-coated steel.
c. Washer and Nut: Zinc-coated steel.

5. Chemical Fasteners: Insert-type stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.

a. Bonding Material: ASTM C881/C881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
b. Stud: ASTM A307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
c. Washer and Nut: Zinc-coated steel.

PART 3 - EXECUTION

3.1 EXPANSION JOINT INSTALLATION

A. Install expansion joints of sizes matching sizes of piping in which they are installed.

B. Install packed-type expansion joints with packing suitable for fluid service.

C. Install metal-bellows expansion joints according to EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."

3.2 PIPE LOOP AND SWING CONNECTION INSTALLATION

A. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.

B. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.

C. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.

D. Connect mains and branch connections to terminal units with at least four pipe fittings, including tee in main.

3.3 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.

B. Install one or two guide(s) as directed on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.

C. Attach guides to pipe, and secure guides to building structure.

D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

E. Anchor Attachments:

1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24; U bolts bolted to anchor.

F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.

1. Anchor Attachment to Steel Structural Members: Attach by welding.
2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.

G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION 230516

SECTION 230517 - SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Sleeves.
2. Sleeve-seal systems.
3. Grout.
4. Silicone sealants.

B. Related Requirements:

1. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop collar.

B. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, anti-corrosion coated or zinc coated, with plain ends and integral welded waterstop collar.

C. Galvanized-Steel Sheet Pipe Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

D. PVC Pipe Sleeves: ASTM D1785, Schedule 40.

2.2 SLEEVE-SEAL SYSTEMS

A. Description:

1. Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
2. Designed to form a hydrostatic seal of 20-psig (137-kPa) minimum).
3. Sealing Elements: As directed interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size.
4. Pressure Plates: As directed
5. Connecting Bolts and Nuts: As directed of length required to secure pressure plates to sealing elements.

2.3 GROUT

A. Description: Nonshrink, recommended for interior and exterior sealing openings in nonfire-rated walls or floors.

B. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.4 SILICONE SEALANTS

A. Silicone, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant, ASTM C920, Type S, Grade NS, Class 25, use NT.

B. Silicone, S, P, 25, T, NT: Single-component, pourable, plus 25 percent and minus 25 percent movement capability, traffic- and nontraffic-use, neutral-curing silicone joint sealant; ASTM C920, Type S, Grade P, Class 25, Uses T and NT. Grade P Pourable (self-leveling) formulation is for opening in floors and other horizontal surfaces that are not fire rated.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch (25-mm) annular clear space between piping and concrete slabs and walls.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

1. Cut sleeves to length for mounting flush with both surfaces.

    a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level.

2. Using grout or silicone sealant, seal space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use sealants appropriate for size, depth, and location of joint.

E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke-Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 078413 "Penetration Firestopping."

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal-system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.

B. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.

3.4 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls Above Grade:

    a. Piping Smaller Than NPS 6 (DN 150): As directed.

b. Piping NPS 6 (DN 150) and Larger: As directed.

2. Exterior Concrete Walls Below Grade:

   a. Piping Smaller Than NPS 6 (DN 150): As directed.

      1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.

   b. Piping NPS 6 (DN 150) and Larger: As directed.

      1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs-on-Grade:

   a. Piping Smaller Than NPS 6 (DN 150): As directed.

      1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.

   b. Piping NPS 6 (DN 150) and Larger: As directed.

4. Concrete Slabs Above Grade:

   a. Piping Smaller Than NPS 6 (DN 150): As directed.
   b. Piping NPS 6 (DN 150) and Larger: Steel-pipe sleeves or PVC-pipe sleeves as directed.

5. Interior Partitions:

   a. Piping Smaller Than NPS 6 (DN 150): Galvanized-steel pipe sleeves or PVC-pipe sleeves as directed.
   b. Piping NPS 6 (DN 150) and Larger: Galvanized-steel sheet sleeves.

END OF SECTION 230517

SECTION 230518 - ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Escutcheons.
2. Floor plates.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 ESCUTCHEONS

A. One-Piece, Steel Type: With polished, chrome-plated or polished brass finish as directed and setscrew fastener.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped steel with polished, chrome-plated finish and spring-clip fasteners.

C. One-Piece, Stamped-Steel Type: With polished, chrome-plated finish and spring-clip fasteners.

D. Split-Plate, Stamped-Steel Type: With polished, chrome-plated finish; concealed and exposed-rivet hinge; and spring-clip fasteners.

2.3 FLOOR PLATES

A. Split Floor Plates: Steel with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. Escutcheons for New Piping and Relocated Existing Piping:

a. Piping with Fitting or Sleeve Protruding from Wall: One-piece deep pattern.
b. Chrome-Plated Piping: One-piece steel or split-plate steel with polished, chrome-plated finish.
c. Insulated Piping: One-piece steel with polished, chrome-plated or polished brass finish as directed.
d. Insulated Piping: One-piece stamped steel or split-plate, stamped steel with concealed hinge or split-plate, stamped steel with exposed-rivet hinge with polished, chrome-plated finish.
e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece steel with polished, chrome-plated or polished brass finish as directed.
f. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece stamped steel or split-plate, stamped steel with concealed hinge or split-plate, stamped steel with exposed-rivet hinge with polished, chrome-plated finish as directed.
g. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece steel with polished, chrome-plated or polished brass finish.
h. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece stamped steel or split-plate, stamped steel with concealed hinge or split-plate, stamped steel with exposed-rivet hinge with polished, chrome-plated finish as directed.

2. Escutcheons for Existing Piping to Remain:

a. Chrome-Plated Piping: Split-plate, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish.
b. Insulated Piping: Split-plate, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish.
c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish.
d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish.

C. Install floor plates for piping penetrations of equipment-room floors.

D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. New Piping and Relocated Existing Piping: Split floor plate.
2. Existing Piping to Remain: Split floor plate.

3.2 FIELD QUALITY CONTROL

A. Using new materials, replace broken and damaged escutcheons and floor plates.

END OF SECTION 230518

SECTION 230519 - METERS AND GAGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bimetallic-actuated thermometers.
2. Liquid-in-glass thermometers.
3. Duct-thermometer mounting brackets.
4. Thermowells.
5. Dial-type pressure gages.
6. Gage attachments.
7. Flowmeters.
8. Thermal-energy meters.

B. Related Requirements:

1. Section 231123 "Facility Natural-Gas Piping" for gas meters.
2. Section 232216 "Steam and Condensate Piping Specialties" for steam and condensate meters.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of meter and gage.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 BIMETALLIC-ACTUATED THERMOMETERS

A. Standard: ASME B40.200.

B. Case: Liquid-filled and sealed type(s); stainless steel with 3-inch (76-mm) or 5-inch (127-mm) nominal diameter as directed.

C. Dial: Nonreflective aluminum with permanently etched scale markings and scales in deg F (deg C) or deg F and deg C as directed.

D. Connector Type(s): Union joint, with unified-inch screw threads as directed.

E. Connector Size: 1/2 inch (13 mm), with ASME B1.1 screw threads.

F. Stem: 0.25 or 0.375 inch (6.4 or 9.4 mm) in diameter; stainless steel.

G. Window: Plain glass or plastic.

H. Ring: Stainless steel.

I. Element: Bimetal coil.

J. Pointer: Dark-colored metal.

K. Accuracy: Plus or minus 1 or 1.5 percent of scale range as directed.

2.2 LIQUID-IN-GLASS THERMOMETERS

A. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:
1. Standard: ASME B40.200.
2. Case: Cast aluminum; 7-inch (178-mm) or 9-inch (229-mm) nominal size unless otherwise indicated.
3. Case Form: As directed
4. Tube: Glass with magnifying lens and blue or red organic liquid.
5. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C) or deg F and deg C as directed.
6. Window: Glass or plastic.
7. Stem: Aluminum and of length to suit installation.

    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.

8. Connector: 1-1/4 inches (32 mm), with ASME B1.1 screw threads.
9. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

B. Plastic-Case, Industrial-Style, Liquid-in-Glass Thermometers:
1. Standard: ASME B40.200.
2. Case: Plastic; 7-inch (178-mm) or 9-inch (229-mm) nominal size unless otherwise indicated.
3. Case Form: As directed
4. Tube: Glass with magnifying lens and blue or red organic liquid.
5. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C) or deg F and deg C as directed.

6. Window: Glass or plastic.
7. Stem: As directed.

    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.

8. Connector: 1-1/4 inches (32 mm), with ASME B1.1 screw threads.
9. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.3 DUCT-THERMOMETER MOUNTING BRACKETS

A. Description: Flanged bracket with screw holes, for attachment to air duct and made to hold thermometer stem.

2.4 THERMOWELLS

A. Thermowells:

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion in piping tee fitting.
3. Material for Use with Copper Tubing: CNR or CUNI.
4. Material for Use with Steel Piping: CRES or CSA as directed.
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, (DN 15, DN 20, or NPS 25,) ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and 1 inch (13, 19, and 25 mm), with ASME B1.1 screw threads.
8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

B. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.5 DIAL-TYPE PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:
1. Standard: ASME B40.100.
2. Case: As Directed type(s); cast aluminum or drawn steel; 4-1/2-inch (114-mm) or 6-inch (152-mm) nominal diameter as directed.
3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
4. Pressure Connection: As directed.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi (kPa) or psi and kPa as directed.
7. Pointer: Dark-colored metal.

8. Window: Glass or plastic.
9. Ring: As directed.
10. Accuracy: As directed of scale range.

B. Direct-Mounted, Plastic-Case, Dial-Type Pressure Gages:
1. Standard: ASME B40.100.
2. Case: Sealed type; plastic; 4-1/2-inch (114-mm) or 6-inch (152-mm) nominal diameter as directed.
3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
4. Pressure Connection: Brass, as directed.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi (kPa) or psi and kPa as directed.
7. Pointer: Dark-colored metal.
8. Window: Glass or plastic.
9. Accuracy: As directed of scale range.

C. Remote-Mounted, Metal-Case, Dial-Type Pressure Gages:
1. Standard: ASME B40.100.
2. Case: Liquid-filled or Sealed type as directed; cast aluminum or drawn steel or metal as directed; 4-1/2-inch (114-mm) or 6-inch (152-mm) nominal diameter as directed with back or front flange as directed and holes for panel mounting.
3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
4. Pressure Connection: Brass, as directed.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi (kPa) or psi and kPa as directed.
7. Pointer: Dark-colored metal.
8. Window: Glass or plastic.
9. Ring: Metal or Stainless steel as directed.
10. Accuracy: Scale range as directed.

D. Remote-Mounted, Plastic-Case, Dial-Type Pressure Gages:
1. Standard: ASME B40.100.
2. Case: Sealed type; plastic; 4-1/2-inch (114-mm) or 6-inch (152-mm) nominal diameter as directed with back or front flange as directed and holes for panel mounting.
3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
4. Pressure Connection: Brass, as directed.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi (kPa) or psi and kPa as directed.
7. Pointer: Dark-colored metal.
8. Window: Glass or plastic as directed.
9. Accuracy: Scale range as directed.

2.6 GAGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass as directed.

B. Siphons: As directed.

C. Valves: As directed.

2.7 FLOWMETERS

A. Pitot-Tube Flowmeters:
1. Description: Flowmeter with sensor and indicator.
2. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
3. Sensor: Insertion type; for inserting probe in piping and measuring flow directly in gallons per minute (liters per second).
    a. Design: Differential-pressure-type measurement for oil or water as directed.
    b. Construction: Stainless-steel probe of length to span inside of pipe, with integral transmitter and direct-reading scale.
    c. Minimum Pressure Rating: 150 psig (1035 kPa).
    d. Minimum Temperature Rating: 250 deg F (121 deg C).
4. Indicator: Hand-held meter; either an integral part of sensor or a separate meter.
5. Integral Transformer: For low-voltage power connection.
6. Accuracy: Plus or minus 3 percent.
7. Display: Shows rate of flow, with register to indicate total volume in gallons (liters).
8. Operating Instructions: Include complete instructions with each flowmeter.

B. Turbine Flowmeters:
1. Description: Flowmeter with sensor and indicator.
2. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
3. Sensor: Impeller turbine; for inserting in pipe fitting or for installing in piping and measuring flow directly in gallons per minute (liters per second).
    a. Design: Device or pipe fitting with inline turbine and integral direct-reading scale as directed.
    b. Construction: Bronze or stainless-steel body, with plastic turbine or impeller.
    c. Minimum Pressure Rating: 150 psig (1035 kPa).
    d. Minimum Temperature Rating: 180 deg F (82 deg C).
4. Indicator: Hand-held meter; either an integral part of sensor or a separate meter.
5. Accuracy: Plus or minus 1-1/2 percent.
6. Display: Shows rate of flow, with register to indicate total volume in gallons (liters).
7. Operating Instructions: Include complete instructions with each flowmeter.

C. Venturi Flowmeters:
1. Description: Flowmeter with calibrated flow-measuring element, hoses or tubing, fittings, valves, indicator, and conversion chart.
2. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
3. Sensor: Venturi-type, calibrated, flow-measuring element; for installation in piping.
    a. Design: Differential-pressure-type measurement as directed

b. Construction: Bronze, brass, or factory-primed steel, with brass fittings and attached tag with flow conversion data.
c. Minimum Pressure Rating: 250 psig (1725 kPa).
d. Minimum Temperature Rating: 250 deg F (121 deg C).
e. End Connections for NPS 2 (DN 50) and Smaller: Threaded.
f. End Connections for NPS 2-1/2 (DN 65) and Larger: Flanged or welded.
g. Flow Range: Flow-measuring element and flowmeter shall cover operating range of equipment or system served.

4. Permanent Indicators: Meter suitable for wall or bracket mounting, calibrated for connected flowmeter element, and having 6-inch- (152-mm-) diameter, or equivalent, dial with fittings and copper tubing for connecting to flowmeter element.

a. Scale: Gallons per minute (Liters per second).
b. Accuracy: Plus or minus 1 percent between 20 and 80 percent of scale range.

5. Portable Indicators: Hand-held, differential-pressure type, calibrated for connected flowmeter element and having two 12-foot (3.7-m) hoses, with carrying case.

a. Scale: Gallons per minute (Liters per second).
b. Accuracy: Plus or minus 2 percent between 20 and 80 percent of scale range.

6. Display: Shows rate of flow, with register to indicate total volume in gallons (liters).
7. Conversion Chart: Flow rate data compatible with sensor.
8. Operating Instructions: Include complete instructions with each flowmeter.

2.8 THERMAL-ENERGY METERS

A. Impeller-Turbine, Thermal-Energy Meters:
1. Description: System with strainer, flow sensor, temperature sensors, transmitter, indicator, and connecting wiring.
2. Flow Sensor: Impeller turbine with corrosion-resistant-metal body and transmitter; for installing in piping.

a. Design: Total thermal-energy measurement.
b. Minimum Pressure Rating: 150 psig (1035 kPa).
c. Minimum Temperature Range: 40 to 250 deg F (5 to 121 deg C).

3. Temperature Sensors: Insertion-type transducer.
4. Indicator: Solid-state, integrating-type meter with integral battery pack; for wall mounting.

a. Data Output: Six-digit electromechanical counter with readout in kilowatts per hour or British thermal units (joules).
b. Battery Pack: Five-year lithium battery.

5. Accuracy: Plus or minus 1 percent.
6. Display: Visually indicates total fluid volume in gallons (liters) and thermal-energy flow in kilowatts per hour or British thermal units (joules).
7. Strainer: Full size of main line piping.

8. Operating Instructions: Include complete instructions with each thermal-energy meter system.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install thermowells with socket extending and in vertical position in piping tees as directed.

B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.

G. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.

H. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

I. Install remote-mounted pressure gages on panel.

J. Install valve and snubber in piping for each pressure gage for fluids (except steam).

K. Install valve and syphon fitting in piping for each pressure gage for steam.

L. Install test plugs in piping tees.

M. Install flow indicators in piping systems in accessible positions for easy viewing.

N. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.

O. Install flowmeter elements in accessible positions in piping systems.

P. Install wafer-orifice flowmeter elements between pipe flanges.

Q. Install differential-pressure-type flowmeter elements, with at least minimum straight lengths of pipe, upstream and downstream from element according to manufacturer's written instructions.

R. Install permanent indicators on walls or brackets in accessible and readable positions.

S. Install connection fittings in accessible locations for attachment to portable indicators.

T. Mount thermal-energy meters on wall if accessible; if not, provide brackets to support meters.

U. Install thermometers in the following locations:

1. Inlet and outlet of each hydronic zone.
2. Inlet and outlet of each hydronic boiler.
3. Two inlets and two outlets of each chiller.
4. Inlet and outlet of each hydronic coil in air-handling units.
5. Two inlets and two outlets of each hydronic heat exchanger.
6. Inlet and outlet of each thermal-storage tank.
7. Outside-, return-, supply-, and mixed-air ducts.

V. Install pressure gages in the following locations:

1. Discharge of each pressure-reducing valve.
2. Inlet and outlet of each chiller chilled-water and condenser-water connection.
3. Suction and discharge of each pump.

3.2 CONNECTIONS

A. Install meters and gages adjacent to machines and equipment to allow space for service and maintenance of meters, gages, machines, and equipment.

B. Connect flowmeter-system elements to meters.

C. Connect flowmeter transmitters to meters.

D. Connect thermal-energy meter transmitters to meters.

3.3 ADJUSTING

A. After installation, calibrate meters according to manufacturer's written instructions.

B. Adjust faces of meters and gages to proper angle for best visibility.

3.4 THERMOMETER SCHEDULE

A. Thermometers at inlet and outlet of each hydronic zone shall be one of the following:

1. Liquid-filled or Sealed, bimetallic-actuated type as directed.
2. Direct or Remote-mounted, metal or plastic-case as directed, vapor-actuated type.
3. Industrial-style, liquid-in-glass type.

B. Thermometers at inlet and outlet of each hydronic boiler shall be one of the following:

1. Liquid-filled or Sealed, bimetallic-actuated type as directed.
2. Direct or Remote-mounted, metal or plastic-case, vapor-actuated typeas directed.
3. Industrial-style, liquid-in-glass type.

C. Thermometers at inlets and outlets of each chiller shall be one of the following:

1. Liquid-filled or Sealed, bimetallic-actuated type as directed.
2. Direct or Remote-mounted, metal or plastic-case, vapor-actuated type.
3. Industrial-style, liquid-in-glass type.

D. Thermometers at inlet and outlet of each hydronic coil in air-handling units and built-up central systems shall be one of the following:

1. Liquid-filled or Sealed, bimetallic-actuated type.
2. Direct Remote-mounted, metal or plastic-case, vapor-actuated type as directed.
3. Industrial-style, liquid-in-glass type.

E. Thermometers at inlets and outlets of each hydronic heat exchanger shall be one of the following:

1. Liquid-filled or Sealed, bimetallic-actuated type as directed.
2. Direct or Remote-mounted, metal or plastic-case, vapor-actuated type as directed.
3. Industrial-style, liquid-in-glass type.

F. Thermometers at inlet and outlet of each hydronic heat-recovery unit shall be one of the following:

1. Liquid-filled or Sealed, bimetallic-actuated type as directed.
2. Direct or Remote-mounted, metal or plastic-case, vapor-actuated type as directed.
3. Industrial-style, liquid-in-glass type.

G. Thermometers at inlet and outlet of each thermal-storage tank shall be one of the following:

1. Liquid-filled or Sealed, bimetallic-actuated type as directed.
2. Direct or Remote-mounted, metal or plastic-case, vapor-actuated type as directed.
3. Industrial-style, liquid-in-glass type.

H. Thermometers at outside-, return-, supply-, and mixed-air ducts shall be one of the following:

1. Liquid-filled or Sealed, bimetallic-actuated type as directed.
2. Direct or Remote-mounted, metal or plastic-case, vapor-actuated type as directed.
3. Industrial-style, liquid-in-glass type.

I. Thermometer stems shall be of length to match thermowell insertion length.

3.5 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping: Minus 40 to plus 160 deg F (Minus 40 to plus 100 deg C) or Minus 40 to plus 160 deg F and minus 40 to plus 100 deg C as directed.

B. Scale Range for Chilled-Water Piping: 0 to 100 deg F (Minus 20 to plus 50 deg C) or 0 to 100 deg F and minus 20 to plus 50 deg C as directed.

C. Scale Range for Chilled-Water Piping: 0 to 150 deg F (Minus 20 to plus 70 deg C) or 0 to 150 deg F and minus 20 to plus 70 deg C as directed.

D. Scale Range for Condenser-Water Piping: 0 to 100 deg F (Minus 20 to plus 50 deg C) or 0 to 100 deg F and minus 20 to plus 50 deg C as directed.

E. Scale Range for Condenser-Water Piping: 0 to 150 deg F (Minus 20 to plus 70 deg C) or 0 to 150 deg F and minus 20 to plus 70 deg C as directed.

F. Scale Range for Condenser-Water Piping: 0 to 250 deg F (0 to 150 deg C) or 0 to 250 deg F and 0 to 150 deg C as directed.

G. Scale Range for Heating, Hot-Water Piping: 0 to 250 deg F (0 to 150 deg C) or 0 to 250 deg F and 0 to 150 deg C as directed.

H. Scale Range for Heating, Hot-Water Piping: 20 to 240 deg F (0 to 150 deg C) or 20 to 240 deg F and 0 to 150 deg C as directed.

I. Scale Range for Heating, Hot-Water Piping: 50 to 400 deg F (0 to 200 deg C) or 50 to 400 deg F and 0 to 200 deg C as directed.

J. Scale Range for Steam and Steam-Condensate Piping: 0 to 250 deg F (0 to 150 deg C) or 0 to 250 deg F and 0 to 150 deg C as directed.

K. Scale Range for Steam and Steam-Condensate Piping: 20 to 240 deg F (0 to 150 deg C) or 20 to 240 deg F and 0 to 150 deg C as directed.

L. Scale Range for Air Ducts: Minus 40 to plus 160 deg F (Minus 40 to plus 100 deg C) or Minus 40 to plus 160 deg F and minus 40 to plus 100 deg C as directed.

M. Scale Range for Air Ducts: 0 to 100 deg F (Minus 20 to plus 50 deg C) or 0 to 100 deg F and minus 20 to plus 50 deg C as directed.

N. Scale Range for Air Ducts: 0 to 150 deg F (Minus 20 to plus 70 deg C) or 0 to 150 deg F and minus 20 to plus 70 deg C as directed.

O. Scale Range for Air Ducts: 20 to 240 deg F (0 to 150 deg C) or 20 to 240 deg F and 0 to 150 deg C as directed.

3.6 PRESSURE-GAGE SCHEDULE

A. Pressure gages at discharge of each pressure-reducing valve shall be:
   1. As directed.

B. Pressure gages at inlet and outlet of each chiller chilled-water and condenser-water connection shall be:
   1. As directed.

C. Pressure gages at suction and discharge of each pump shall be:
   1. As directed

3.7 PRESSURE-GAGE SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping: 0 to 100 psi (0 to 600 kPa) or 0 to 100 psi and 0 to 600 kPa as directed.

B. Scale Range for Chilled-Water Piping: 0 to 160 psi (0 to 1100 kPa) or 0 to 160 psi and 0 to 1100 kPa as directed.

C. Scale Range for Chilled-Water Piping: 0 to 300 psi (0 to 2500 kPa) or 0 to 300 psi and 0 to 2500 kPa as directed.

D. Scale Range for Condenser-Water Piping: 0 to 100 psi (0 to 600 kPa) or 0 to 100 psi and 0 to 600 kPa as directed.

E. Scale Range for Condenser-Water Piping: 0 to 160 psi (0 to 1100 kPa) or 0 to 160 psi and 0 to 1100 kPa as directed.

F. Scale Range for Condenser-Water Piping: 0 to 300 psi (0 to 2500 kPa) or 0 to 300 psi and 0 to 2500 kPa as directed.

G. Scale Range for Heating, Hot-Water Piping: 0 to 100 psi (0 to 600 kPa) or 0 to 100 psi and 0 to 600 kPa as directed.

H. Scale Range for Heating, Hot-Water Piping: 0 to 160 psi (0 to 1100 kPa) or 0 to 160 psi and 0 to 1100 kPa as directed.

I. Scale Range for Heating, Hot-Water Piping: 0 to 300 psi (0 to 2500 kPa) or 0 to 300 psi and 0 to 2500 kPa as directed.

J. Scale Range for Steam Piping: 0 to 100 psi (0 to 600 kPa) or 0 to 100 psi and 0 to 600 kPa as directed.

K. Scale Range for Steam Piping: 0 to 160 psi (0 to 1100 kPa) or 0 to 160 psi and 0 to 1100 kPa as directed.

L. Scale Range for Steam Piping: 0 to 200 psi (0 to 1400 kPa) or 0 to 200 psi and 0 to 1400 kPa as directed.

3.8 FLOWMETER SCHEDULE

A. Flowmeters for Chilled-Water Piping: As directed.

B. Flowmeters for Condenser-Water Piping: As directed.

C. Flowmeters for Heating, Hot-Water Piping: As directed.

D. Flowmeters for Steam and Steam-Condensate Piping: Turbine or Venturi type as directed.

3.9 THERMAL-ENERGY METER SCHEDULE

A. Thermal-Energy Meters: Impeller-turbine type.

END OF SECTION 230519

SECTION 230523.11 - GLOBE VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bronze globe valves.
2. Iron globe valves.
3. Chainwheels.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

1. ASME B1.20.1 for threads for threaded-end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
4. ASME B16.18 for solder-joint connections.
5. ASME B31.1 for power piping valves.
6. ASME B31.9 for building services piping valves.

C. Refer to HVAC valve schedule articles for applications of valves.

D. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

E. Valve Sizes: Same as upstream piping unless otherwise indicated.

F. Valves in Insulated Piping: With 2-inch (50-mm) stem extensions.

2.2 BRONZE GLOBE VALVES

A. Bronze Globe Valves, Class 125:
   1. Description:

      a. Standard: MSS SP-80, Type 1.
      b. CWP Rating: 200 psig (1380 kPa).
      c. Body Material: ASTM B62, bronze with integral seat and screw-in bonnet.
      d. Ends: Threaded or solder joint.
      e. Stem and Disc: Bronze or PTFE as directed.
      f. Packing: Asbestos free.
      g. Handwheel: Malleable iron, bronze, or aluminum.

B. Bronze Globe Valves, Class 150:
   1. Description:

      a. Standard: MSS SP-80, Type 2.
      b. CWP Rating: 300 psig (2070 kPa).
      c. Body Material: ASTM B62, bronze with integral seat and union-ring bonnet.
      d. Ends: Threaded.
      e. Stem: Bronze.
      f. Disc: Bronze or PTFE.
      g. Packing: Asbestos free.
      h. Handwheel: Malleable iron, bronze, or aluminum.

2.3 IRON GLOBE VALVES

A. Iron Globe Valves, Class 125:
   1. Description:

      a. Standard: MSS SP-85, Type I.
      b. CWP Rating: 200 psig (1380 kPa).
      c. Body Material: ASTM A126, gray iron with bolted bonnet.
      d. Ends: Flanged.
      e. Trim: Bronze.
      f. Packing and Gasket: Asbestos free.
      g. Operator: Handwheel or chainwheel.

B. Iron Globe Valves, Class 250:
   1. Description:

      a. Standard: MSS SP-85, Type I.
      b. CWP Rating: 500 psig (3450 kPa).
      c. Body Material: ASTM A126, gray iron with bolted bonnet.
      d. Ends: Flanged.
      e. Trim: Bronze.
      f. Packing and Gasket: Asbestos free.

g. Operator: Handwheel or chainwheel.

2.4 CHAINWHEELS

A. Description: Valve actuation assembly with sprocket rim, chain guides, chain, and attachment brackets for mounting chainwheels directly to handwheels.

1. Sprocket Rim with Chain Guides: Ductile iron, of type and size required for valve. Include zinc or epoxy coating.
2. Chain: Hot-dip-galvanized steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install chainwheels on operators for globe valves NPS 4 (DN 100) and larger and more than 96 inches (2400 mm) above floor. Extend chains to 60 inches (1520 mm) above finished floor.

3.2 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:

1. Throttling Service except Steam: Globe valves.
2. Throttling Service, Steam: Globe valves.

B. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.

C. Select valves with the following end connections:

1. For Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules.
2. For Copper Tubing, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules.
3. For Copper Tubing, NPS 5 (DN 125) and Larger: Flanged ends.
4. For Steel Piping, NPS 2 (DN 50) and Smaller: Threaded ends.
5. For Steel Piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules.
6. For Steel Piping, NPS 5 (DN 125) and Larger: Flanged ends.

3.4 CHILLED-WATER VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller: Bronze globe valves, Class 125 or Class 150, with bronze or PTFE disc as directed, and with soldered or threaded ends as directed.

B. Pipe NPS 2-1/2 (DN 65) and Larger: Iron globe valves, Class 125 or Class 250, with flanged ends as directed.

3.5 CONDENSER-WATER VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller: Bronze globe valves, Class 125 or Class 150, with bronze or PTFE disc, and with soldered or threaded ends as directed.

B. Pipe NPS 2-1/2 (DN 65) and Larger: Iron globe valves, Class 125 or Class 250, with flanged ends as directed.

3.6 HEATING-WATER VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller: Bronze globe valves, Class 125 or Class 150 as directed, with bronze or PTFE disc as directed, and soldered or threaded ends as directed.

B. Pipe NPS 2-1/2 (DN 65) and Larger: Iron globe valves, Class 125Class 250 as directed, with flanged ends.

3.7 LOW-PRESSURE STEAM VALVE SCHEDULE (15 PSIG (104 kPa) OR LESS)

A. Pipe NPS 2 (DN 50) and Smaller: Bronze globe valves, Class 125 or Class 150 as directed, with bronze or nonmetallic disc as directed, and soldered or threaded ends as directed.

B. Pipe NPS 2-1/2 (DN 65) and Larger: Iron globe valves, Class 125 or Class 250 as directed, with flanged ends.

3.8 HIGH-PRESSURE STEAM VALVE SCHEDULE (MORE THAN 15 PSIG (104 kPa)

A. Pipe NPS 2 (DN 50) and Smaller: Bronze globe valves, Class 125 or Class 150, with bronze or nonmetallic disc, and soldered or threaded ends as directed.

B. Pipe Sizes NPS 2-1/2 (DN 65) and Larger: Iron globe valves, Class 125 or Class 250 as directed.

3.9 STEAM-CONDENSATE VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller: Bronze globe valves, Class 125 or Class 150 as directed, with bronze or nonmetallic disc as directed, and soldered or threaded ends as directed.

B. Pipe NPS 2-1/2 (DN 65) and Larger: Iron globe valves, Class 125 or Class 250 as directed.

END OF SECTION 230523.11

SECTION 230523.12 - BALL VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Brass ball valves.
2. Bronze ball valves.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

1. ASME B1.20.1 for threads for threaded-end valves.
2. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
3. ASME B16.18 for solder-joint connections.
4. ASME B31.1 for power piping valves.
5. ASME B31.9 for building services piping valves.

C. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

D. Refer to HVAC valve schedule articles for applications of valves.

E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

F. Valve Sizes: Same as upstream piping unless otherwise indicated.

G. Valve Actuator Types:

1. Gear Actuator: For quarter-turn valves NPS 4 (DN 100) and larger.
2. Handlever: For quarter-turn valves smaller than NPS 4 (DN 100).

H. Valves in Insulated Piping:

1. Include 2-inch (50-mm) stem extensions.
2. Extended operating handle of nonthermal-conductive material, and protective sleeves that allow operation of valves without breaking the vapor seals or disturbing insulation.
3. Memory stops that are fully adjustable after insulation is applied.

I. Valve Bypass and Drain Connections: MSS SP-45.

2.2 BRASS BALL VALVES

A. Brass Ball Valves, One Piece:
1. Description:

a. Standard: MSS SP-110.
b. CWP Rating: 400 psig (2760 kPa).
c. Body Design: One piece.
d. Body Material: Forged brass.
e. Ends: Threaded.
f. Seats: PTFE.
g. Stem: Brass.
h. Ball: Chrome-plated brass.
i. Port: Reduced.

B. Brass Ball Valves, Two-Piece with Full Port and Brass Trim, Threaded Ends:
1. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig (1035 kPa).
c. CWP Rating: 600 psig (4140 kPa).
d. Body Design: Two piece.
e. Body Material: Forged brass.
f. Ends: Threaded.
g. Seats: PTFE.
h. Stem: Brass.
i. Ball: Chrome-plated brass.
j. Port: Full.

C. Brass Ball Valves, Two-Piece with Full Port and Brass Trim, Press Ends:
1. Description:

a. Standard: MSS SP-110.
b. CWP Rating: 600 psig (4140 kPa).
c. Body Design: Two piece.
d. Body Material: Forged brass.
e. Ends: Press.
f. Seats: PTFE or RPTFE.
g. Stem: Brass.
h. Ball: Chrome-plated brass.
i. Port: Full.
j. O-Ring Seal: Buna-N or EPDM.

D. Brass Ball Valves, Two-Piece with Full Port and Stainless-Steel Trim, Threaded Ends:
   1. Description:
      a. Standard: MSS SP-110.
      b. SWP Rating: 150 psig (1035 kPa).
      c. CWP Rating: 600 psig (4140 kPa).
      d. Body Design: Two piece.
      e. Body Material: Forged brass.
      f. Ends: Threaded.
      g. Seats: PTFE.
      h. Stem: Stainless steel.
      i. Ball: Stainless steel, vented.
      j. Port: Full.

E. Brass Ball Valves, Two-Piece with Regular Port and Brass Trim:
   1. Description:
      a. Standard: MSS SP-110.
      b. SWP Rating: 150 psig (1035 kPa).
      c. CWP Rating: 600 psig (4140 kPa).
      d. Body Design: Two piece.
      e. Body Material: Forged brass.
      f. Ends: Threaded.
      g. Seats: PTFE.
      h. Stem: Brass.
      i. Ball: Chrome-plated brass.
      j. Port: Regular.

F. Brass Ball Valves, Two-Piece with Regular Port and Stainless-Steel Trim:
   1. Description:
      a. Standard: MSS SP-110.
      b. SWP Rating: 150 psig (1035 kPa).
      c. CWP Rating: 600 psig (4140 kPa).
      d. Body Design: Two piece.
      e. Body Material: Brass or bronze.
      f. Ends: Threaded.
      g. Seats: PTFE.
      h. Stem: Stainless steel.
      i. Ball: Stainless steel, vented.
      j. Port: Regular.

2.3 BRONZE BALL VALVES

A. Bronze Ball Valves, One-Piece with Bronze Trim:
   1. Description:
      a. Standard: MSS SP-110.
      b. CWP Rating: 400 psig (2760 kPa).

c. Body Design: One piece.
d. Body Material: Bronze.
e. Ends: Threaded.
f. Seats: PTFE.
g. Stem: Bronze.
h. Ball: Chrome-plated brass.
i. Port: Reduced.

B. Bronze Ball Valves, One-Piece with Stainless-Steel Trim:
1. Description:

a. Standard: MSS SP-110.
b. CWP Rating: 600 psig (4140 kPa).
c. Body Design: One piece.
d. Body Material: Bronze.
e. Ends: Threaded.
f. Seats: PTFE.
g. Stem: Stainless steel.
h. Ball: Stainless steel, vented.
i. Port: Reduced.

C. Bronze Ball Valves, Two-Piece with Full Port and Bronze or Brass Trim, Threaded Ends:
1. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig (1035 kPa).
c. CWP Rating: 600 psig (4140 kPa).
d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE.
h. Stem: Bronze.
i. Ball: Chrome-plated brass.
j. Port: Full.

D. Bronze Ball Valves, Two-Piece with Full Port and Stainless-Steel Trim:
1. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig (1035 kPa).
c. CWP Rating: 600 psig (4140 kPa).
d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE.
h. Stem: Stainless steel.
i. Ball: Stainless steel, vented.
j. Port: Full.

E. Bronze Ball Valves, Two-Piece with Regular Port and Bronze or Brass Trim:
1. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig (1035 kPa).
c. CWP Rating: 600 psig (4140 kPa).
d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE.
h. Stem: Bronze.
i. Ball: Chrome-plated brass.
j. Port: Regular.

F. Bronze Ball Valves, Two-Piece with Regular Port and Stainless-Steel Trim:
1. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig (1035 kPa).
c. CWP Rating: 600 psig (4140 kPa).
d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE.
h. Stem: Stainless steel.
i. Ball: Stainless steel, vented.
j. Port: Regular.

PART 3 - EXECUTION

3.1 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

3.2 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valves with specified SWP classes or CWP ratings are unavailable, the same types of valves with higher SWP classes or CWP ratings may be substituted.

B. Select valves with the following end connections:

1. For Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded ends except where solder-joint valve-end option or press-end option is indicated in valve schedules below.
2. For Steel Piping, NPS 2 (DN 50) and Smaller: Threaded ends.

3.3 CHILLED-WATER VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller: Brass or bronze ball valves, one or two piece as directed, with trim as directed, port as directed, joint ends as directed.

1. Valves may be provided with solder-joint ends instead of threaded ends.

3.4 CONDENSER-WATER VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller: Brass or bronze ball valves, one or two piece as directed, with trim as directed, port as directed, joint ends as directed.

1. Valves may be provided with solder-joint ends instead of threaded ends.

3.5 HEATING-WATER VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller: Brass or bronze ball valves, one or two piece as directed, with trim as directed, and port as directed.

3.6 LOW-PRESSURE STEAM VALVE SCHEDULE (15 PSIG (104 kPa) OR LESS)

A. Pipe NPS 2 (DN 50) and Smaller: Brass or bronze ball valves, one or two piece as directed with trim as directed, and port as directed.

3.7 HIGH-PRESSURE STEAM VALVE SCHEDULE (MORE THAN 15 PSIG (104 kPa)

A. Pipe NPS 2 (DN 50) and Smaller: Brass or bronze, one or two pieces as directed with trim as directed, and port as directed.

3.8 STEAM-CONDENSATE VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller: Brass or bronze ball valves, one or two piece as directed, with trim as directed, and port as directed.

END OF SECTION 230523.12

SECTION 230523.13 - BUTTERFLY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Iron, single-flange butterfly valves.
2. High-performance butterfly valves.
3. Chainwheels.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

1. ASME B16.1 for flanges on iron valves.
2. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
3. ASME B31.1 for power piping valves.
4. ASME B31.9 for building services piping valves.

C. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

D. Valve Sizes: Same as upstream piping unless otherwise indicated.

E. Valve Actuator Types:

1. Gear Actuator: For valves NPS 8 (DN 200) and larger.
2. Handlever: For valves NPS 6 (DN 150) and smaller.
3. Chainwheel: Device for attachment to gear, stem, or other actuator of size and with chain for mounting height, according to "Valve Installation" Article.

F. Valves in Insulated Piping: With 2-inch (50-mm) stem extensions with extended necks.

2.2 IRON, SINGLE-FLANGE BUTTERFLY VALVES

A. Iron, Single-Flange Butterfly Valves with Aluminum-Bronze Disc:
   1. Description:

      a. Standard: MSS SP-67, Type I.
      b. CWP Rating: 150 psig (1035 kPa) or 200 psig (1380 kPa) as directed.
      c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
      d. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
      e. Seat: EPDM or NBR as directed.
      f. Stem: One- or two-piece stainless steel.
      g. Disc: Aluminum bronze.

B. Iron, Single-Flange Butterfly Valves with Ductile-Iron Disc:
   1. Description:

      a. Standard: MSS SP-67, Type I.
      b. CWP Rating: 150 psig (1035 kPa) or 200 psig (1380 kPa) as directed.
      c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
      d. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
      e. Seat: EPDM or NBR as directed.
      f. Stem: One- or two-piece stainless steel.
      g. Disc: Nickel-plated or -coated ductile iron.

C. Iron, Single-Flange Butterfly Valves with Stainless-Steel Disc:
   1. Description:

      a. Standard: MSS SP-67, Type I.
      b. CWP Rating: 150 psig (1035 kPa) or 200 psig (1380 kPa) as directed.
      c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
      d. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
      e. Seat: EPDM or NBR as directed.
      f. Stem: One- or two-piece stainless steel.
      g. Disc: Stainless steel.

2.3 HIGH-PERFORMANCE BUTTERFLY VALVES

A. Single-Flange, High-Performance Butterfly Valves, Class 150:
   1. Description:

      a. Standard: MSS SP-68.
      b. CWP Rating: 285 psig (1965 kPa) at 100 deg F (38 deg C).
      c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
      d. Body Material: Carbon steel, cast iron, ductile iron, or stainless steel.
      e. Seat: Reinforced PTFE or metal.
      f. Stem: Stainless steel; offset from seat plane.

g. Disc: Carbon steel.
h. Service: Bidirectional.

B. Class 300, Single-Flange, High-Performance Butterfly Valves:
1. Description:

a. Standard: MSS SP-68.
b. CWP Rating: 720 psig (4965 kPa) at 100 deg F (38 deg C).
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: Carbon steel, cast iron, or ductile iron.
e. Seat: Reinforced PTFE or metal.
f. Stem: Stainless steel; offset from seat plane.
g. Disc: Carbon steel.
h. Service: Bidirectional.

2.4 CHAINWHEELS

A. Description: Valve actuation assembly with sprocket rim, chain guides, chain, and attachment brackets for mounting chainwheels directly to hand wheels.

1. Sprocket Rim with Chain Guides: Ductile iron, of type and size required for valve. Include zinc or epoxy coating.
2. Chain: Hot-dip, galvanized steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install chainwheels on operators for butterfly valves NPS 4 (DN 100) and larger and more than 96 inches (2400 mm) above floor. Extend chains to 60 inches (1520 mm) above finished floor.

3.2 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.3 CHILLED-WATER VALVE SCHEDULE

A. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): as directed.
2. Iron, Single-Flange Butterfly Valves, NPS 14 to NPS 24 (DN 350 to DN 600): as directed.
3. High-Performance Butterfly Valves: Single flange, Class 150 or Class 300 as directed.

3.4 CONDENSER-WATER VALVE SCHEDULE

A. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): As directed.
2. Iron, Single-Flange Butterfly Valves, NPS 14 to NPS 24 (DN 350 to DN 600): as directed
3. High-Performance Butterfly Valves: Single flange, Class 150 or Class 300 as directed.

3.5 HEATING-WATER VALVE SCHEDULE

A. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): As directed.
2. Iron, Single-Flange Butterfly Valves, NPS 14 to NPS 24 (DN 350 to DN 600): As directed.
3. High-Performance Butterfly Valves: Single flange, Class 150 or Class 300 as directed.

3.6 LOW-PRESSURE STEAM VALVE SCHEDULE (15 PSIG (104 kPa) OR LESS)

A. Pipe NPS 2-1/2 (DN 65) and Larger: High-performance butterfly valves, single flange, Class 150 or Class 300 as directed.

3.7 HIGH-PRESSURE STEAM VALVE SCHEDULE (MORE THAN 15 PSIG (104 kPa)

A. Pipe NPS 2-1/2 (DN 65) and Larger: High-performance butterfly valves, single flange, Class 150 or Class 300 as directed.

3.8 STEAM-CONDENSATE VALVE SCHEDULE

A. Pipe NPS 2-1/2 (DN 65) and Larger: High-performance butterfly valves, single flange, Class 150 or Class 300 as directed.

END OF SECTION 230523.13

SECTION 230523.14 - CHECK VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bronze lift check valves.
2. Bronze swing check valves.
3. Iron swing check valves.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

1. ASME B1.20.1 for threads for threaded-end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
4. ASME B16.18 for solder joint.
5. ASME B31.1 for power piping valves.
6. ASME B31.9 for building services piping valves.

C. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

D. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

E. Valve Sizes: Same as upstream piping unless otherwise indicated.

F. Valve Bypass and Drain Connections: MSS SP-45.

2.2 BRONZE SWING CHECK VALVES

A. Bronze Swing Check Valves with Bronze Disc, Class 125:

1. Description:

    a. Standard: MSS SP-80, Type 3.
    b. CWP Rating: 200 psig (1380 kPa).
    c. Body Design: Horizontal flow.
    d. Body Material: ASTM B62, bronze.
    e. Ends: Threaded.
    f. Disc: Bronze.

B. Bronze Swing Check Valves with Nonmetallic Disc, Class 125:
    1. Description:

        a. Standard: MSS SP-80, Type 4.
        b. CWP Rating: 200 psig (1380 kPa).
        c. Body Design: Horizontal flow.
        d. Body Material: ASTM B62, bronze.
        e. Ends: Threaded.
        f. Disc: PTFE.

C. Bronze Swing Check Valves with Bronze Disc, Class 150:
    1. Description:

        a. Standard: MSS SP-80, Type 3.
        b. CWP Rating: 300 psig (2070 kPa).
        c. Body Design: Horizontal flow.
        d. Body Material: ASTM B62, bronze.
        e. Ends: Threaded.
        f. Disc: Bronze.

D. Bronze Swing Check Valves with Nonmetallic Disc, Class 150:
    1. Description:

        a. Standard: MSS SP-80, Type 4.
        b. CWP Rating: 300 psig (2070 kPa).
        c. Body Design: Horizontal flow.
        d. Body Material: ASTM B62, bronze.
        e. Ends: Threaded.
        f. Disc: PTFE.

2.3 IRON SWING CHECK VALVES

A. Iron Swing Check Valves with Metal Seats, Class 125:
    1. Description:

        a. Standard: MSS SP-71, Type I.
        b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
        c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
        d. Body Design: Clear or full waterway.
        e. Body Material: ASTM A126, gray iron with bolted bonnet.
        f. Ends: Flanged.

g. Trim: Bronze.
h. Gasket: Asbestos free.

B. Iron Swing Check Valves with Nonmetallic-to-Metal Seats, Class 125:
1. Description:

a. Standard: MSS SP-71, Type I.
b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
d. Body Design: Clear or full waterway.
e. Body Material: ASTM A126, gray iron with bolted bonnet.
f. Ends: Flanged.
g. Trim: Composition.
h. Seat Ring: Bronze.
i. Disc Holder: Bronze.
j. Disc: PTFE.
k. Gasket: Asbestos free.

C. Iron Swing Check Valves with Metal Seats, Class 250:
1. Description:

a. Standard: MSS SP-71, Type I.
b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 500 psig (3450 kPa).
c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
d. Body Design: Clear or full waterway.
e. Body Material: ASTM A126, gray iron with bolted bonnet.
f. Ends: Flanged.
g. Trim: Bronze.
h. Gasket: Asbestos free.

2.4 IRON SWING CHECK VALVES WITH CLOSURE CONTROL

A. Iron Swing Check Valves with Lever- and Spring-Closure Control, Class 125:
1. Description:

a. Standard: MSS SP-71, Type I.
b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
d. Body Design: Clear or full waterway.
e. Body Material: ASTM A126, gray iron with bolted bonnet.
f. Ends: Flanged.
g. Trim: Bronze.
h. Gasket: Asbestos free.
i. Closure Control: Factory-installed, exterior lever and spring.

B. Iron Swing Check Valves with Lever and Weight-Closure Control, Class 125:
1. Description:

a. Standard: MSS SP-71, Type I.
b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).

c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
d. Body Design: Clear or full waterway.
e. Body Material: ASTM A126, gray iron with bolted bonnet.
f. Ends: Flanged.
g. Trim: Bronze.
h. Gasket: Asbestos free.
i. Closure Control: Factory-installed, exterior lever and weight.

PART 3 - EXECUTION

3.1 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install swing check valves for proper direction of flow in horizontal position with hinge pin level.

3.2 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:

1. Pump-Discharge Check Valves:

a. NPS 2 (DN 50) and Smaller: Bronze swing check valves with bronze or nonmetallic disc.
b. NPS 2-1/2 (DN 65) and Larger: Iron swing check valves with lever and weight or with spring; metal or resilient-seat check valves.

B. If valves with specified SWP classes or CWP ratings are unavailable, the same types of valves with higher SWP classes or CWP ratings may be substituted.

C. Select valves, except wafer types, with the following end connections:

1. For Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules.

2. For Copper Tubing, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules.
3. For Copper Tubing, NPS 5 (DN 125) and Larger: Flanged ends.
4. For Steel Piping, NPS 2 (DN 50) and Smaller: Threaded ends.
5. For Steel Piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules.
6. For Steel Piping, NPS 5 (DN 125) and Larger: Flanged ends.

3.4 CHILLED-WATER VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:

1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
2. Bronze swing check valves with bronze or nonmetallic disc as directed, Class 125 or Class 150 as directed.

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Iron Valves, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): May be provided with threaded ends instead of flanged ends.
2. NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Iron swing check valves with lever and spring or weight closure control as directed, Class 125.
3. Iron swing check valves with metal or nonmetallic-to-metal seats as directed, Class 125 or Class 250 as directed.

3.5 CONDENSER-WATER VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:

1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
2. Bronze swing check valves with bronze or nonmetallic disc as directed, Class 125 or Class 150 as directed.

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Iron Valves, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): May be provided with threaded ends instead of flanged ends.
2. NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Iron swing check valves with lever and spring or weight-closure control, Class 125 as directed.
3. Iron swing check valves with metal or nonmetallic-to-metal seats, Class 125 or Class 250 as directed.

3.6 HEATING-WATER VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:

1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
2. Bronze swing check valves with bronze or nonmetallic disc, Class 125 Class 150 as directed.

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Iron Valves, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): May be provided with threaded ends instead of flanged ends.
2. NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Iron swing check valves with lever and spring or weight-closure control, Class 125 as directed.
3. Iron swing check valves with metal or nonmetallic-to-metal seats, Class 125 or Class 250 as directed.

3.7 LOW-PRESSURE STEAM VALVE SCHEDULE (15 PSIG (104 kPa) OR LESS)

A. Pipe NPS 2 (DN 50) and Smaller:

1. Bronze swing check valves with bronze or nonmetallic disc as directed, Class 125 or Class 150 as directed.

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Iron Valves, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): May be provided with threaded ends instead of flanged ends.
2. NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Iron swing check valves with lever and spring or weight-closure control, Class 125 as directed.
3. Iron swing check valves with metal or nonmetallic-to-metal seats, Class 125 or Class 250 as directed.

3.8 HIGH-PRESSURE STEAM VALVE SCHEDULE (MORE THAN 15 PSIG (104 kPa)

A. Pipe NPS 2 (DN 50) and Smaller:

1. Bronze swing check valves with bronze or nonmetallic disc, Class 125 or Class 150 as directed.

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Iron Valves, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): May be provided with threaded ends instead of flanged ends.
2. NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Iron swing check valves with lever and spring or weight-closure control, Class 125 as directed.
3. Iron swing check valves with metal or nonmetallic-to-metal seats, Class 125 or Class 250 as directed.

3.9 STEAM-CONDENSATE VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:

B. Bronze swing check valves with bronze or nonmetallic disc, Class 125 or Class 150 as directed.

C. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Iron Valves, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): May be provided with threaded ends instead of flanged ends.
2. NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Iron swing check valves with lever and spring or weight-closure control, Class 125 as directed.
3. Iron swing check valves with metal or nonmetallic-to-metal seats, Class 125 or Class 250 as directed.

END OF SECTION 230523.14

SECTION 230523.15 - GATE VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bronze gate valves.
2. Iron gate valves.
3. Chainwheels.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

1. ASME B1.20.1 for threads for threaded-end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
4. ASME B16.18 for solder joint.
5. ASME B31.1 for power piping valves.
6. ASME B31.9 for building services piping valves.

C. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.

D. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

E. Valve Sizes: Same as upstream piping unless otherwise indicated.

F. RS Valves in Insulated Piping: With 2-inch (50-mm) stem extensions.

G. Valve Bypass and Drain Connections: MSS SP-45.

2.2 BRONZE GATE VALVES

A. Bronze Gate Valves, NRS, Class 125:
   1. Description:

      a. Standard: MSS SP-80, Type 1.
      b. CWP Rating: 200 psig (1380 kPa).
      c. Body Material: ASTM B62, bronze with integral seat and screw-in bonnet.
      d. Ends: Threaded or solder joint.
      e. Stem: Bronze.
      f. Disc: Solid wedge; bronze.
      g. Packing: Asbestos free.
      h. Handwheel: Malleable iron, bronze, or aluminum.

B. Bronze Gate Valves, RS, Class 125:
   1. Description:

      a. Standard: MSS SP-80, Type 2.
      b. CWP Rating: 200 psig (1380 kPa).
      c. Body Material: ASTM B62, bronze with integral seat and screw-in bonnet.
      d. Ends: Threaded or solder joint.
      e. Stem: Bronze.
      f. Disc: Solid wedge; bronze.
      g. Packing: Asbestos free.
      h. Handwheel: Malleable iron, bronze, or aluminum.

C. Bronze Gate Valves, NRS, Class 150:
   1. Description:

      a. Standard: MSS SP-80, Type 1.
      b. CWP Rating: 300 psig (2070 kPa).
      c. Body Material: ASTM B62, bronze with integral seat and union-ring bonnet.
      d. Ends: Threaded.
      e. Stem: Bronze.
      f. Disc: Solid wedge; bronze.
      g. Packing: Asbestos free.
      h. Handwheel: Malleable iron, bronze, or aluminum.

D. Bronze Gate Valves, RS, Class 150:
   1. Description:

      a. Standard: MSS SP-80, Type 2.
      b. CWP Rating: 300 psig (2070 kPa).
      c. Body Material: ASTM B62, bronze with integral seat and union-ring bonnet.
      d. Ends: Threaded.
      e. Stem: Bronze.
      f. Disc: Solid wedge; bronze.
      g. Packing: Asbestos free.
      h. Handwheel: Malleable iron, bronze, or aluminum.

2.3 IRON GATE VALVES

A. Iron Gate Valves, NRS, Class 125:
   1. Description:

      a. Standard: MSS SP-70, Type I.
      b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
      c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
      d. Body Material: ASTM A126, gray iron with bolted bonnet.
      e. Ends: Flanged.
      f. Trim: Bronze.
      g. Disc: Solid wedge.
      h. Packing and Gasket: Asbestos free.

B. Iron Gate Valves, OS&Y, Class 125:
   1. Description:

      a. Standard: MSS SP-70, Type I.
      b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
      c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
      d. Body Material: ASTM A126, gray iron with bolted bonnet.
      e. Ends: Flanged.
      f. Trim: Bronze.
      g. Disc: Solid wedge.
      h. Packing and Gasket: Asbestos free.

C. Iron Gate Valves, NRS, Class 250:
   1. Description:

      a. Standard: MSS SP-70, Type I.
      b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 500 psig (3450 kPa).
      c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
      d. Body Material: ASTM A126, gray iron with bolted bonnet.
      e. Ends: Flanged.
      f. Trim: Bronze.
      g. Disc: Solid wedge.
      h. Packing and Gasket: Asbestos free.

D. Iron Gate Valves, OS&Y, Class 250:
   1. Description:

      a. Standard: MSS SP-70, Type I.
      b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 500 psig (3450 kPa).
      c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
      d. Body Material: ASTM A126, gray iron with bolted bonnet.
      e. Ends: Flanged.
      f. Trim: Bronze.
      g. Disc: Solid wedge.
      h. Packing and Gasket: Asbestos free.

2.4 CHAINWHEELS

A. Description: Valve actuation assembly with sprocket rim, chain guides, chain, and attachment brackets for mounting chainwheels directly to hand wheels.

1. Sprocket Rim with Chain Guides: Ductile iron, of type and size required for valve. Include zinc or epoxy coating.
2. Chain: Hot-dip-galvanized steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install chainwheels on operators for gate valves NPS 4 (DN 100) and larger and more than 96 inches (2400 mm) above floor. Extend chains to 60 inches (1520 mm) above finished floor.

3.2 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:

1. Shutoff Service: Gate valves.

B. If valves with specified SWP classes or CWP ratings are unavailable, the same types of valves with higher SWP classes or CWP ratings may be substituted.

C. Select valves, except wafer types, with the following end connections:

1. For Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded ends, except where solder-joint valve-end option is indicated in valve schedules below.
2. For Copper Tubing, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends, except where threaded valve-end option is indicated in valve schedules below.
3. For Copper Tubing, NPS 5 (DN 125) and Larger: Flanged ends.
4. For Steel Piping, NPS 2 (DN 50) and Smaller: Threaded ends.

5. For Steel Piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends, except where threaded valve-end option is indicated in valve schedules below.
6. For Steel Piping, NPS 5 (DN 125) and Larger: Flanged ends.

3.4 CHILLED-WATER VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller: Bronze valves, as directed.

B. Pipe NPS 2-1/2 (DN 65) and Larger: Iron gate valves, as directed.

3.5 CONDENSER-WATER VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller: Bronze valves, as directed.

B. Pipe NPS 2-1/2 (DN 65) and Larger: Iron gate valves, as directed.

3.6 HEATING-WATER VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller: Bronze valves, as directed.

B. Pipe NPS 2-1/2 (DN 65) and Larger: Iron gate valves, as directed.

3.7 LOW-PRESSURE STEAM VALVE SCHEDULE (15 PSIG (104 kPa) OR LESS)

A. Pipe NPS 2 (DN 50) and Smaller: Bronze gate valves, as directed.

B. Pipe NPS 2-1/2 (DN 65) and Larger: Iron gate valves, as directed.

3.8 HIGH-PRESSURE STEAM VALVE SCHEDULE (MORE THAN 15 PSIG (104 kPa)

A. Pipe NPS 2 (DN 50) and Smaller: Bronze gate valves, as directed.

B. Pipe NPS 2-1/2 (DN 65) and Larger: Iron gate valves, as directed.

3.9 STEAM-CONDENSATE VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller: Bronze gate valves, as directed.

B. Pipe NPS 2-1/2 (DN 65) and Larger: Iron gate valves, as directed.

END OF SECTION 230523.15

SECTION 230523.16 - PLUG VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Lubricated plug valves.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

1. ASME B1.20.1 for threads for threaded-end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
4. ASME B31.1 for power piping valves.
5. ASME B31.9 for building services piping valves.

C. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.

D. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

E. Valve Sizes: Same as upstream piping unless otherwise indicated.

F. Valve Actuator Types: Wrench. Furnish Owner with one wrench for every five or 10 plug valves, for each size square plug-valve head as directed.

2.2 LUBRICATED PLUG VALVES

A. Class 125, Lubricated Plug Valves with Threaded Ends:
1. Description:

a. Standard: MSS SP-78, Type I single gland.

b. NPS 2-1/2 to NPS 4 (DN 65 to DN 100), CWP Rating: 200 psig (1380 kPa).
c. Body Material: ASTM A48/A48M or ASTM A126, cast iron with lubrication-sealing system.
d. Pattern: Regular or short venturi.
e. Plug: Cast iron or bronze with sealant groove.

B. Class 125, Lubricated Plug Valves with Flanged Ends:
1. Description:

a. Standard: MSS SP-78, Type I single gland or Type II regular gland.
b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
d. Body Material: ASTM A48/A48M or ASTM A126, cast iron with lubrication-sealing system.
e. Pattern: Regular or short venturi.
f. Plug: Cast iron or bronze with sealant groove.

C. Class 125, Cylindrical, Lubricated Plug Valves with Threaded Ends:
1. Description:

a. Standard: MSS SP-78, Type IV.
b. NPS 2-1/2 to NPS 4 (DN 65 to DN 100), CWP Rating: 200 psig (1380 kPa).
c. Body Material: ASTM A48/A48M or ASTM A126, cast iron with lubrication-sealing system.
d. Pattern: Regular or short venturi.
e. Plug: Cast iron or bronze with sealant groove.

D. Class 125, Cylindrical, Lubricated Plug Valves with Flanged Ends:
1. Description:

a. Standard: MSS SP-78, Type IV.
b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
c. Body Material: ASTM A48/A48M or ASTM A126, cast iron with lubrication-sealing system.
d. Pattern: Regular or short venturi.
e. Plug: Cast iron or bronze with sealant groove.

E. Class 250, Lubricated Plug Valves with Threaded Ends:
1. Description:

a. Standard: MSS SP-78, Type I single gland or Type II regular gland as directed.
b. NPS 2-1/2 to NPS 4 (DN 65 to DN 100), CWP Rating: 400 psig (2760 kPa).
c. Body Material: ASTM A48/A48M or ASTM A126, cast iron with lubrication-sealing system.
d. Pattern: Regular or short venturi.
e. Plug: Cast iron or bronze with sealant groove.

F. Class 250, Lubricated Plug Valves with Flanged Ends:
1. Description:

a. Standard: MSS SP-78, Type I single gland or Type II regular gland as directed.
b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 400 psig (2760 kPa).
c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
d. Body Material: ASTM A48/A48M or ASTM A126, cast iron with lubrication-sealing system.
e. Pattern: Regular or short venturi.
f. Plug: Cast iron or bronze with sealant groove.

G. Class 250, Cylindrical, Lubricated Plug Valves with Threaded Ends:
1. Description:

a. Standard: MSS SP-78, Type IV.
b. NPS 2-1/2 to NPS 4 (DN 65 to DN 100), CWP Rating: 400 psig (2760 kPa).
c. Body Material: ASTM A48/A48M or ASTM A126, cast iron with lubrication-sealing system.
d. Pattern: Regular or short venturi.
e. Plug: Cast iron or bronze with sealant groove.

H. Class 250, Cylindrical, Lubricated Plug Valves with Flanged Ends:
1. Description:

a. Standard: MSS SP-78, Type IV.
b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 400 psig (2760 kPa).
c. Body Material: ASTM A48/A48M or ASTM A126, Grade 40 cast iron with lubrication-sealing system.
d. Pattern: Regular or short venturi.
e. Plug: Cast iron or bronze with sealant groove.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install chainwheels on operators for plug valves NPS 4 (DN 100) and larger and more than 96 inches (2400 mm) above floor. Extend chains to 60 inches (1520 mm) above finished floor.

3.3 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:

1. Shutoff Service: Plug valves.

B. If valves with CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.

C. Select valves with the following end connections:

1. For Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded ends.
2. For Copper Tubing, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules.
3. For Copper Tubing, NPS 5 (DN 125) and Larger: Flanged ends.
4. For Steel Piping, NPS 2 (DN 50) and Smaller: Threaded ends.
5. For Steel Piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules.
6. For Steel Piping, NPS 5 (DN 125) and Larger: Flanged ends.
7. For Grooved-End Copper Tubing and Steel Piping except Steam and Steam Condensate Piping: Valve ends may be grooved.

3.5 HOT-WATER AND CHILLED-WATER VALVE SCHEDULE

A. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Lubricated Plug Valves: As directed

3.6 CONDENSER-WATER VALVE SCHEDULE

A. Pipe NPS 2-1/2 (DN 65) and Larger: Lubricated plug valves, as directed.

3.7 STEAM-CONDENSATE VALVE SCHEDULE

A. Pipe NPS 2-1/2 (DN 65) and Larger: Lubricated plug valves, as directed.

END OF SECTION 230523.16

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Thermal-hanger shield inserts.
4. Fastener systems.
5. Equipment supports.

B. Related Requirements:

1. Section 055000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Section 230516 "Expansion Fittings and Loops for HVAC Piping" for pipe guides and anchors.
3. Section 230548 "Vibration and Seismic Controls for HVAC" or Section 230548.13 "Vibration Controls for HVAC" for vibration isolation devices or as directed.
4. Section 233113 "Metal Ducts" and Section 233116 "Nonmetal Ducts" for duct hangers and supports.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following; include Product Data for components:

1. Trapeze pipe hangers.
2. Equipment supports.

D. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of trapeze hangers.
2. Include design calculations for designing trapeze hangers.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.4 QUALITY ASSURANCE

A. Structural-Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code, Section IX.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design trapeze pipe hangers and equipment supports.

B. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

2.2 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized, hot-dip galvanized, or electro-galvanized.
3. Nonmetallic Coatings: Plastic coated, or epoxy powder-coated.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel or stainless steel as directed.

B. Stainless-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

C. Copper Pipe and Tube Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-plated steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-plated steel or stainless steel as directed.

2.3 TRAPEZE PIPE HANGERS

A. Description: MSS SP-58, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.4 THERMAL-HANGER SHIELD INSERTS

A. Insulation-Insert Material for Cold Piping: ASTM C552, Type II cellular glass with 100-psi (688-kPa) or ASTM C591, Type VI, Grade 1 polyisocyanurate with 125-psi (862-kPa) minimum compressive strength and vapor barrier.

B. Insulation-Insert Material for Hot Piping: Water-repellent-treated, ASTM C533, Type I calcium silicate with 100-psi (688-kPa) ASTM C552, Type II cellular glass with 100-psi (688-kPa) or ASTM C591, Type VI, Grade 1 polyisocyanurate with 125-psi (862-kPa) minimum compressive strength.

C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

E. Insert Length: Extend 2 inches (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated or stainless-steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.6 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.7 MATERIALS

A. Aluminum: ASTM B221 (ASTM B221M).

B. Carbon Steel: ASTM A1011/A1011M.

C. Structural Steel: ASTM A36/A36M, carbon-steel plates, shapes, and bars; black and galvanized.

D. Stainless Steel: ASTM A240/A240M.

E. Grout: ASTM C1107/C1107M, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).

3.2 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A36/A36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Fiberglass Pipe-Hanger Installation: Comply with applicable portions of MSS SP-58. Install hangers and attachments as required to properly support piping from building structure.

D. Metal or Fiberglass Framing System Installation as directed: Arrange for grouping of parallel runs of piping, and support together on field-assembled strut systems.

E. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

F. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

G. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.

H. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

I. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

J. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

K. Install lateral bracing with pipe hangers and supports to prevent swaying.

L. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 (DN 65) and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

M. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

N. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

O. Insulated Piping:

1. Attach clamps and spacers to piping.

    a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
    b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
    c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

    a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

    a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:

    a. NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
    b. NPS 4 (DN 100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
    c. NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.
    d. NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.
    e. NPS 16 to NPS 24 (DN 400 to DN 600): 24 inches (610 mm) long and 0.105 inch (2.67 mm) thick.

5. Pipes NPS 8 (DN 200) and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make bearing surface smooth.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches (40 mm).

3.6 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils (0.05 mm).

B. Touchup: Comply with requirements in Section 099113 "Exterior Painting", Section 099123 "Interior Painting" and Section 099600 "High-Performance Coatings" for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780/A780M.

3.7 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use carbon-steel pipe hangers and supports, metal trapeze pipe hangers and metal framing systems and attachments for general service applications.

F. Use stainless-steel pipe hangers and fiberglass pipe hangers and fiberglass strut systems and stainless-steel or corrosion-resistant attachments for hostile environment applications.

G. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing as directed.

H. Use padded hangers for piping that is subject to scratching.

I. Use thermal-hanger shield inserts for insulated piping and tubing.

J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F (566 deg C), pipes NPS 4 to NPS 24 (DN 100 to DN 600), requiring up to 4 inches (100 mm) of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36 (DN 20 to DN 900), requiring clamp flexibility and up to 4 inches (100 mm) of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 (DN 15 to DN 600) if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4 (DN 15 to DN 100), to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8 (DN 20 to DN 200).
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8 (DN 10 to DN 200).
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3 (DN 10 to DN 80).
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 (DN 65 to DN 900) if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.

17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30 (DN 25 to DN 750), from two rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24 (DN 65 to DN 600), from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 (DN 50 to DN 1050) if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is unnecessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 (DN 50 to DN 600) if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is unnecessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 (DN 50 to DN 750) if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24 (DN 24 to DN 600).
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 (DN 20 to DN 600) if longer ends are required for riser clamps.

L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches (150 mm) for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F (49 to 232 deg C) piping installations.

M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.

7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb (340 kg).
    b. Medium (MSS Type 32): 1500 lb (680 kg).
    c. Heavy (MSS Type 33): 3000 lb (1360 kg).

13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches (32 mm).
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include

auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

a. Horizontal (MSS Type 54): Mounted horizontally.
b. Vertical (MSS Type 55): Mounted vertically.
c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

P. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

Q. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION 230529

SECTION 230533 - HEAT TRACING FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes heat tracing for HVAC piping with the following electric heating cables:

1. Plastic insulated, series resistance.
2. Self-regulating, parallel resistance.

B. Related Requirements:

1. Section 210533 "Heat Tracing for Fire-Suppression Piping."
2. Section 220533 "Heat Tracing for Plumbing Piping."

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For electric heating cable.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace electric heating cable that fails in materials or workmanship within specified warranty period.

1. Warranty Period: Three or Five years from date of Substantial Completion as directed.

PART 2 - PRODUCTS

2.1 PLASTIC-INSULATED, SERIES-RESISTANCE HEATING CABLES

A. Comply with IEEE 515.1.

B. Heating Element: Single- or dual-stranded resistor wire. Terminate with waterproof, factory-assembled, nonheating leads with connectors at both ends.

C. Electrical Insulating Jacket: Minimum 4.0-mil (0.10-mm) Kapton with silicone, Tefzel, or polyolefin.

D. Cable Cover: Aluminum braid and silicone or Hylar outer jacket.

E. Maximum Operating Temperature (Power On): 150 deg F (65 deg C).

F. Maximum Exposure Temperature (Power Off): 185 deg F (85 deg C).

G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

H. Capacities and Characteristics:

1. Maximum Heat Output: 6 W/ft. (19.7 W/m) or 7.5 W/ft. (24.6 W/m) maximum as directed.
2. Piping Diameter: As directed.
3. Number of Parallel Cables: As directed.
4. Spiral Wrap Pitch: As directed.
5. Electrical Characteristics for Single-Circuit Connection:

    a. Volts: As directed.
    b. Phase: As directed.
    c. Hertz: As directed.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed.
    f. Maximum Overcurrent Protection: As directed.

2.2 SELF-REGULATING, PARALLEL-RESISTANCE HEATING CABLES

A. Comply with IEEE 515.1.

B. Heating Element: Pair of parallel No. 16 or No. 18 AWG as directed, tinned or nickel-coated as directed, stranded copper bus wires embedded in crosslinked conductive polymer core, which varies heat output in response to temperature along its length. Terminate with waterproof, factory-assembled, nonheating leads with connectors at one end, and seal the opposite end watertight. Cable shall be capable of crossing over itself once without overheating.

C. Electrical Insulating Jacket: Flame-retardant polyolefin.

D. Cable Cover: As directed.

E. Maximum Operating Temperature (Power On): 150 deg F (65 deg C).

F. Maximum Exposure Temperature (Power Off): 185 deg F (85 deg C).

G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

H. Capacities and Characteristics:

1. Maximum Heat Output: As directed
2. Piping Diameter: As directed.
3. Number of Parallel Cables: As directed.
4. Spiral Wrap Pitch: As directed.
5. Electrical Characteristics for Single-Circuit Connection:

a. Volts: As directed.
b. Phase: As directed.
c. Hertz: As directed.
d. Full-Load Amperes: As directed.
e. Minimum Circuit Ampacity: As directed.
f. Maximum Overcurrent Protection: As directed.

2.3 CONTROLS

A. Remote bulb unit with adjustable temperature range from 30 to 50 deg F (minus 1 to plus 10 deg C).

B. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected cable.

C. Remote bulb on capillary, resistance temperature device, or thermistor for directly sensing pipe-wall temperature.

D. Corrosion-resistant, waterproof control enclosure.

2.4 ACCESSORIES

A. Cable Installation Accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer.

B. Warning Labels: Refer to Section 230553 "Identification for HVAC Piping and Equipment."

C. Warning Tape: Continuously printed "Electrical Tracing"; vinyl, at least 3 mils (0.08 mm) thick, and with pressure-sensitive, permanent, waterproof, self-adhesive back.

1. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches (150 mm): 3/4 inch (19 mm) minimum.
2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches (150 mm) or Larger: 1-1/2 inches (38 mm) minimum.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install electric heating cable across expansion joints according to manufacturer's written instructions; use slack cable to allow movement without damage to cable.

B. Install electric heating cables after piping has been tested and before insulation is installed.

C. Install electric heating cables according to IEEE 515.1.

D. Install insulation over piping with electric cables according to Section 230719 "HVAC Piping Insulation."

E. Install warning tape on piping insulation where piping is equipped with electric heating cables.

F. Set field-adjustable switches and circuit-breaker trip ranges.

G. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

H. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform tests after cable installation but before application of coverings such as insulation, wall or ceiling construction, or concrete.
2. Test cables for electrical continuity and insulation integrity before energizing.
3. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.

B. Repeat tests for continuity, insulation resistance, and input power after applying thermal insulation on pipe-mounted cables.

C. Cables will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

E. Remove and replace damaged heat-tracing cables.

END OF SECTION 230533

SECTION 230548 - VIBRATION AND SEISMIC CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Open-spring isolators.
5. Housed-spring isolators.
6. Restrained-spring isolators.
7. Housed-restrained-spring isolators.
8. Pipe-riser resilient supports.
9. Resilient pipe guides.
10. Elastomeric hangers.
11. Spring hangers.
12. Snubbers.
13. Restraint channel bracings.
14. Restraint cables.
15. Seismic-restraint accessories.
16. Mechanical anchor bolts.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Delegated-Design Submittal: For each vibration isolation and seismic-restraint device.

1. Include design calculations and details for selecting vibration isolators and seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

B. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are unavailable, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Wind-Restraint Loading:

1. Basic Wind Speed: As directed.
2. Building Classification Category: As directed.
3. Minimum 10 lb/sq. ft. (48.8 kg/sq. m) multiplied by maximum area of HVAC component projected on vertical plane normal to wind direction, and 45 degrees either side of normal.

B. Seismic-Restraint Loading:

1. Site Class as Defined in the IBC:
2. Assigned Seismic Use Group or Building Category as Defined in the IBC: As directed.

    a. Component Importance Factor: 1.0 or 1.5 as directed.
    b. Component Response Modification Factor: As directed.
    c. Component Amplification Factor: 1.0 or 2.5 as directed.

3. Design Spectral Response Acceleration at Short Periods (0.2 Second): As directed.
4. Design Spectral Response Acceleration at 1.0-Second Period: As directed.

2.2 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads: As directed.
1. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
2. Size: Factory or field cut to match requirements of supported equipment.
3. Pad Material: Oil and water resistant with elastomeric properties.
4. Surface Pattern: As directed.
5. Infused nonwoven cotton or synthetic fibers.
6. Load-bearing metal plates adhered to pads.

2.3 ELASTOMERIC ISOLATION MOUNTS

A. Double-Deflection, Elastomeric Isolation Mounts: As directed.
   1. Mounting Plates:
      a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.
      b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.
   2. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.4 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts: As directed.
   1. Description: All-directional isolator with seismic restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
      a. Housing: Cast-ductile iron or welded steel.
      b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.5 OPEN-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators: As directed.
   1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   5. Baseplates: Factory-drilled steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates shall limit floor load to 500 psig (3447 kPa).
   6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

2.6 HOUSED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing:
   1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

5. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.

    a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig (3447 kPa).
    b. Top housing as directed.

2.7 RESTRAINED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint:
    1. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.

        a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig (3447 kPa).
        b. Top plate with threaded mounting holes or elastomeric pad as directed.
        c. Internal leveling bolt that acts as blocking during installation.

    2. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
    3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
    4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
    5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
    6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.8 HOUSED-RESTRAINED-SPRING ISOLATORS

A. Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing:
    1. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with adjustable or non-adjustable snubbers to limit vertical movement as directed.

        a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig (3447 kPa).
        b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.

    2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
    3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
    4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
    5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.9 PIPE-RISER RESILIENT SUPPORT

A. Description: All-directional, acoustical pipe anchor consisting of two steel tubes separated by a minimum 1/2-inch- (13-mm-) thick neoprene.

1. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
2. Maximum Load Per Support: 500 psig (3.45 MPa) on isolation material providing equal isolation in all directions.

2.10 RESILIENT PIPE GUIDES

A. Description: Telescopic arrangement of two steel tubes or post and sleeve arrangement separated by a minimum 1/2-inch- (13-mm-) thick neoprene.

1. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.11 ELASTOMERIC HANGERS

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods:
1. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
2. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.12 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression:
1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
8. Self-centering hanger-rod cap to ensure concentricity between hanger rod and support spring coil.

2.13 SNUBBERS

A. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
3. Maximum 1/4-inch (6-mm) air gap, and minimum 1/4-inch- (6-mm-) thick resilient cushion.

2.14 RESTRAINT CHANNEL BRACINGS

A. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.15 RESTRAINT CABLES

A. Restraint Cables: ASTM A603 galvanized or ASTM A492 stainless-steel cables as directed. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.16 SEISMIC-RESTRAINT ACCESSORIES

A. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or Reinforcing steel angle clamped to hanger rod.

B. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

C. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings and matched to type and size of attachment devices used.

D. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

E. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application as directed.

B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry present and future static and seismic loads within specified loading limits.

3.2 VIBRATION CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed

B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

C. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

D. Equipment Restraints:

1. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
3. Install seismic-restraint devices using methods approved as directed that provides required submittals for component.

E. Piping Restraints:

1. Comply with requirements in MSS SP-127.
2. Space lateral supports a maximum of 40 feet (12 m) o.c., and longitudinal supports a maximum of 80 feet (24 m) o.c.
3. Brace a change of direction longer than 12 feet (3.7 m).

F. Install cables so they do not bend across edges of adjacent equipment or building structure.

G. Install seismic-restraint devices using methods approved as directed that provides required submittals for component.

H. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

I. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

J. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

K. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.3 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 232113 "Hydronic Piping" for piping flexible connections.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage or Engage a qualified testing agency to perform tests and inspections as directed.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.

3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust limit stops on restrained-spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

END OF SECTION 230548

SECTION 230548.13 - VIBRATION CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Open-spring isolators.
5. Housed-spring isolators.
6. Restrained-spring isolators.
7. Housed-restrained-spring isolators.
8. Pipe-riser resilient supports.
9. Resilient pipe guides.
10. Elastomeric hangers.
11. Spring hangers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Delegated-Design Submittal: For each vibration isolation device.

1. Include design calculations for selecting vibration isolators.

PART 2 - PRODUCTS

2.1 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:
1. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
2. Size: Factory or field cut to match requirements of supported equipment.
3. Pad Material: Oil and water resistant with elastomeric properties.
4. Surface Pattern: As directed.
5. Infused nonwoven cotton or synthetic fibers.
6. Load-bearing metal plates adhered to pads.

2.2 ELASTOMERIC ISOLATION MOUNTS

A. Double-Deflection, Elastomeric Isolation Mounts:
1. Mounting Plates:

a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.
b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.

2. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.3 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts:
1. Description: All-directional isolator with restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.

a. Housing: Cast-ductile iron or welded steel.
b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.4 OPEN-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators:
1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Baseplates: Factory-drilled steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates shall limit floor load to 500 psig (3447 kPa).
6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

2.5 HOUSED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing:
1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.

a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig (3447 kPa).
b. Top housing as directed.

2.6 RESTRAINED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint:
   1. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.
      a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig (3447 kPa).
      b. Top plate with threaded mounting holes or elastomeric pad as directed.
      c. Internal leveling bolt that acts as blocking during installation.
   2. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
   3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.7 HOUSED-RESTRAINED-SPRING ISOLATORS

A. Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing:
   1. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with adjustable or non-adjustable snubbers to limit vertical movement as directed.
      a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psig (3447 kPa).
      b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.
   2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.8 PIPE-RISER RESILIENT SUPPORT

A. Description: All-directional, acoustical pipe anchor consisting of two steel tubes separated by a minimum 1/2-inch- (13-mm-) thick neoprene
   1. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
   2. Maximum Load Per Support: 500 psig (3.45 MPa)on isolation material providing equal isolation in all directions.

2.9 RESILIENT PIPE GUIDES

A. Description: Telescopic arrangement of two steel tubes or post and sleeve arrangement separated by a minimum 1/2-inch- (13-mm-) thick neoprene

1. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.10 ELASTOMERIC HANGERS

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods:
1. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
2. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.11 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression:
1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
8. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

PART 3 - EXECUTION

3.1 VIBRATION CONTROL DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed

B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

END OF SECTION 230548.13

SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Duct labels.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Material and Thickness: As directed.
2. Letter Color: As directed.
3. Background Color: As directed.
4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
5. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
6. Fasteners: Stainless-steel rivets or self-tapping screws.
7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch (1.6 mm) or 1/8 inch (3.2 mm) thick as directed and having predrilled holes for attachment hardware.
2. Letter Color: As directed.
3. Background Color: As directed.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
6. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm),

and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch (A4) bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch (1.6 mm) or 1/8 inch (3.2 mm) thick as directed and having predrilled holes for attachment hardware.

B. Letter Color: As directed.

C. Background Color: As directed.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).

F. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction according to ASME A13.1.

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover or cover full circumference as directed of pipe and to attach to pipe without fasteners or adhesive.

C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: Size letters according to ASME A13.1 for piping or At least 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm) and proportionately larger lettering for greater viewing distances as directed.

2.4 DUCT LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch (1.6 mm) or 1/8 inch (3.2 mm) thick as directed and having predrilled holes for attachment hardware.

B. Letter Color: As directed

C. Background Color: As directed

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).

F. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings; also include duct size and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions or as separate units on each duct label to indicate flow direction.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.3 PIPE LABEL INSTALLATION

A. Piping Color-Coding: Painting of piping is specified in Section 099123 "Interior Painting" or Section 099600 "High-Performance Coatings" as directed

B. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet (15 m) along each run. Reduce intervals to 25 feet (7.6 m) in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

C. Pipe Label Color Schedule:

1. Chilled-Water Piping: White letters on a safety-green background orBlack letters on a safety-orange background as directed.
2. Condenser-Water Piping: White letters on a safety-green background or Black letters on a safety-orange background as directed.
3. Heating Water Piping: White letters on a safety-green background or Black letters on a safety-orange background as directed.
4. Refrigerant Piping: As directed.
5. Low-Pressure Steam Piping: As directed.
6. High-Pressure Steam Piping: As directed.
7. Steam Condensate Piping: As directed.

3.4 DUCT LABEL INSTALLATION

A. Install plastic-laminated or self-adhesive duct labels as directed with permanent adhesive on air ducts in the following color codes:

1. Blue: For cold-air supply ducts.
2. Yellow: For hot-air supply ducts.
3. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.

B. Locate labels near points where ducts enter into and exit from concealed spaces and at maximum intervals of 50 feet (15 m) in each space where ducts are exposed or concealed by removable ceiling system.

END OF SECTION 230553

SECTION 230566 - ANTIMICROBIAL ULTRAVIOLET LAMP SYSTEMS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. UV-C lamp systems for packaged air-handling units.
2. Controls.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: For each UV-C lamp system.

1. Include plans, elevations, sections, mounting, and attachment details.
2. Include details of UV-C lamp system assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Elevations and sections, drawn to scale and coordinated with each other, using input from installers of the items involved.

B. Contractor's Construction Schedule.

C. Application for Payment and schedule of values.

D. Product Certificates: For each type of UV lamp, fixture, and system.

E. Product test reports.

F. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

1. Warranty Period, System: Five years from date of Substantial Completion.
2. Warranty Period, Lamp: One year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE Compliance:

1. Test UV-C lamp systems according to ASHRAE 185.1, "Method of Testing UV-C Lights for Use in Air-Handling Units or Air Ducts to Inactivate Airborne Microorganisms."
2. Test UV-C lamp systems according to ASHRAE 185.2, "Method of Testing Ultraviolet Lamps for Use in HVAC&R Units or Air Ducts on Irradiated Surfaces."

2.2 MANUFACTURERS

2.3 ANTIMICROBIAL UV-C LAMP SYSTEMS FOR PACKAGED AIR-HANDLING UNITS

A. Description: Factory-assembled UV-C lamp system with NEMA 4X power supply housing, four each, 1/2- or 3/4-inch (12.7- or 19-mm) electrical knock-outs, power supply with integrated lamp plug, lamp compression nut, and UV lamp.

B. Power Supply: UL listed, single phase, 120 or 240 V ac, 50 or 60 Hz, with a programmed rapid start.

1. Power Factor: High power factor, Class P, Sound Rated A, Type 1 Outdoor, and with inherent thermal protection and without polychlorinated biphenyl.
2. Output: Automatically sense and maximize lamp output, energy efficiency, and reliability for lamp lengths from 17 to 61 inches (432 to 1549 mm).
3. Operating Temperature: From 34 to 194 deg F (1 to 90 deg C).
4. Safety: Integral interlock switch on power supply.
5. Power Consumption: Maximum 15 W/sq. ft. (161.5 W/sq. m).
6. Electrical Connection: Single electrical connection with service disconnect.

C. UV-C Lamps: Encapsulated lamps with lamp wattage and model number visibly printed on all lamps, less than 8 Mg of mercury in each lamp. Lamps do not produce ozone.

1. Quantity and Type: One or T5, hot cathode, single-ended, four pin as directed.
2. Output: UV-C energy, primarily at 253.7-nm wavelength with a 360-degree energy distribution.
3. Base: Long-mount base lamp. Lamp filament extends into the airstream beyond plenum walls and insulation.
4. Operating Temperature: From 34 to 158 deg F (1 to 70 deg C), 100-percent relative humidity, at any velocity.
5. Lamp Protection: Hermetically sealed with a thin layer of UV-C-transmissible fluorinated ethylene propylene to provide protection against lamp breakage and to ensure lamp contents from a broken lamp are contained.
6. Lamp Life: Minimum of 9000 hours with greater than 85 percent of initial output at end of lamp life.

D. Power Supply Housing: High-performance, white polycarbonate for external thermal rejection, equipped with lamp support for lamp lengths up to 61 inches (1549 mm) and a weathertight cover with an integrated seal. Housing contains all components in one integral assembly for safety and serviceability without tools.

1. Interlock: Disrupt lever on the cover actuates the interlock switch to disconnect or restore power when removed or installed. Padlock eyelets lock the housing cover to guard against unwanted entry.
2. Surface Installation Mounting: Four mounting holes and gasket to seal housing to the mounting surface.

E. Lamp Holder and Lamp Clamp: Four-pin type accommodates a single-ended lamp.

1. Lamp Holder Construction: UV-resistant materials and designed to connect the lamp to the plug.
2. Lamp Clamp Construction: UV-resistant materials to ensure a watertight connection. A seal between the single-ended UV lamp and the lamp plug prevents electrical shock, connection shorts, and lamp or power supply failure, from lamp pin oxidation or arcing.

2.4 CONTROLS

A. Comply with requirements in Section 230923 "Direct-Digital Control System for HVAC" for control equipment and in Section 230993.11 "Sequence of Operations for HVAC DDC."

B. Interface with DDC System for HVAC: Factory-installed hardware and software (where applicable) to enable the DDC system for HVAC to monitor, control, and display status and alarms.

C. Lamp and Power Supply Monitoring: Factory-assembled and tested, consisting of a housing, PC board, and wire block. Construction is designed to withstand installation inside air-handling unit airstream.

1. Housing: Industrial-grade plastic equipped with a direct-reading high-output green LED, two mounting holes, and an external wiring block for wiring to a remote sensing or input device. PC board converts inductive field to a regulated electromotive force of 1 to 5 V dc, maximum.

2. Wiring Block: One positive and one negative terminal for No. 18 AWG and smaller wire.
3. Remote Monitor(s): Installed outside the plenum in a suitable NEMA enclosure to directly or remotely monitor the lamp and power supply combination, with option for a single signal to the DDC system.

D. Operating Control: Monitor lamp and power supply combination and provide a single on/off signal to the DDC system. UV-C lamp system operates continuously. Interlock UV-C lamp system operation with air-handling unit and component access doors. When an access door is opened, UV-C lamp system is de-energized.

PART 3 - EXECUTION

3.1 INSTALLATION OF ANTIMICROBIAL UV-C LAMP SYSTEMS FOR LARGE AIR-HANDLING UNITS

A. Install UV-C lamp systems according to manufacturer's installation manual and drawings unless otherwise indicated.

B. Install UV lamps in each UV-C lamp system.

C. Install UV-C lamp systems in locations that are accessible and that will permit servicing and maintenance.

D. Provide sufficient length of wiring loom to facilitate lamp connection to a remotely located power supply and/or power supply housing, such that lamp and loom can be mounted anywhere in the system.

E. Seal air-handling unit penetrations to maintain integrity of air-handling unit casings.

F. Irradiation: Quantity of UV lamps are to be installed to provide an equal distribution of available UV-C energy. When installed, UV-C energy produced shall be of the lowest possible reflected and shadowed losses, distributed in a 360-degree pattern within the cavity or plenum space.

G. Intensity: UV-C lamp system modeling shall be included in the submittal and must contain necessary calculations to demonstrate a minimum of 6 W/sq. ft. (64.6 W/sq. m) or 4 W/sq. ft. (43.0 W/sq. m) of coil surface area as directed to achieve a minimum of 100 microwatts/sq. cm equally distributed on the target surface as recommended by ASHRAE.

H. Housing Installation: Power supply housing can be installed inside or outside air-handling units or plenums.

I. UV Lamp Installation: Mount UV lamp to irradiate surfaces, as well as the available line of sight airstream, through proper lamp placement, and incident angle reflection.

J. Safety: Comply with requirements in UL 1995, "Standard of Safety for Heating and Cooling Equipment." Provide mechanical interlock switch on access panels and doors to UV lamp systems, or within view of UV lamp systems, to ensure that UV-C lamp systems will be de-

energized when these accesses are opened. Warning signs and labels are specified in Section 230553 "Identification for HVAC Piping and Equipment."

K. Signage: Comply with requirements in UL 1995 "Heating and Cooling Equipment." Mark access panels and doors to UV-C lamp systems with warning signs stating, "WARNING: UV LIGHT SOURCE" and "DISCONNECT POWER BEFORE SERVICING." Warning signs and labels are specified in Section 230553 "Identification for HVAC Piping and Equipment."

L. Identify UV-C lamp systems with equipment labels. Comply with requirements for equipment labels specified in Section 230553 "Identification for HVAC Piping and Equipment."

M. After installation, adjust UV-C lamp systems and supports to maximize exposure to surfaces, before energizing system.

3.2 ELECTRIC CONNECTIONS

A. Provide electrical power and service disconnects to products requiring electrical connections.

B. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

C. Comply with requirements for service disconnects in Section 262816 "Enclosed Switches and Circuit Breakers."

D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

E. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.3 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operational Test: After installing UV-C lamp systems, and after electrical circuitry has been energized, test units to confirm proper operation.

2. Safety Interlock: Confirm proper operation of safety interlock power switches on access panels and doors.

D. UV-C lamp systems and components will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.5 CLEANING

A. Wipe lamps clean using manufacturers' recommended cleaning methods and materials.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain UV-C lamp systems as directed.

END OF SECTION 230566

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Balancing Air Systems:

    a. Constant-volume air systems.
    b. Variable-air-volume systems.

2. Balancing Hydronic Piping Systems:

    a. Constant-flow hydronic systems.
    b. Variable-flow hydronic systems.

1.2 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. NEBB: National Environmental Balancing Bureau.

C. TAB: Testing, adjusting, and balancing.

D. TABB: Testing, Adjusting, and Balancing Bureau.

E. TAB Specialist: An independent entity meeting qualifications to perform TAB work.

F. TDH: Total dynamic head.

1.3 ACTION SUBMITTALS

A. TAB Report: Documentation indicating that Work complies with ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

1.4 INFORMATIONAL SUBMITTALS

A. Strategies and Procedures Plan: Within as directed number of days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.

B. Certified TAB reports.

1.5 QUALITY ASSURANCE

A. TAB Specialists Qualifications: Certified by AABC.

1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC.
2. TAB Technician: Employee of the TAB specialist and certified by AABC as a TAB technician.

B. TAB Specialists Qualifications: Certified by NEBB or TABB.

1. TAB Field Supervisor: Employee of the TAB specialist and certified by NEBB or TABB.
2. TAB Technician: Employee of the TAB specialist and certified by NEBB or TABB as a TAB technician.

C. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.

B. Examine installed systems for balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. Examine equipment performance data including fan and pump curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.

J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

K. Examine strainers. Verify that startup screens have been replaced by permanent screens with indicated perforations.

L. Examine control valves for proper installation for their intended function of throttling, diverting, or mixing fluid flows.

M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

N. Examine system pumps to ensure absence of entrained air in the suction piping.

O. Examine operating safety interlocks and controls on HVAC equipment.

P. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures for balancing the systems.

B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:

1. Airside:

a. Duct systems are complete with terminals installed.
b. Volume, smoke, and fire dampers are open and functional.
c. Clean filters are installed.
d. Fans are operating, free of vibration, and rotating in correct direction.
e. Variable-frequency controllers' startup is complete and safeties are verified.
f. Automatic temperature-control systems are operational.
g. Ceilings are installed.
h. Windows and doors are installed.

i. Suitable access to balancing devices and equipment is provided.

2. Hydronics:

a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
b. Piping is complete with terminals installed.
c. Water treatment is complete.
d. Systems are flushed, filled, and air purged.
e. Strainers are pulled and cleaned.
f. Control valves are functioning per the sequence of operation.
g. Shutoff and balance valves have been verified to be 100 percent open.
h. Pumps are started and proper rotation is verified.
i. Pump gage connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
j. Variable-frequency controllers' startup is complete and safeties are verified.
k. Suitable access to balancing devices and equipment is provided.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system as directed and in this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
2. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," and Section 230719 "HVAC Piping Insulation."

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) and metric (SI) units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross-check the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

G. Verify that motor starters are equipped with properly sized thermal protection.

H. Check dampers for proper position to achieve desired airflow path.

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

K. Check for proper sealing of air-handling-unit components.

L. Verify that air duct system is sealed as specified in Section 233113 "Metal Ducts."

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.

    a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
    b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
    c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
    d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.

2. Measure fan static pressures as follows:

    a. Measure static pressure directly at the fan outlet or through the flexible connection.
    b. Measure static pressure directly at the fan inlet or through the flexible connection.
    c. Measure static pressure across each component that makes up the air-handling system.
    d. Report artificial loading of filters at the time static pressures are measured.

3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
4. Obtain approval as directed for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.

5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.

1. Measure airflow of submain and branch ducts.
2. Adjust submain and branch duct volume dampers for specified airflow.
3. Re-measure each submain and branch duct after all have been adjusted.

C. Adjust air inlets and outlets for each space to indicated airflows.

1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
2. Measure inlets and outlets airflow.
3. Adjust each inlet and outlet for specified airflow.
4. Re-measure each inlet and outlet after they have been adjusted.

3.6 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Adjust the variable-air-volume systems as follows:

1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.
2. Verify that the system is under static pressure control.
3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
4. Calibrate and balance each terminal unit for maximum and minimum design airflow as follows:

    a. Adjust controls so that terminal is calling for maximum airflow. Some controllers require starting with minimum airflow. Verify calibration procedure for specific project.
    b. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor.
    c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
    d. Adjust controls so that terminal is calling for minimum airflow.
    e. Measure airflow and adjust calibration factor as required for design minimum airflow. Record calibration factor. If no minimum calibration is available, note any deviation from design airflow.
    f. When in full cooling or full heating, ensure that there is no mixing of hot-deck and cold-deck airstreams unless so designed.

g. On constant volume terminals, in critical areas where room pressure is to be maintained, verify that the airflow remains constant over the full range of full cooling to full heating. Note any deviation from design airflow or room pressure.

5. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.

   a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
   b. Set terminals for maximum airflow. If system design includes diversity, adjust terminals for maximum and minimum airflow so that connected total matches fan selection and simulates actual load in the building.
   c. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
   d. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
   e. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.

6. Measure fan static pressures as follows:

   a. Measure static pressure directly at the fan outlet or through the flexible connection.
   b. Measure static pressure directly at the fan inlet or through the flexible connection.
   c. Measure static pressure across each component that makes up the air-handling system.
   d. Report any artificial loading of filters at the time static pressures are measured.

7. Set final return and outside airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.

   a. Balance the return-air ducts and inlets the same as described for constant-volume air systems.
   b. Verify that terminal units are meeting design airflow under system maximum flow.

8. Re-measure the inlet static pressure at the most critical terminal unit and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls contractor.
9. Verify final system conditions as follows:

   a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
   b. Re-measure and confirm that total airflow is within design.
   c. Re-measure final fan operating data, rpms, volts, amps, and static profile.
   d. Mark final settings.
   e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.
   f. Verify tracking between supply and return fans.

3.7 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports for pumps, coils, and heat exchangers. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required coil and heat exchanger flow rates with pump design flow rate.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:

1. Check liquid level in expansion tank.
2. Check highest vent for adequate pressure.
3. Check flow-control valves for proper position.
4. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
5. Verify that motor starters are equipped with properly sized thermal protection.
6. Check that air has been purged from the system.

3.8 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

A. Adjust pumps to deliver total design gpm.

1. Measure total water flow.

    a. Position valves for full flow through coils.
    b. Measure flow by main flow meter, if installed.
    c. If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.

2. Measure pump TDH as follows:

    a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
    b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
    c. Convert pressure to head and correct for differences in gage heights.
    d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
    e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

3. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

B. Adjust flow-measuring devices installed in mains and branches to design water flows.

1. Measure flow in main and branch pipes.
2. Adjust main and branch balance valves for design flow.
3. Re-measure each main and branch after all have been adjusted.

C. Adjust flow-measuring devices installed at terminals for each space to design water flows.

1. Measure flow at terminals.
2. Adjust each terminal to design flow.
3. Re-measure each terminal after it is adjusted.
4. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
5. Perform temperature tests after flows have been balanced.

D. For systems with pressure-independent valves at terminals:

1. Measure differential pressure and verify that it is within manufacturer's specified range.
2. Perform temperature tests after flows have been verified.

E. For systems without pressure-independent valves or flow-measuring devices at terminals:

1. Measure and balance coils by either coil pressure drop or temperature method.
2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

F. Verify final system conditions as follows:

1. Re-measure and confirm that total water flow is within design.
2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
3. Mark final settings.

G. Verify that memory stops have been set.

3.9 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

B. Adjust the variable-flow hydronic system as follows:

1. Verify that the differential-pressure sensor is located as indicated.
2. Determine whether there is diversity in the system.

C. For systems with no diversity:

1. Adjust pumps to deliver total design gpm.

a. Measure total water flow.

1) Position valves for full flow through coils.
2) Measure flow by main flow meter, if installed.
3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.

b. Measure pump TDH as follows:

1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
3) Convert pressure to head and correct for differences in gage heights.
4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

2. Adjust flow-measuring devices installed in mains and branches to design water flows.

a. Measure flow in main and branch pipes.
b. Adjust main and branch balance valves for design flow.
c. Re-measure each main and branch after all have been adjusted.

3. Adjust flow-measuring devices installed at terminals for each space to design water flows.

a. Measure flow at terminals.
b. Adjust each terminal to design flow.
c. Re-measure each terminal after it is adjusted.
d. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
e. Perform temperature tests after flows have been balanced.

4. For systems with pressure-independent valves at terminals:

a. Measure differential pressure and verify that it is within manufacturer's specified range.
b. Perform temperature tests after flows have been verified.

5. For systems without pressure-independent valves or flow-measuring devices at terminals:

a. Measure and balance coils by either coil pressure drop or temperature method.
b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

6. Prior to verifying final system conditions, determine the system differential-pressure set point.
7. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
8. Mark final settings and verify that all memory stops have been set.

9. Verify final system conditions as follows:

    a. Re-measure and confirm that total water flow is within design.
    b. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
    c. Mark final settings.

10. Verify that memory stops have been set.

D. For systems with diversity:

1. Determine diversity factor.
2. Simulate system diversity by closing required number of control valves, as approved by the design engineer.
3. Adjust pumps to deliver total design gpm.

    a. Measure total water flow.

        1) Position valves for full flow through coils.
        2) Measure flow by main flow meter, if installed.
        3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.

    b. Measure pump TDH as follows:

        1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
        2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
        3) Convert pressure to head and correct for differences in gage heights.
        4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
        5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

    c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

4. Adjust flow-measuring devices installed in mains and branches to design water flows.

    a. Measure flow in main and branch pipes.
    b. Adjust main and branch balance valves for design flow.
    c. Re-measure each main and branch after all have been adjusted.

5. Adjust flow-measuring devices installed at terminals for each space to design water flows.

    a. Measure flow at terminals.
    b. Adjust each terminal to design flow.
    c. Re-measure each terminal after it is adjusted.

d. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
e. Perform temperature tests after flows have been balanced.

6. For systems with pressure-independent valves at terminals:

a. Measure differential pressure and verify that it is within manufacturer's specified range.
b. Perform temperature tests after flows have been verified.

7. For systems without pressure-independent valves or flow-measuring devices at terminals:

a. Measure and balance coils by either coil pressure drop or temperature method.
b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

8. Open control valves that were shut. Close a sufficient number of control valves that were previously open to maintain diversity, and balance terminals that were just opened.
9. Prior to verifying final system conditions, determine system differential-pressure set point.
10. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
11. Mark final settings and verify that memory stops have been set.
12. Verify final system conditions as follows:

a. Re-measure and confirm that total water flow is within design.
b. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
c. Mark final settings.

13. Verify that memory stops have been set.

3.10 TOLERANCES

A. Set HVAC system's airflow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
2. Air Outlets and Inlets: Plus or minus 10 percent.
3. Heating-Water Flow Rate: Plus or minus 10 percent.
4. Cooling-Water Flow Rate: Plus or minus 10 percent.

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.11 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.
3. Certify validity and accuracy of field data.

B. Final Report Contents: In addition to certified field-report data, include the following:

1. Pump curves.
2. Fan curves.
3. Manufacturers' test data.
4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance; do not include Shop Drawings and Product Data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.
2. Name and address of the TAB specialist.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:

    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans and pump performance forms including the following:

    a. Settings for outdoor-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Face and bypass damper settings at coils.
    e. Fan drive settings including settings and percentage of maximum pitch diameter.
    f. Inlet vane settings for variable-air-volume systems.
    g. Settings for supply-air, static-pressure controller.
    h. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:

1. Unit Data:

    a. Unit identification.
    b. Location.
    c. Make and type.
    d. Model number and unit size.
    e. Manufacturer's serial number.
    f. Unit arrangement and class.
    g. Discharge arrangement.
    h. Sheave make, size in inches (mm), and bore.
    i. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).
    j. Number, make, and size of belts.
    k. Number, type, and size of filters.

2. Motor Data:

    a. Motor make, and frame type and size.
    b. Horsepower and rpm.
    c. Volts, phase, and hertz.
    d. Full-load amperage and service factor.
    e. Sheave make, size in inches (mm), and bore.
    f. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).

3. Test Data (Indicated and Actual Values):

    a. Total airflow rate in cfm (L/s).
    b. Total system static pressure in inches wg (Pa).
    c. Fan rpm.
    d. Discharge static pressure in inches wg (Pa).
    e. Filter static-pressure differential in inches wg (Pa).
    f. Preheat-coil static-pressure differential in inches wg (Pa).
    g. Cooling-coil static-pressure differential in inches wg (Pa).
    h. Heating-coil static-pressure differential in inches wg (Pa).
    i. Outdoor airflow in cfm (L/s).
    j. Return airflow in cfm (L/s).
    k. Outdoor-air damper position.
    l. Return-air damper position.
    m. Vortex damper position.

F. Apparatus-Coil Test Reports:

1. Coil Data:

    a. System identification.
    b. Location.
    c. Coil type.
    d. Number of rows.
    e. Fin spacing in fins per inch (mm) o.c.
    f. Make and model number.
    g. Face area in sq. ft. (sq. m).
    h. Tube size in NPS (DN).
    i. Tube and fin materials.
    j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

    a. Airflow rate in cfm (L/s).
    b. Average face velocity in fpm (m/s).
    c. Air pressure drop in inches wg (Pa).
    d. Outdoor-air, wet- and dry-bulb temperatures in deg F (deg C).
    e. Return-air, wet- and dry-bulb temperatures in deg F (deg C).
    f. Entering-air, wet- and dry-bulb temperatures in deg F (deg C).
    g. Leaving-air, wet- and dry-bulb temperatures in deg F (deg C).
    h. Water flow rate in gpm (L/s).
    i. Water pressure differential in feet of head or psig (kPa).
    j. Entering-water temperature in deg F (deg C).
    k. Leaving-water temperature in deg F (deg C).
    l. Refrigerant expansion valve and refrigerant types.
    m. Refrigerant suction pressure in psig (kPa).
    n. Refrigerant suction temperature in deg F (deg C).
    o. Inlet steam pressure in psig (kPa).

G. Gas- and Oil-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:

1. Unit Data:

    a. System identification.
    b. Location.
    c. Make and type.
    d. Model number and unit size.
    e. Manufacturer's serial number.
    f. Fuel type in input data.
    g. Output capacity in Btu/h (kW).
    h. Ignition type.
    i. Burner-control types.
    j. Motor horsepower and rpm.
    k. Motor volts, phase, and hertz.
    l. Motor full-load amperage and service factor.
    m. Sheave make, size in inches (mm), and bore.
    n. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).

2. Test Data (Indicated and Actual Values):

    a. Total airflow rate in cfm (L/s).
    b. Entering-air temperature in deg F (deg C).
    c. Leaving-air temperature in deg F (deg C).
    d. Air temperature differential in deg F (deg C).
    e. Entering-air static pressure in inches wg (Pa).
    f. Leaving-air static pressure in inches wg (Pa).
    g. Air static-pressure differential in inches wg (Pa).
    h. Low-fire fuel input in Btu/h (kW).
    i. High-fire fuel input in Btu/h (kW).
    j. Manifold pressure in psig (kPa).
    k. High-temperature-limit setting in deg F (deg C).
    l. Operating set point in Btu/h (kW).
    m. Motor voltage at each connection.
    n. Motor amperage for each phase.
    o. Heating value of fuel in Btu/h (kW).

H. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:

1. Unit Data:

    a. System identification.
    b. Location.
    c. Coil identification.
    d. Capacity in Btu/h (kW).
    e. Number of stages.
    f. Connected volts, phase, and hertz.
    g. Rated amperage.
    h. Airflow rate in cfm (L/s).
    i. Face area in sq. ft. (sq. m).
    j. Minimum face velocity in fpm (m/s).

2. Test Data (Indicated and Actual Values):

    a. Heat output in Btu/h (kW).
    b. Airflow rate in cfm (L/s).
    c. Air velocity in fpm (m/s).
    d. Entering-air temperature in deg F (deg C).
    e. Leaving-air temperature in deg F (deg C).
    f. Voltage at each connection.
    g. Amperage for each phase.

I. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:

    a. System identification.
    b. Location.
    c. Make and type.

d. Model number and size.
e. Manufacturer's serial number.
f. Arrangement and class.
g. Sheave make, size in inches (mm), and bore.
h. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).

2. Motor Data:

a. Motor make, and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches (mm), and bore.
f. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm (L/s).
b. Total system static pressure in inches wg (Pa).
c. Fan rpm.
d. Discharge static pressure in inches wg (Pa).
e. Suction static pressure in inches wg (Pa).

J. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

a. System and air-handling-unit number.
b. Location and zone.
c. Traverse air temperature in deg F (deg C).
d. Duct static pressure in inches wg (Pa).
e. Duct size in inches (mm).
f. Duct area in sq. ft. (sq. m).
g. Indicated airflow rate in cfm (L/s).
h. Indicated velocity in fpm (m/s).
i. Actual airflow rate in cfm (L/s).
j. Actual average velocity in fpm (m/s).
k. Barometric pressure in psig (Pa).

K. Air-Terminal-Device Reports:

1. Unit Data:

a. System and air-handling unit identification.
b. Location and zone.
c. Apparatus used for test.
d. Area served.
e. Make.
f. Number from system diagram.

g. Type and model number.
h. Size.
i. Effective area in sq. ft. (sq. m).

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm (L/s).
b. Air velocity in fpm (m/s).
c. Preliminary airflow rate as needed in cfm (L/s).
d. Preliminary velocity as needed in fpm (m/s).
e. Final airflow rate in cfm (L/s).
f. Final velocity in fpm (m/s).
g. Space temperature in deg F (deg C).

L. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data:

a. System and air-handling-unit identification.
b. Location and zone.
c. Room or riser served.
d. Coil make and size.
e. Flowmeter type.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm (L/s).
b. Entering-water temperature in deg F (deg C).
c. Leaving-water temperature in deg F (deg C).
d. Water pressure drop in feet of head or psig (kPa).
e. Entering-air temperature in deg F (deg C).
f. Leaving-air temperature in deg F (deg C).

M. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:

1. Unit Data:

a. Unit identification.
b. Location.
c. Service.
d. Make and size.
e. Model number and serial number.
f. Water flow rate in gpm (L/s).
g. Water pressure differential in feet of head or psig (kPa).
h. Required net positive suction head in feet of head or psig (kPa).
i. Pump rpm.
j. Impeller diameter in inches (mm).
k. Motor make and frame size.
l. Motor horsepower and rpm.
m. Voltage at each connection.

n. Amperage for each phase.
o. Full-load amperage and service factor.
p. Seal type.

2. Test Data (Indicated and Actual Values):

a. Static head in feet of head or psig (kPa).
b. Pump shutoff pressure in feet of head or psig (kPa).
c. Actual impeller size in inches (mm).
d. Full-open flow rate in gpm (L/s).
e. Full-open pressure in feet of head or psig (kPa).
f. Final discharge pressure in feet of head or psig (kPa).
g. Final suction pressure in feet of head or psig (kPa).
h. Final total pressure in feet of head or psig (kPa).
i. Final water flow rate in gpm (L/s).
j. Voltage at each connection.
k. Amperage for each phase.

N. Instrument Calibration Reports:

1. Report Data:

a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

3.12 VERIFICATION OF TAB REPORT

A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of as directed.

B. As directed personnel shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

E. If TAB work fails, proceed as follows:

1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.

2. If the second final inspection also fails, Owner may contract the services of another TAB specialist to complete TAB work according to the Contract Documents and deduct the cost of the services from the original TAB specialist's final payment.
3. If the second verification also fails, as directed personel may contact AABC Headquarters regarding the AABC National Performance Guaranty.

F. Prepare test and inspection reports.

3.13 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 230593

SECTION 230713 - DUCT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following duct services:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in unconditioned space.
4. Indoor, exposed return located in unconditioned space.
5. Indoor, concealed, Type I, commercial, kitchen hood exhaust.
6. Indoor, exposed, Type I, commercial, kitchen hood exhaust.
7. Indoor, concealed oven and warewash exhaust.
8. Indoor, exposed oven and warewash exhaust.
9. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
10. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
11. Outdoor, concealed supply and return.
12. Outdoor, exposed supply and return.

B. Related Sections:

1. Section 230716 "HVAC Equipment Insulation."
2. Section 230719 "HVAC Piping Insulation."
3. Section 233113 "Metal Ducts" for duct liners.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.
3. Detail application of field-applied jackets.
4. Detail application at linkages of control devices.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C553, Type II and ASTM C1290, as directed. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

G. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C612, Type IA or Type IB. For duct and plenum applications, provide insulation as directed. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.2 FIRE-RATED INSULATION SYSTEMS

A. Fire-Rated Blanket: As directed High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 1 or 2-hour fire rating by an NRTL acceptable to authorities having jurisdiction.

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

C. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

D. PVC Jacket Adhesive: Compatible with PVC jacket.

2.4 MASTICS AND COATINGS

A. Materials shall be compatible with insulation materials, jackets, and substrates.

B. Vapor-Retarder Mastic: Water based; suitable for indoor use on below ambient services.
   1. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
   2. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
   3. Comply with MIL-PRF-19565C, Type II, for permeance requirements, with supplier listing on DOD QPD - Qualified Products Database.
   4. Color: White.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
   1. Water-Vapor Permeance: ASTM E96, greater than 1.0 perm (0.66 metric perms) at manufacturer's recommended dry film thickness.
   2. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
   3. Color: White.

2.5 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Fire- and water-resistant, flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
   4. Color: Aluminum.

B. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Fire- and water-resistant, flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
   4. Color: White.

2.6 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.
5. Vinyl Jacket: White vinyl with a permeance of 1.3 perms (0.86 metric perm) when tested according to ASTM E96/E96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.7 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm), in a Leno weave, for ducts.

2.8 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
1. Adhesive: As recommended by jacket material manufacturer.
2. Color: As directed.

D. Aluminum Jacket: Comply with ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.
1. Sheet and roll stock ready for shop or field sizing or Factory cut and rolled to size as directed.
2. Finish and thickness are indicated in field-applied jacket schedules.
3. Moisture Barrier for Indoor Applications: As directed.
4. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper or 2.5-mil- (0.063-mm-) thick polysurlyn as directed.

E. Self-Adhesive Outdoor Jacket: 60-mil- (1.5-mm-) thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with white or stucco-embossed aluminum-foil facing as directed.

2.9 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
1. Width: 3 inches (75 mm).

2. Thickness: 11.5 mils (0.29 mm).
3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.
1. Width: 3 inches (75 mm).
2. Thickness: 6.5 mils (0.16 mm).
3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
1. Width: 2 inches (50 mm).
2. Thickness: 6 mils (0.15 mm).
3. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
4. Elongation: 500 percent.
5. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. Width: 2 inches (50 mm).
2. Thickness: 3.7 mils (0.093 mm).
3. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
4. Elongation: 5 percent.
5. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.

2.10 SECUREMENTS

A. Aluminum Bands: ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) or 3/4 inch (19 mm) wide with wing seal or closed seal.

B. Insulation Pins and Hangers:

1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
   a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
   b. Spindle: As directed fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
   c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

2. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
   a. Baseplate: Perforated, nylon sheet, 0.030 inch (0.76 mm) thick by 1-1/2 inches (38 mm) in diameter.
   b. Spindle: Nylon, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches (63 mm).
   c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

3. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
   a. Baseplate: Galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
   b. Spindle: As directed fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
   c. Adhesive-backed base with a peel-off protective cover.

4. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick, sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
   a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

5. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.

D. Wire: As directed.

2.11 CORNER ANGLES

A. PVC Corner Angles: 30 mils (0.8 mm) thick, minimum 1 by 1 inch (25 by 25 mm), PVC according to ASTM D1784, Class 16354-C. White or color-coded to match adjacent surface.

B. Aluminum Corner Angles: 0.040 inch (1.0 mm) thick, minimum 1 by 1 inch (25 by 25 mm), aluminum according to ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14.

PART 3 - EXECUTION

3.1 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.

B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.

3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches (50 mm) or 4 inches (100 mm) o.c as directed.

    a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.3 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches (50 mm).
4. Seal jacket to wall flashing with flashing sealant.

C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches (50 mm).

1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

E. Insulation Installation at Floor Penetrations:

1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches (50 mm).
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.4 INSTALLATION OF MINERAL-FIBER INSULATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 or 50 percent coverage of duct and plenum surfaces as directed.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

    a. On duct sides with dimensions 18 inches (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
    b. On duct sides with dimensions larger than 18 inches (450 mm), place pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
    c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
    d. Do not overcompress insulation during installation.
    e. Impale insulation over pins and attach speed washers.
    f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches (50 mm) from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
b. Install vapor stops for ductwork and plenums operating below 50 deg F (10 deg C) at 18-foot (5.5-m) intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches (75 mm).

5. Overlap unfaced blankets a minimum of 2 inches (50 mm) on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches (450 mm) o.c.
6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.

B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 or 50 percent coverage of duct and plenum surfaces as directed.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

a. On duct sides with dimensions 18 inches (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
b. On duct sides with dimensions larger than 18 inches (450 mm), space pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
d. Do not overcompress insulation during installation.
e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches (50 mm) from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.

b. Install vapor stops for ductwork and plenums operating below 50 deg F (10 deg C) at 18-foot (5.5-m) intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches (75 mm).

5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.

3.5 FIELD-APPLIED JACKET INSTALLATION

A. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

B. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

C. Where metal jackets are indicated, install with 2-inch (50-mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches (300 mm) o.c. and at end joints.

3.6 FIRE-RATED INSULATION SYSTEM INSTALLATION

A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.

B. Insulate duct access panels and doors to achieve same fire rating as duct.

C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Section 078413 "Penetration Firestopping."

3.7 FINISHES

A. Insulation with ASJ or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

C. Do not field paint aluminum or stainless-steel jackets.

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.9 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in unconditioned space.
4. Indoor, exposed return located in unconditioned space.
5. Indoor, concealed, Type I, commercial, kitchen hood exhaust.
6. Indoor, exposed, Type I, commercial, kitchen hood exhaust.
7. Indoor, concealed oven and warewash exhaust.
8. Indoor, exposed oven and warewash exhaust.
9. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
10. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
11. Outdoor, concealed supply and return.
12. Outdoor, exposed supply and return.

B. Items Not Insulated:

1. Fibrous-glass ducts.

2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
3. Factory-insulated flexible ducts.
4. Factory-insulated plenums and casings.
5. Flexible connectors.
6. Vibration-control devices.
7. Factory-insulated access panels and doors.

3.10 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, Supply-Air Duct and Plenum Insulation: Mineral-fiber thick as directed and nominal density as directed.

B. Concealed, Return-Air Duct and Plenum Insulation: Mineral-fiber thick as directed and nominal density as directed.

C. Concealed, Outdoor-Air Duct and Plenum Insulation: Mineral-fiber thick as directed and nominal density as directed.

D. Concealed, Exhaust-Air Duct and Plenum Insulation: Mineral-fiber thick as directed and nominal density as directed.

E. Concealed, Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: Fire-rated blanket or board; thickness as required to achieve 2-hour fire rating.

F. Exposed, Supply-Air Duct and Plenum Insulation: Mineral-fiber thick as directed and nominal density as directed.

G. Exposed, Return-Air Duct and Plenum Insulation: Mineral-fiber thick as directed and nominal density as directed.

H. Exposed, Outdoor-Air Duct and Plenum Insulation: Mineral-fiber thick as directed and nominal density as directed.

I. Exposed, Exhaust-Air Duct and Plenum Insulation: Mineral-fiber thick as directed and nominal density as directed.

J. Exposed, Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: Fire-rated blanket or board; thickness as required to achieve 2-hour fire rating.

3.11 ABOVEGROUND, OUTDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a duct system, selection from materials listed is Contractor's option.

B. Concealed, Supply-Air Duct and Plenum Insulation: Mineral-fiber thick as directed and nominal density as directed.

C. Concealed, Return-Air Duct and Plenum Insulation: Mineral-fiber thick as directed and nominal density as directed.

D. Concealed, Outdoor-Air Duct and Plenum Insulation: Mineral-fiber thick as directed and nominal density as directed.

E. Exposed, Supply-Air Duct and Plenum Insulation: Mineral-fiber thick as directed and nominal density as directed.

F. Exposed, Return-Air Duct and Plenum Insulation: Mineral-fiber thick as directed and nominal density as directed.

3.12 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Ducts and Plenums, Concealed:

1. None.
2. PVC or PVC, Color-Coded by System: 20 mils (0.5 mm) or 30 mils (0.8 mm) thick as directed.
3. Aluminum, as directed: Thickness as directed.

D. Ducts and Plenums, Exposed:

1. None.
2. PVC or PVC, Color-Coded by System: 20 mils (0.5 mm) or 30 mils (0.8 mm) thick as directed.
3. Aluminum, as directed: Thickness as directed.

3.13 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Ducts and Plenums, Concealed:

1. None.
2. PVC or PVC, Color-Coded by System: 20 mils (0.5 mm) or 30 mils (0.8 mm) thick as directed.
3. Aluminum, as directed: Thickness as directed.

D. Ducts and Plenums, Exposed, up to 48 Inches (1200 mm) in Diameter or with Flat Surfaces up to 72 Inches (1800 mm):

1. Aluminum, as directed: Thickness as directed.

E. Ducts and Plenums, Exposed, Larger Than 48 Inches (1200 mm) in Diameter or with Flat Surfaces Larger Than 72 Inches (1800 mm):

1. Painted Aluminum, Smooth or Stucco Embossed as directed.

END OF SECTION 230713

SECTION 230716 - HVAC EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following HVAC equipment that is not factory insulated:

1. Heat exchangers.
2. Chilled-water pumps.
3. Dual-service heating and cooling pumps.
4. Heating, hot-water pumps.
5. Expansion/compression tanks.
6. Air separators.

B. Related Sections:

1. Section 230713 "Duct Insulation."
2. Section 230719 "HVAC Piping Insulation."

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail attachment and covering of heat tracing inside insulation.
3. Detail removable insulation at equipment connections.
4. Detail application of field-applied jackets.
5. Detail application at linkages of control devices.
6. Detail field application for each equipment type.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Products shall not contain asbestos, lead, mercury, or mercury compounds.

B. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C871.

C. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

D. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

E. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   1. Block Insulation: ASTM C552, Type I.
   2. Special-Shaped Insulation: ASTM C552, Type III.
   3. Board Insulation: ASTM C552, Type IV.
   4. Factory fabricate shapes according to ASTM C450 and ASTM C585.

F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534, Type I for tubular materials and Type II for sheet materials.

G. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C553, Type II and ASTM C1290, as directed. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

H. High-Temperature, Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C553, Type V, without factory-applied jacket.

I. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C612, Type IA or Type IB. Provide insulation as directed. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

J. High-Temperature, Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C612, Type III, without factory-applied jacket.

K. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ or FSK jacket complying with ASTM C1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C612, Type IB. Nominal density is 2.5 lb/cu. ft. (40 kg/cu. m) or more. Thermal conductivity (k-value)

at 100 deg F (55 deg C) is 0.29 Btu x in./h x sq. ft. x deg F (0.042 W/m x K) or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

L. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C534 or ASTM C1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.

M. Polystyrene: Rigid, extruded cellular polystyrene intended for use as thermal insulation. Comply with ASTM C578, Type IV or Type XIII, except thermal conductivity (k-value) shall not exceed 0.26 Btu x in./h x sq. ft. x deg F (0.038 W/m x K) after 180 days of aging. Fabricate shapes according to ASTM C450 and ASTM C585.

2.2 INSULATING CEMENTS

A. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C449.

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F (minus 73 to plus 93 deg C).

C. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

D. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

E. Polystyrene Adhesive: Solvent- or water-based, synthetic resin adhesive with a service temperature range of minus 20 to plus 140 deg F (29 to plus 60 deg C).

F. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

G. PVC Jacket Adhesive: Compatible with PVC jacket.

2.4 MASTICS AND COATINGS

A. Materials shall be compatible with insulation materials, jackets, and substrates.

B. Vapor-Retarder Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
   1. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
   2. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
   3. Comply with MIL-PRF-19565C, Type II, for permeance requirements, with supplier listing on DOD QPD - Qualified Products Database.
   4. Color: White.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
   1. Water-Vapor Permeance: ASTM E96, greater than 1.0 perm (0.66 metric perms) at manufacturer's recommended dry film thickness.
   2. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
   3. Color: White.

2.5 SEALANTS

A. Joint Sealants:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Permanently flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C).
   4. Color: White or gray.

B. FSK and Metal Jacket Flashing Sealants:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Fire- and water-resistant, flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
   4. Color: Aluminum.

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Fire- and water-resistant, flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
   4. Color: White.

2.6 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

   1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
   2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
   3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.
   4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.
   5. PVDC Jacket for Indoor Applications: 4-mil- (0.10-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perm (0.013 metric perm) when tested according to ASTM E96/E96M and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E84.

   6. PVDC Jacket for Outdoor Applications: 6-mil- (0.15-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perm (0.007 metric perm) when tested according to ASTM E96/E96M and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E84.

7. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

8. Vinyl Jacket: White vinyl with a permeance of 1.3 perms (0.86 metric perm) when tested according to ASTM E96/E96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.7 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm), in a Leno weave, for equipment.

2.8 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
1. Adhesive: As recommended by jacket material manufacturer.
2. Color: White or Color-code jackets as directed
3. Factory-fabricated tank heads and tank side panels.

D. Aluminum Jacket: Comply with ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.
1. Sheet and roll stock ready for shop or field sizing or Factory cut and rolled to size as directed.
2. Finish and thickness are indicated in field-applied jacket schedules.
3. Moisture Barrier for Indoor Applications: As directed.
4. Moisture Barrier for Outdoor Applications: As directed.
5. Factory-Fabricated Fitting Covers:

    a. Same material, finish, and thickness as jacket.
    b. Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.
    c. Tee covers.
    d. Flange and union covers.
    e. End caps.
    f. Beveled collars.
    g. Valve covers.
    h. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

E. Self-Adhesive Outdoor Jacket: 60-mil- (1.5-mm-) thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross laminated polyethylene film covered with white or stucco-embossed aluminum-foil facing as directed.

F. PVDC Jacket for Indoor Applications: 4-mil- (0.10-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perm (0.013 metric perm) when tested according to ASTM E96/E96M and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E84.

G. PVDC Jacket for Outdoor Applications: 6-mil- (0.15-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perm (0.007 metric perm) when tested according to ASTM E96/E96M and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E84.

H. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

2.9 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
   1. Width: 3 inches (75 mm).
   2. Thickness: 11.5 mils (0.29 mm).
   3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
   4. Elongation: 2 percent.
   5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
   6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.
   1. Width: 3 inches (75 mm).
   2. Thickness: 6.5 mils (0.16 mm).
   3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
   4. Elongation: 2 percent.
   5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
   6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
   1. Width: 2 inches (50 mm).
   2. Thickness: 6 mils (0.15 mm).
   3. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
   4. Elongation: 500 percent.
   5. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
   1. Width: 2 inches (50 mm).
   2. Thickness: 3.7 mils (0.093 mm).
   3. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
   4. Elongation: 5 percent.
   5. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.

E. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
   1. Width: 3 inches (75 mm).

2. Film Thickness: 4 mils (0.10 mm).
3. Adhesive Thickness: 1.5 mils (0.04 mm).
4. Elongation at Break: 145 percent.
5. Tensile Strength: 55 lbf/inch (10.1 N/mm) in width.

F. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
1. Width: 3 inches (75 mm).
2. Film Thickness: 6 mils (0.15 mm).
3. Adhesive Thickness: 1.5 mils (0.04 mm).
4. Elongation at Break: 145 percent.
5. Tensile Strength: 55 lbf/inch (10.1 N/mm) in width.

2.10 SECUREMENTS

A. Aluminum Bands: ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) or 3/4 inch (19 mm) wide as directed with wing seal or closed seal.

B. Insulation Pins and Hangers:

1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
   a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
   b. Spindle: Fully annealed as directed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
   c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

2. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
   a. Baseplate: Perforated, nylon sheet, 0.030 inch (0.76 mm) thick by 1-1/2 inches (38 mm) in diameter.
   b. Spindle: Nylon, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches (63 mm).
   c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

3. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
   a. Baseplate: Galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
   b. Spindle: Fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
   c. Adhesive-backed base with a peel-off protective cover.

4. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick as directed with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
   a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

5. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-(0.41-mm-) thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.

D. Wire: As directed.

2.11 CORNER ANGLES

A. PVC Corner Angles: 30 mils (0.8 mm) thick, minimum 1 by 1 inch (25 by 25 mm), PVC according to ASTM D1784, Class 16354-C. White or color-coded to match adjacent surface.

B. Aluminum Corner Angles: 0.040 inch (1.0 mm) thick, minimum 1 by 1 inch (25 by 25 mm), aluminum according to ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14.

PART 3 - EXECUTION

3.1 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches (50 mm) or 4 inches (100 mm) o.c. as directed

    a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

O. For above ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.3 INSTALLATION OF EQUIPMENT, TANK, AND VESSEL INSULATION

A. Mineral-Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 or 50 percent coverage as directed of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.
4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:

    a. Do not weld anchor pins to ASME-labeled pressure vessels.
    b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
    c. On tanks and vessels, maximum anchor-pin spacing is 3 inches (75 mm) from insulation end joints, and 16 inches (400 mm) o.c. in both directions.
    d. Do not over compress insulation during installation.
    e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
    f. Impale insulation over anchor pins and attach speed washers.
    g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches (150 mm) from each end. Install wire or cable between two circumferential girdles 12 inches (300 mm) o.c. Install a wire ring around each end and around outer periphery of center openings and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional

circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches (1200 mm) o.c. Use this network for securing insulation with tie wire or bands.

7. Stagger joints between insulation layers at least 3 inches (75 mm).
8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.

1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
2. Seal longitudinal seams and end joints.

C. Insulation Installation on Pumps:

1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch (150-mm) centers, starting at corners. Install 3/8-inch- (10-mm-) diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
2. Fabricate boxes as directed.
3. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.4 FIELD-APPLIED JACKET INSTALLATION

A. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

B. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

C. Where metal jackets are indicated, install with 2-inch (50-mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with

weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches (300 mm) o.c. and at end joints.

D. Where PVDC jackets are indicated, install as follows:

1. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches (850 mm) or less. 33-1/2-inch- (850-mm-) circumference limit allows for 2-inch- (50-mm-) overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
2. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.5 FINISHES

A. Equipment Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections: Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.7 BREECHING INSULATION SCHEDULE

A. Round, Exposed Breeching and Connector: High-temperature mineral-fiber blanket or board as directed, 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.

B. Round, Concealed Breeching and Connector Insulation: High-temperature mineral-fiber blanket or board as directed, 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.

3.8 EQUIPMENT INSULATION SCHEDULE

A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.

B. Insulate indoor and outdoor equipment that is not factory insulated.

C. Chilled-water pump insulation shall be one of the following:

1. Cellular Glass: 3 inches (75 mm) thick.
2. Mineral-Fiber Board: 2 inches (50 mm) thick and nominal density as directed.
3. Phenolic: 2 inches (50 mm) thick.

D. Heat-Exchanger (Water-to-Water for Heating Service) Insulation: Mineral-fiber pipe and tank, 2 inches (50 mm) thick.

E. Dual-service heating and cooling pump insulation shall be one of the following:

1. Cellular Glass: 3 inches (75 mm) thick.
2. Mineral-Fiber Board: 2 inches (50 mm) thick and nominal density as directed.

F. Heating-Hot-Water Pump Insulation: Mineral-Fiber Board: 2 inches (50 mm) thick and nominal density as directed.

G. Chilled-water expansion/compression tank insulation shall be one of the following:

1. Cellular Glass: 1-1/2 inches (38 mm) thick.
2. Flexible Elastomeric: 1 inch (25 mm) thick.
3. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
4. Polyolefin: 1 inch (25 mm) thick.

H. Dual-service heating and cooling expansion/compression tank insulation shall be one of the following:

1. Cellular Glass: 1-1/2 inches (38 mm) thick.
2. Flexible Elastomeric: 1 inch (25 mm) thick.
3. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
4. Polyolefin: 1 inch (25 mm) thick.

I. Heating-Hot-Water Expansion/Compression Tank Insulation: Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.

J. Chilled-water air-separator insulation shall be one of the following:

1. Cellular Glass: 2 inches (50 mm) thick.
2. Flexible Elastomeric: 1 inch (25 mm) thick.
3. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
4. Polyolefin: 1 inch (25 mm) thick.

K. Dual-service heating and cooling air-separator insulation shall be one of the following:

1. Cellular Glass: 2 inches (50 mm) thick.
2. Flexible Elastomeric: 1 inch (25 mm) thick.
3. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
4. Polyolefin: 1 inch (25 mm) thick.

L. Heating-Hot-Water Air-Separator Insulation: Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.

3.9 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Equipment, Concealed:

1. None.
2. PVC or PVC, Color-Coded by System as directed: 20 mils (0.5 mm) or 30 mils (0.8 mm) thick as directed.
3. Aluminum, as directed: Thickness as directed.

D. Equipment, Exposed, up to 48 Inches (1200 mm) in Diameter or with Flat Surfaces up to 72 Inches (1800 mm):

1. None.
2. PVC or PVC, Color-Coded by System as directed: 20 mils (0.5 mm) or 30 mils (0.8 mm) thick as directed.
3. Aluminum, as directed: Thickness as directed.

E. Equipment, Exposed, Larger Than 48 Inches (1200 mm) in Diameter or with Flat Surfaces Larger Than 72 Inches (1800 mm):

1. None.
2. Painted Aluminum, Smooth or Stucco Embossed as directed.

3.10 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Equipment, Exposed, up to 48 Inches (1200 mm) in Diameter or with Flat Surfaces up to 72 Inches (1800 mm):

1. Painted Aluminum, as directed: Thickness as directed.

D. Equipment, Exposed, Larger Than 48 Inches (1200 mm) in Diameter or with Flat Surfaces Larger Than 72 Inches (1800 mm):

1. Painted Aluminum, as directed with Thickness as directed.

END OF SECTION 230716

SECTION 230719 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following HVAC piping systems:

1. Chilled-water and brine piping, indoors and outdoors.
2. Heating hot-water piping, indoors and outdoors.
3. Refrigerant suction and hot-gas piping, indoors and outdoors.
4. Dual-service heating and cooling piping, indoors and outdoors.

B. Related Sections:

1. Section 230713 "Duct Insulation."
2. Section 230716 "HVAC Equipment Insulation."
3. Section 232113.13 "Underground Hydronic Piping" for loose-fill pipe insulation in underground piping outside the building.
4. Section 336313 "Underground Steam and Condensate Distribution Piping" for loose-fill pipe insulation in underground piping outside the building.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Sustainable Design Submittals:

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail attachment and covering of heat tracing inside insulation.
3. Detail insulation application at pipe expansion joints for each type of insulation.
4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
5. Detail removable insulation at piping specialties.
6. Detail application of field-applied jackets.
7. Detail application at linkages of control devices.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Products shall not contain asbestos, lead, mercury, or mercury compounds.

B. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C871.

C. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C795.

D. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

E. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
1. Block Insulation: ASTM C552, Type I.
2. Special-Shaped Insulation: ASTM C552, Type III.
3. Board Insulation: ASTM C552, Type IV.
4. Preformed Pipe Insulation without Jacket: Comply with ASTM C552, Type II, Class 1.
5. Preformed Pipe Insulation with Factory-Applied ASJ or ASJ-SSL as directed: Comply with ASTM C552, Type II, Class 2.
6. Factory fabricate shapes according to ASTM C450 and ASTM C585.

F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534, Type I for tubular materials.

G. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C1290, Type I.

H. Mineral-Fiber, Preformed Pipe Insulation:
1. Type I, 850 deg F (454 deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C547, Type I, Grade A, as directed. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2. Type II, 1200 deg F (649 deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C547, Type II, Grade A, as directed. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

I. Mineral-Fiber, Pipe Insulation Wicking System: Preformed pipe insulation complying with ASTM C547, Type I, Grade A, with absorbent cloth factory-applied to the entire inside surface of preformed pipe insulation and extended through the longitudinal joint to outside surface of insulation under insulation jacket. Factory apply a white, polymer, vapor-retarder jacket with self-sealing adhesive tape seam and evaporation holes running continuously along the longitudinal seam, exposing the absorbent cloth.

J. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C534 or ASTM C1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.

2.2 INSULATING CEMENTS

A. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C449.

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F (minus 73 to plus 93 deg C).

C. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

D. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

E. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

F. PVC Jacket Adhesive: Compatible with PVC jacket.

2.4 MASTICS AND COATINGS

A. Materials shall be compatible with insulation materials, jackets, and substrates.

B. Vapor-Retarder Mastic: Water based; suitable for indoor use on below-ambient services.
1. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
2. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
3. Comply with MIL-PRF-19565C, Type II, for permeance requirements, with supplier listing on DOD QPD - Qualified Products Database.
4. Color: White.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.
   1. Water-Vapor Permeance: ASTM E96, greater than 1.0 perm (0.66 metric perms) at manufacturer's recommended dry film thickness.
   2. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
   3. Color: White.

2.5 SEALANTS

A. Joint Sealants:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Permanently flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C).
   4. Color: White or gray.

B. FSK and Metal Jacket Flashing Sealants:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Fire- and water-resistant, flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
   4. Color: Aluminum.

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Fire- and water-resistant, flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
   4. Color: White.

2.6 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

   1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
   2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
   3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.
   4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.
   5. PVDC Jacket for Indoor Applications: 4-mil- (0.10-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perm (0.013 metric perm) when tested according to ASTM E96/E96M and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E84.

   6. PVDC Jacket for Outdoor Applications: 6-mil- (0.15-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perm (0.007 metric perm) when tested according to ASTM E96/E96M and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E84.

7. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

8. Vinyl Jacket: White vinyl with a permeance of 1.3 perms (0.86 metric perms) when tested according to ASTM E96/E96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.7 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm), in a Leno weave, for pipe.

2.8 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil face, fiberglass-reinforced scrim with kraft-paper backing.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
1. Adhesive: As recommended by jacket material manufacturer.
2. Color: White or Color-code jackets based on system as directed.
3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

    a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

D. Aluminum Jacket: Comply with ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.
1. Sheet and roll stock ready for shop or field sizing or Factory cut and rolled to size.
2. Finish and thickness are indicated in field-applied jacket schedules.
3. Moisture Barrier for Indoor Applications: As directed.
4. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper or 2.5-mil- (0.063-mm-) thick polysurlyn as directed.
5. Factory-Fabricated Fitting Covers:

    a. Same material, finish, and thickness as jacket.
    b. Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
    c. Tee covers.
    d. Flange and union covers.
    e. End caps.
    f. Beveled collars.
    g. Valve covers.
    h. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

E. Self-Adhesive Outdoor Jacket: 60-mil- (1.5-mm-) thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross-laminated polyethylene film covered with white or stucco-embossed aluminum-foil facing as directed.

F. PVDC Jacket for Indoor Applications: 4-mil- (0.10-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms (0.013 metric perms) when tested according to ASTM E96/E96M and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E84.

G. PVDC Jacket for Outdoor Applications: 6-mil- (0.15-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms (0.007 metric perms) when tested according to ASTM E96/E96M and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E84.

H. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

2.9 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
1. Width: 3 inches (75 mm).
2. Thickness: 11.5 mils (0.29 mm).
3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.
1. Width: 3 inches (75 mm).
2. Thickness: 6.5 mils (0.16 mm).
3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
1. Width: 2 inches (50 mm).
2. Thickness: 6 mils (0.15 mm).
3. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
4. Elongation: 500 percent.
5. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. Width: 2 inches (50 mm).
2. Thickness: 3.7 mils (0.093 mm).
3. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.

4. Elongation: 5 percent.
5. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.

E. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
1. Width: 3 inches (75 mm).
2. Film Thickness: 4 mils (0.10 mm).
3. Adhesive Thickness: 1.5 mils (0.04 mm).
4. Elongation at Break: 145 percent.
5. Tensile Strength: 55 lbf/inch (10.1 N/mm) in width.

F. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
1. Width: 3 inches (75 mm).
2. Film Thickness: 6 mils (0.15 mm).
3. Adhesive Thickness: 1.5 mils (0.04 mm).
4. Elongation at Break: 145 percent.
5. Tensile Strength: 55 lbf/inch (10.1 N/mm) in width.

2.10 SECUREMENTS

A. Aluminum Bands: As directed ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) or 3/4 inch (19 mm) wide with wing seal or closed seal.

B. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.

C. Wire: As directed.

PART 3 - EXECUTION

3.1 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches (50 mm) or 4 inches (100 mm) o.c. as directed

    a. For below-ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

P. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.3 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches (50 mm).
4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.4 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for

above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.

8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches (50 mm) over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.5 INSTALLATION OF CELLULAR-GLASS INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches (150 mm) o.c.
4. For insulation with factory-applied jackets on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.7 INSTALLATION OF MINERAL-FIBER PREFORMED PIPE INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches (150 mm) o.c.
4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.

4. Install insulation to flanges as specified for flange insulation application.

3.8 INSTALLATION OF POLYOLEFIN INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Seal split-tube longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyolefin sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of polyolefin pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install cut sections of polyolefin pipe and sheet insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.9 FIELD-APPLIED JACKET INSTALLATION

A. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

B. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

C. Where metal jackets are indicated, install with 2-inch (50-mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches (300 mm) o.c. and at end joints.

D. Where PVDC jackets are indicated, install as follows:

1. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
2. Wrap factory-presized jackets around individual pipe insulation sections with one end overlapping the previously installed sheet. Install presized jacket with an approximate overlap at butt joint of 2 inches (50 mm) over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.
3. Continuous jacket can be spiral-wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.
4. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches (850 mm) or less. The 33-1/2-inch- (850-mm-) circumference limit allows for 2-inch- (50-mm-) overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
5. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.10 FINISHES

A. Pipe Insulation with ASJ or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

3.11 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.12 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.13 INDOOR PIPING INSULATION SCHEDULE

A. Chilled Water and Brine, above 40 Deg F (5 Deg C): Insulation shall be one of the following:

1. Cellular Glass: 1-1/2 inches (38 mm) or 2 inches (50 mm) thick as directed.
2. Flexible Elastomeric: 1 inch (25 mm) thick.
3. Mineral-Fiber, Preformed Pipe, Type I or Pipe Insulation Wicking System: Thickness as directed.
4. Polyolefin: 1 inch (25 mm) thick.

B. Heating-Hot-Water Supply and Return, 200 Deg F (93 Deg C) and Below: Insulation shall be one of the following:

1. Cellular Glass: 1-1/2 inches (38 mm) or 2 inches (50 mm) thick as directed.
2. Mineral-Fiber, Preformed Pipe, Type I: 1 inch (25 mm) or 2 inches (50 mm) thick as directed.

C. Refrigerant Suction and Hot-Gas Piping: Thickness as directed.

D. Refrigerant Suction and Hot-Gas Flexible Tubing: As directed.

E. Dual-Service Heating and Cooling, 40 to 200 Deg F (5 to 93 Deg C): Insulation shall be one of the following:

1. Cellular Glass: 1-1/2 inches (38 mm) or 2 inches (50 mm) thick as directed.
2. Mineral-Fiber, Preformed Pipe, Type I: As directed.

3.14 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Chilled Water and Brine: Insulation shall be one of the following:

1. Cellular Glass: 3 inches (75 mm) thick.
2. Flexible Elastomeric: 3 inches (75 mm) thick.
3. Mineral-Fiber, Preformed Pipe Insulation, Type I: 3 inches (75 mm) thick.
4. Polyolefin: 3 inches (75 mm) thick.

B. Heating-Hot-Water Supply and Return, 200 Deg F (93 Deg C) and Below: Insulation shall be one of the following:

1. Cellular Glass: 3 inches (75 mm) thick.
2. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.

C. Refrigerant Suction and Hot-Gas Piping: Insulation shall be one of the following:

1. Cellular Glass: 2 inches (50 mm) thick.
2. Flexible Elastomeric: 2 inches (50 mm) thick.
3. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.
4. Polyolefin: 2 inches (50 mm) thick.

D. Refrigerant Suction and Hot-Gas Flexible Tubing: Insulation shall be one of the following:

1. Flexible Elastomeric: 2 inches (50 mm) thick.
2. Polyolefin: 2 inches (50 mm) thick.

E. Dual-Service Heating and Cooling: Insulation shall be one of the following:

1. Cellular Glass: 3 inches (75 mm) thick.
2. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.

3.15 OUTDOOR, UNDERGROUND PIPING INSULATION SCHEDULE

A. Loose-fill insulation, for belowground piping, is specified in Section 232113.13 "Underground Hydronic Piping" and Section 336313 "Underground Steam and Condensate Distribution Piping."

B. Chilled Water, All Sizes: Cellular glass, 2 inches (50 mm) thick.

C. Heating-Hot-Water Supply and Return, All Sizes, 200 Deg F (93 Deg C) and Below: Cellular glass, 3 inches (75 mm) thick.

D. Dual-Service Heating and Cooling, All Sizes, 40 to 200 Deg F (4 to 93 Deg C): Cellular glass, 3 inches (75 mm) thick.

3.16 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:

1. None.
2. PVC or PVC, Color-Coded by System as directed: 20 mils (0.5 mm) or 30 mils (0.8 mm) thick as directed.
3. Aluminum, as directed: Thickness as directed.

D. Piping, Exposed:

1. None.
2. PVC or PVC, Color-Coded by System as directed: 20 mils (0.5 mm) or 30 mils (0.8 mm) thick as directed.
3. Aluminum, as directed: Thickness as directed.

3.17 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:

1. None.
2. PVC or PVC, Color-Coded by System: 20 mils (0.5 mm) or 30 mils (0.8 mm) thick as directed.
3. Aluminum, as directed: Thickness as directed.

D. Piping, Exposed:

1. PVC: Thickness as directed.

3.18 UNDERGROUND, FIELD-INSTALLED INSULATION JACKET

A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

END OF SECTION 230719

SECTION 230800 - COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes Cx process requirements for the following HVAC systems, assemblies, and equipment:

1. Energy supply systems.
2. Heat generation systems.
3. Cooling generation systems.
4. Central-station air-handling systems.
5. Air, steam, and hydronic distribution systems.
6. Heating and cooling terminal and unitary equipment.
7. HVAC controls.
8. TAB verification.

B. Related Requirements:

1. Section 019113 "General Commissioning Requirements" for general Cx process requirements and CxA responsibilities.
2. For construction checklists, comply with requirements in various Division 23 Sections specifying HVAC systems, system components, equipment, and products.

1.2 DEFINITIONS

A. Cx: Commissioning, as defined in Section 019113 "General Commissioning Requirements."

B. CxA: Commissioning Authority, as defined in Section 019113 "General Commissioning Requirements."

C. DDC: Direct digital controls.

D. HVAC: Heating, ventilating, and air conditioning.

E. "Systems," "Assemblies," "Subsystems," "Equipment," and "Components": Where these terms are used together or separately, they shall mean "as-built" systems, assemblies, subsystems, equipment, and components.

F. TAB: Testing, adjusting, and balancing.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 CONSTRUCTION CHECKLIST REVIEW

A. Review and provide written comments on draft construction checklists. CxA will create required draft construction checklists and provide them to Contractor.

B. Return draft construction checklist review comments within 10 days of receipt.

C. When review comments have been resolved, the CxA will provide final construction checklists, marked "Approved for Use, (date)."

D. Use only construction checklists, marked "Approved for Use, (date)."

3.2 Cx TESTING PREPARATION

A. Certify that HVAC systems, subsystems, and equipment have been installed, calibrated, and started and that they are operating according to the Contract Documents and approved submittals.

B. Certify that HVAC instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents and approved submittals, and that pretest set points have been recorded.

C. Certify that TAB procedures have been completed and that TAB reports have been submitted, discrepancies corrected, and corrective work approved.

D. Set systems, subsystems, and equipment into operating mode to be tested according to approved test procedures (for example, normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

3.3 Cx TEST CONDITIONS

A. Perform tests using design conditions, whenever possible.

1. Simulated conditions may, with approval of Architect, be imposed using an artificial load when it is impractical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by CxA and document simulated conditions and methods of simulation. After tests, return configurations and settings to normal operating conditions.
2. Cx test procedures may direct that set points be altered when simulating conditions is impractical.
3. Cx test procedures may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are impractical.

B. If tests cannot be completed because of a deficiency outside the scope of the HVAC system, document the deficiency and report it to Architect. After deficiencies are resolved, reschedule tests.

C. If seasonal testing is specified, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.4 Cx TESTS COMMON TO HVAC SYSTEMS

A. Measure capacities and effectiveness of systems, assemblies, subsystems, equipment, and components, including operational and control functions, to verify compliance with acceptance criteria.

B. Test systems, assemblies, subsystems, equipment, and components operating modes, interlocks, control responses, responses to abnormal or emergency conditions, and response according to acceptance criteria.

C. Coordinate schedule with, and perform Cx activities at the direction of, CxA.

D. Comply with construction checklist requirements, including material verification, installation checks, startup, and performance tests requirements specified in Division 23 Sections specifying HVAC systems and equipment.

E. Provide technicians, instrumentation, tools, and equipment to perform and document the following:

1. Construction checklist verification tests.
2. Construction checklist verification test demonstrations.
3. Cx tests.
4. Cx test demonstrations.

F. Vibration Isolation in HVAC Systems:

1. Prerequisites: Acceptance of results of construction checklists for vibration and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment" or Section 230548.13 "Vibration Controls for HVAC Piping and Equipment" as directed
2. Components to Be Tested:

    a. Vibration isolation and seismic control devices in HVAC systems.
    b. Structural systems.

3. Test Purpose: Evaluate effectiveness of vibration isolation and seismic control devices.
4. Test Conditions: Measure vibration of the facility structure at three locations designated by Owner's witness while the isolated equipment operates.
5. Test Conditions: Measure vibration of the facility structure at three locations designated by Owner's witness at the following operating conditions:

    a. Maximum speed.
    b. Minimum speed.

c. Critical speed.

6. Acceptance Criteria: Structure-borne vibration not to exceed specified performance.

G. Heat Tracing in HVAC Systems:

1. Prerequisites: Acceptance of results of construction checklists for heat tracing specified in HVAC systems. Comply with requirements listed in Section 230533 "Heat Tracing for HVAC Piping."
2. Equipment and Systems to Be Tested:

a. Self-regulating, parallel-resistance heating cables.
b. Heater trace circuit controller.

3. Test Purpose:

a. Evaluate response to ambient temperature below freeze-protection set point.
b. Evaluate heating cable fault alarm.

4. Test Conditions:

a. Subject temperature sensor to temperature approximately 3 deg F (2 deg C) above freeze-protection set point (initial set point 41 deg F (5 deg C). Monitor sensed temperature with a calibration-grade thermometer. Gradually change set point or sensed temperature until freeze-protection circuit is energized.
b. Subject temperature sensor to temperature approximately 3 deg F (2 deg C) below freeze-protection set point (initial set point 41 deg F (5 deg C). Monitor sensed temperature with a calibration-grade thermometer. Gradually change set point or sensed temperature until freeze-protection circuit is de-energized.
c. Simulate an electrical fault on the heating cable.

5. Acceptance Criteria:

a. Freeze-protection circuit is energized at set-point temperature minus 2 deg F (1 deg C).
b. Freeze-protection circuit is de-energized at set-point temperature plus 2 deg F (1 deg C).
c. Heater trace circuit controller initiates an alarm of cable fault. Alarm is correctly reported at the fire-alarm control panel.

3.5 TAB VERIFICATION

A. Prerequisites: Completion of "Examination" Article requirements and correction of deficiencies, as specified in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

B. Completion of "Preparation" Article requirements for preparation of a TAB plan that includes strategies and step-by-step procedures, and system-readiness checks and reports, as specified in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

C. Scope: HVAC air systems and hydronic piping systems.

D. Purpose: Differential flow relationships intended to maintain air pressurization differentials between the various areas of Project.

E. Conditions of the Test:

1. Cx Test Demonstration Sampling Rate: As specified in "Inspections" Article in Section 230593 "Testing, Adjusting, and Balancing for HVAC."
2. Systems operating in full heating mode with minimum outside-air volume.
3. Systems operating in full cooling mode with minimum outside-air volume.
4. For measurements at air-handling units with economizer controls; systems operating in economizer mode with 100 percent outside air.

F. Acceptance Criteria:

1. Under all conditions, rechecked measurements comply with "Inspections" Article in Section 230593 "Testing, Adjusting, and Balancing for HVAC."
2. Additionally, no rechecked measurement shall differ from measurements documented in the final report by more than two times the tolerances allowed.
3. Under all conditions, where the Contract Documents indicate a differential in airflow between supply and exhaust and/or return in a space, the differential relationship shall be maintained.

3.6 HEATING CONTROL SYSTEM Cx TESTS

A. Heating-Water Supply Temperature Control:

1. Prerequisites: Installation verification of the following:

a. Startup of boiler or steam to hot-water converter as directed.
b. Startup of heating-water pump(s) as directed.
c. TAB of heating-water flow and pressure.
d. Input Device: Heating-water supply temperature; as directed.
e. Output Device: Control valve.
f. Display the following at the operator's workstation:

1) Heating-water supply temperature.
2) Heating-water supply temperature set point.
3) Control-valve position.

2. Scope: Heating-water system.
3. Purpose: Control of heating-water supply temperature at input device.
4. Conditions of the Test:

a. Minimum heating-water flow.
b. Midrange Heating-Water Flow: 50 to 60 percent of maximum.
c. Maximum heating-water flow.

5. Acceptance Criteria: Under all conditions, heating-water supply temperature is within plus or minus 2.0 deg F (1.1 deg C) of set point.

B. Heating-Water Supply Temperature Reset:

1. Prerequisites: Installation verification of the following:

   a. Startup of boiler or steam to hot-water converter as directed.
   b. Startup of heating-water pump(s).
   c. TAB of heating-water flow and pressure.
   d. Input Device: Heating-water supply temperature; as directed.
   e. Input Device: Outdoor-air temperature; electric, outdoor-air-reset controller or outdoor-air sensor as directed.
   f. Output Device: Control valve.
   g. Display the following at the operator's workstation:

      1) Outdoor-air temperature.
      2) Heating-water supply temperature.
      3) Heating-water supply temperature set point.
      4) Control-valve position.

2. Scope: Heating-water system.
3. Purpose: Control of heating-water supply temperature at heating-water supply temperature input device in response to variable outdoor-air temperature input; electric, outdoor-air-reset controller or outdoor-air sensor as directed.
4. Conditions of the Test: Outdoor-air temperature input value may be overridden for this test.

   a. Low Temperature: Outdoor-air temperature between minus 30 and 0 deg F (minus 34 and minus 18 deg C).
   b. Midrange Temperature: Outdoor-air temperature between 30 and 45 deg F (minus 1 and plus 7 deg C).
   c. High Temperature: Outdoor-air temperature above 65 deg F (18 deg C).

5. Acceptance Criteria: Heating-water supply temperature resets in straight-line relationship with outdoor-air temperature for the following reset schedule. Under all conditions, heating-water supply temperature is within 2.0 deg F (1.1 deg C) of set point.

   a. 195 deg F (90 deg C) heating water when outdoor-air temperature is minus 30 deg F (minus 34 deg C).
   b. 130 deg F (54 deg C) heating water when outdoor-air temperature is 65 deg F (18 deg C).
   c. Under all conditions, heating-water supply temperature is within plus or minus 2.0 deg F (1.1 deg C) of set point.

C. Control Primary Circulating Pump(s):

1. Prerequisites: Installation verification of the following:

   a. Startup of heating-water pump(s).

b. Input Device: Outdoor-air temperature; electric, outdoor-air-reset controller or outdoor-air sensor as directed.
c. Output Device: Heating-water pump; starter or DDC system command to starter relay.
d. Display the following at the operator's workstation:

1) Outdoor-air temperature.
2) Operating status of primary circulating pump(s).

2. Scope: Heating-water pump(s) and associated controls.
3. Purpose: On-off control of heating-water pump(s) in response to variable outdoor-air temperature input; electric, outdoor-air-reset controller or outdoor-air sensor.
4. Conditions of the Test:

a. High Temperature: Outdoor-air temperature above 65 deg F (18 deg C).
b. Low Temperature: Outdoor-air temperature below 65 deg F (18 deg C).

5. Acceptance Criteria:

a. High Temperature: Pump(s) are off when outside-air temperature is above 65 deg F (18 deg C).
b. Low Temperature: Pump(s) are on when outside-air temperature is below 65 deg F (18 deg C).

3.7 CENTRAL REFRIGERATION SYSTEM Cx TESTS

A. Start and Stop Condenser-Water Pump(s):

1. Prerequisites: Installation verification of the following:

a. Startup of condenser-water pump(s).
b. Startup of cooling tower.
c. Input Device: Water pressure transducer.
d. Input Device: Space thermostat or DDC system outdoor-air temperature as directed.
e. Input Device: Time clock or DDC system time schedule as directed.
f. Output Device: Hard wired through motor starter; DDC system binary output.
g. Output Device: Time clock or Binary output.
h. Display the following at the operator's workstation:

1) Low-level cooling-tower sump alarm.
2) Outdoor-air temperature.
3) Cooling (software) demand indication.
4) Time and time schedule.
5) Condenser-water pump(s) on-off status.
6) Condenser-water pump(s) on-off indication.
7) Condenser-water flow indication.

2. Scope:

a. Condenser-water system, including condenser-water pump(s), cooling towers, and associated controls.

3. Purpose:

a. Condenser-water pump(s) lockout.
b. Condenser-water pump(s) start.
c. Condenser-water pump(s) shutdown.
d. Low-level cooling-tower sump alarm.
e. Condenser-water pump(s) time-of-day schedule.

4. Conditions of the Test:

a. Verify Lockout: Start with condenser-water pump enable-input devices in the "disable" state to prevent pump start. One by one, place the enable-input devices in the "enable" state, and then return each to the "disable" state before placing the next enable-input device to the "enable" state.
b. Verify Start: Start with condenser-water pump enable-input devices in the "disable" state to prevent pump start. One by one, place the enable-input devices in the "enable" state.
c. Verify Shutdown: Place all enable-input devices in the "enable" state to allow the pump(s) to start. One by one, place the enable-input devices in the "disable" state, and then return each to the "enable" state before placing the next enable-input device to the "disable" state.
d. Verify Schedule: Compare condenser-water pump start and stop schedule times with Owner-approved time-of-day schedule.

5. Acceptance Criteria:

a. Lockout: No single enable-input device starts the pump(s) when released to the "enable" state.
b. Start: Condenser-water pump(s) start when, and only when, all enable-input devices are in the "enable" state.
c. Shutdown: Each enable-input device stops the condenser-water pump(s) when placed in the "disable" state, regardless of the state of other enable-input devices.
d. Schedule: Condenser-water pump start and stop schedule times agree with Owner-approved time-of-day schedule.

B. Start and Stop Chilled-Water Pump(s):

1. Prerequisites: Installation verification of the following:

a. Startup of chilled-water pump(s).
b. Startup of condenser-water pump(s)
c. Startup of cooling tower.
d. Input Device: Flow switch in condenser-water circuit.
e. Output Device: Starter or DDC system command to starter relay as directed.
f. Display of the following at the operator's workstation:

1) Chilled-water flow indication.
2) Condenser-water flow indication.

3) Chilled-water pump(s) on-off status.
4) Chilled-water pump(s) on-off indication.

2. Scope: Chilled-water system, including chilled-water pump(s), associated controls, and condenser-water system controls.
3. Purpose:

a. Chilled-water pump(s) start.
b. Chilled-water pump(s) shutdown.

4. Conditions of the Test:

a. Verify Start: Start with chilled-water pump enable-input device in the "disable" state to prevent pump start. Place the enable-input device in the "enable" state.
b. Verify Shutdown: Start with the enable-input device in the "enable" state to allow the pump(s) to run. Then place the enable-input device in the "disable" state.

5. Acceptance Criteria:

a. Start: Chilled-water pump(s) start when, and only when, the enable-input device is in the "enable" state.
b. Shutdown: The enable-input device stops the chilled-water pump(s) when placed in the "disable" state.

C. Start and Stop Cooling-Tower Fans(s):

1. Prerequisites: Installation verification of the following:

a. Input Device: Flow switch in condenser-water circuit.
b. Output Device: Starter or DDC system command to starter relay.
c. Display:

1) Condenser-water flow indication.
2) Cooling-tower fan(s) on-off indication.

2. Scope: Condenser-water system, including cooling tower, condenser-water pump(s), and associated controls.
3. Purpose:

a. Cooling-tower fan(s) start.
b. Cooling-tower fan(s) shutdown.

4. Conditions of the Test:

a. Verify Start: Start with cooling-tower fan enable-input device in the "disable" state to prevent fan(s) start. Place the enable-input device in the "enable" state.
b. Verify Shutdown: Start with the enable-input device in the "enable" state to allow the fan(s) to run. Then place the enable-input device in the "disable" state.

5. Acceptance Criteria:

a. Start: Chilled-water pump(s) start when, and only when, the enable-input device is in the "enable" state.
b. Shutdown: The enable-input device stops the chilled-water pump(s) when placed in the "disable" state.

D. Alternative Chiller(s):

1. Prerequisites: Installation verification of the following:

a. Input Device: Electric alternator or DDC system software as directed.
b. Output Device: Chiller or DDC system command to chiller terminal strip as directed.
c. Display:

1) Chiller(s) on-off indication.
2) Chiller failure alarm.

2. Scope:

a. Chilled-water system and associated controls.
b. Condenser-water system and associated controls.

3. Purpose:

a. Lead-lag rotation of chillers.
b. Replacement of failed chiller in rotation.
c. Adding and dropping chillers as follows: As directed.
d. Replacement of failed chiller in add/drop sequence.
e. Chiller failure alarm initiation.

4. Conditions of the Test:

a. Lead-Lag Rotation - Chiller Start: Create a number of chilled-water system start-stop cycles equal to the number of chillers plus one.
b. Lead-Lag Rotation - Lead Chiller Fail: Disable the lead chiller while it is running.
c. Lead-Lag Rotation - Lag Chiller Fail: Disable a lag chiller while it is running.
d. Lead-Lag Rotation - Chiller Start Fail: Disable a chiller while it is in standby mode. Initiate a lead-lag rotation call for the disabled chiller to start.
e. Add/Drop Sequence - Increasing Demand: Increase chilled-water demand incrementally to observe the corresponding addition of chillers. Increase demand gradually as the load approaches the set point for adding the next chiller, to permit observation of the actual load at the time the next chiller is enabled.
f. Add/Drop Sequence - Decreasing Demand: Decrease chilled-water demand incrementally to observe the corresponding dropping of chillers. Decrease demand gradually as the load approaches the set point for dropping the next chiller, to permit observation of the actual load at the time the next chiller is disabled.

5. Acceptance Criteria:

a. Lead-Lag Rotation - Chiller Start: On each chilled-water system start event, the other or next chiller in rotation as directed starts as the lead chiller, and the previous lead chiller is designated as the last lag chiller.
b. Lead-Lag Rotation - Lead Chiller Fail: When the lead chiller fails, the other or next chiller in rotation starts as the lead chiller, and a chiller failure alarm is initiated for the failed chiller.
c. Lead-Lag Rotation - Lag Chiller Fail: When the lag chiller fails, the next chiller in rotation starts as the lead chiller, and a chiller failure alarm is initiated for the failed chiller.
d. Lead-Lag Rotation - Chiller Start Fail: When a chiller fails to start, the next chiller in rotation starts in its place, and a chiller failure alarm is initiated for the failed chiller.
e. Add/Drop Sequence - Increasing Demand: Chillers are added at the specified load set point, plus or minus 5 percent. Chilled-water supply temperature remains stable within plus or minus 2.0 deg F (1.1 deg C) of set point.
f. Add/Drop Sequence - Decreasing Demand: Chillers are dropped at the specified load set point, plus or minus 5 percent. Chilled-water supply temperature remains stable within plus or minus 2.0 deg F (1.1 deg C) of set point.
g. Add/Drop Sequence - Operating Chiller Fail: When an operating chiller fails, the next chiller in sequence starts and a chiller failure alarm is initiated for the failed chiller.
h. Add/Drop Sequence - Chiller Start Fail: When a chiller fails to start, the next chiller in sequence starts in its place and a chiller failure alarm is initiated for the failed chiller.

3.8 TERMINAL UNIT EQUIPMENT Cx TESTS

A. VAV Terminal Air Units with Coils:

1. Prerequisites: Installation verification of the following:

a. Occupancy Input Device: Occupancy sensor.
b. Occupancy Output Device: DDC system binary output.
c. Room Temperature Input Device: Room thermostat or Electronic temperature sensor as directed.
d. Room Temperature Output Device: Pneumatic or Electronic damper actuators and control-valve operators as directed.
e. Display the following at the operator's workstation:

1) Room/area served.
2) Room occupied/unoccupied.
3) Room temperature indication.
4) Room temperature set point.
5) Room temperature set point, occupied.
6) Room temperature set point, unoccupied.
7) Air-damper position as percentage open.
8) Control-valve position as percentage open.

2. Scope: VAV terminal air units with hydronic or steam coils in supply-air systems as directed, and associated controls.

3. Purpose:

   a. Occupancy-dependent room temperature set-point reset.
   b. Room temperature control.

4. Conditions of the Test:

   a. Cx Test Demonstration Sampling Rate: 10 percent of each model/size unit.
   b. Temperature Control - Occupied: Start with the room unoccupied. Occupy the room and observe the change to occupied status. Observe temperature control until room temperature is stable at occupied set point, plus or minus 1.0 deg F (0.6 deg C).
   c. Temperature Control - Unoccupied: Start with the room occupied. Vacate the room and observe the change to unoccupied status. Observe temperature control until room temperature is stable at unoccupied set point, plus or minus 1.0 deg F (0.6 deg C).

5. Acceptance Criteria:

   a. Temperature Control - Occupied:

      1) Control system status changes from "occupied" to "unoccupied" after the specified time.
      2) Room temperature is stable at occupied set point, plus or minus 1.0 deg F (0.6 deg C) within 10 minutes of occupancy. Room temperature does not overshoot or undershoot set point by more than 2.0 deg F (1.1 deg C) during transition.

   b. Temperature Control - Unoccupied:

      1) Control system status changes from "unoccupied" to "occupied" immediately or after five minutes of continuous occupancy as directed.
      2) Room temperature is stable at unoccupied set point, plus or minus 1.0 deg F (0.6 deg C) within 30 minutes of occupancy.

3.9 AIR-HANDLING SYSTEM Cx TESTS

A. Supply Fan(s) Variable-Volume Control:

1. Prerequisites: Installation verification of the following:

   a. Volume Control Input Device: Static-pressure transmitter or Differential-pressure switch sensing supply-duct static pressure referenced to conditioned-space static pressure as directed.
   b. Volume Control Output Device: As directed.
   c. Volume Control Input Device: Static-pressure transmitter or Differential-pressure switch sensing supply-duct static pressure referenced to conditioned-space static pressure as directed.

d. Volume Control Output Device: Receiver controller or DDC system analog output to motor speed controller as directed. Set variable-speed drive to minimum speed when fan is stopped.
e. High-Pressure Input Device: Static-pressure transmitter sensing supply-duct static pressure referenced to static pressure outside the duct.
f. High-Pressure Output Device: As directed.
g. Display the following at the operator's workstation:

1) Supply-fan-discharge static-pressure indication.
2) Supply-fan-discharge static-pressure set point.
3) Supply-fan airflow rate.
4) Supply-fan inlet vane position or speed as directed.

2. Scope: VAV supply fan units and associated controls.
3. Purpose:

a. Supply-air discharge static pressure control.
b. Response to excess supply-air discharge static pressure condition.

4. Conditions of the Test:

a. Minimum supply-air flow.
b. Midrange Supply-Air Flow: 50 to 60 percent of maximum.
c. Maximum supply-air flow.
d. Excess supply-air discharge static pressure.

5. Acceptance Criteria:

a. At all supply-air flow rates, and during changes in supply-air flow, discharge air static pressure is at set point plus or minus 2 percent.
b. Fan stops and an alarm is initiated at the operator's workstation when supply-air discharge static pressure is at the excess static pressure, plus or minus 2 percent.

B. Air-Handler Mixed-Air Control:

1. Prerequisites: Installation verification of the following:

a. Minimum Position Input Device: Time clock or DDC system time schedule as directed.
b. Output Device: As directed to modulating damper actuator(s).
c. Heating Reset Input Device: Room thermostat or DDC system software as directed.
d. Supply or Mixed-Air Temperature Input Device as directed: Duct-mounted thermostat or Electronic temperature sensor as directed.
e. Cooling Reset Input Device: Outdoor- and return-air, duct-mounted thermostats or electronic temperature sensors.
f. Display the following at the operator's workstation:

1) Mixed-air-temperature indication.
2) Mixed-air-temperature set point.
3) Mixed-air damper position.

2. Scope: Air handler with mixed-air control and associated controls.
3. Purpose:

    a. Occupied time control.
    b. Minimum damper position control.
    c. Heating reset control.
    d. Supply or Mixed-air temperature control as directed.
    e. Cooling reset control.
    f. Unoccupied time control.

4. Conditions of the Test:

    a. Occupied Time Control: Start in unoccupied schedule. Advance to occupied schedule time.
    b. Minimum Damper Position Control: Command system to mode in which minimum damper position is required.
    c. Heating Reset Control: Create a call for heating.
    d. Supply or Mixed-Air Temperature Control as directed: Override supply or mixed-air temperature set point to a value 2.0 deg F (1.1 deg C) above current supply or mixed-air temperature as directed.
    e. Cooling Reset Control: Override outdoor-air temperature to a value that exceeds return-air temperature or enthalpy to a value that exceeds return-air enthalpy as directed.
    f. Unoccupied Time Control: Advance to unoccupied schedule time.
    g. Control Data Trend Log: Set up a data trend log of the following input device values and output device commands. Record data at hourly intervals. Submit trend data for 24-hour periods in which natural conditions require heating reset control, supply or mixed-air temperature control, and cooling reset control as directed.

        1) Minimum position input device.
        2) Heating reset input device.
        3) Supply or Mixed-air temperature input device as directed.
        4) Cooling reset input device.

5. Acceptance Criteria:

    a. Occupied Time Control: Mixed-air control is active in occupied mode.
    b. Minimum Damper Position Control: Controller opens minimum outdoor-air dampers or positions outdoor-air dampers to minimum position.
    c. Heating Reset Control: Controller closes minimum outdoor-air dampers or sets outdoor-air dampers to minimum position.
    d. Supply or Mixed-Air Temperature Control as directed: Controller modulates outdoor-, return, and relief-air dampers to maintain temporary supply or mixed-air temperature set point as directed, plus or minus 1.0 deg F (0.6 deg C).
    e. Cooling Reset Control: Controller sets outdoor-air dampers to minimum position when outdoor-air temperature exceeds return-air temperature or enthalpy exceeds return-air enthalpy as directed.
    f. Unoccupied Time Control: Controller positions outdoor- and relief-air dampers closed and return-air dampers open.
    g. Control Data Trend Log: Data verify control according to sequence of control.

END OF SECTION 230800

SECTION 230923 - DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. DDC system for monitoring and controlling of HVAC systems.
2. Delivery of selected control devices to equipment and systems manufacturers for factory installation and to HVAC systems installers for field installation.

B. Related Requirements:

1. Section 230923.13 "Energy Meters" for thermal and electric power energy meters that connect to DDC systems.
2. Section 230923.17 "Level Instruments" for liquid-level switches, sensors, and transmitters that connect to DDC systems.
3. Section 230923.22 "Position Instruments" for limit switches that connect to DDC systems.
4. Section 230923.33 "Vibration Instruments" for vibration instruments that connect to DDC systems.
5. Section 230923.43 "Weather Stations" for weather stations that connect to DDC systems.
6. Section 230993.11 "Sequence of Operations for HVAC DDC" for control sequences in DDC systems.
7. Communications Cabling:

    a. Section 260523 "Control-Voltage Electrical Power Cables" for balanced twisted pair communications cable.
    b. Section 271513 "Communications Copper Horizontal Cabling" for balanced twisted pair communications cable.
    c. Section 271523 "Communications Optical Fiber Backbone Cabling" for optical fiber communications cable.

8. Raceways:

    a. Section 260533 "Raceways and Boxes for Electrical Systems" for raceways for low-voltage control cable.
    b. Section 270528 "Pathways for Communications Systems" for raceways for balanced twisted pair cabling and optical fiber cable.

1.2 DEFINITIONS

A. Algorithm: A logical procedure for solving a recurrent mathematical problem. A prescribed set of well-defined rules or processes for solving a problem in a finite number of steps.

B. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.

C. BACnet Specific Definitions:

1. BACnet: Building Automation Control Network Protocol, ASHRAE 135. A communications protocol allowing devices to communicate data over and services over a network.
2. BACnet Interoperability Building Blocks (BIBBs): BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBs are combined to build the BACnet functional requirements for a device.
3. BACnet/IP: Defines and allows using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnetworks that share the same BACnet network number.
4. BACnet Testing Laboratories (BTL): Organization responsible for testing products for compliance with ASHRAE 135, operated under direction of BACnet International.
5. PICS (Protocol Implementation Conformance Statement): Written document that identifies the particular options specified by BACnet that are implemented in a device.

D. Binary: Two-state signal where a high signal level represents ON" or "OPEN" condition and a low signal level represents "OFF" or "CLOSED" condition. "Digital" is sometimes used interchangeably with "Binary" to indicate a two-state signal.

E. Controller: Generic term for any standalone, microprocessor-based, digital controller residing on a network, used for local or global control. Three types of controllers are indicated: Network Controller, Programmable Application Controller, and Application-Specific Controller.

F. Control System Integrator: An entity that assists in expansion of existing enterprise system and support of additional operator interfaces to I/O being added to existing enterprise system.

G. COV: Changes of value.

H. DDC System Provider: Authorized representative of, and trained by, DDC system manufacturer and responsible for execution of DDC system Work indicated.

I. Distributed Control: Processing of system data is decentralized and control decisions are made at subsystem level. System operational programs and information are provided to remote subsystems and status is reported back. On loss of communication, subsystems shall be capable of operating in a standalone mode using the last best available data.

J. DOCSIS: Data-Over Cable Service Interface Specifications.

K. Gateway: Bidirectional protocol translator that connects control systems that use different communication protocols.

L. HLC: Heavy load conditions.

M. I/O: System through which information is received and transmitted. I/O refers to analog input (AI), binary input (BI), analog output (AO) and binary output (BO). Analog signals are continuous and represent control influences such as flow, level, moisture, pressure, and temperature. Binary signals convert electronic signals to digital pulses (values) and generally represent two-position operating and alarm status. "Digital," (DI and (DO), is sometimes used interchangeably with "Binary," (BI) and (BO), respectively.

N. LAN: Local area network.

O. LNS: LonWorks Network Services.

P. LON Specific Definitions:

1. FTT-10: Echelon Transmitter-Free Topology Transceiver.
2. LonMark: Association comprising suppliers and installers of LonTalk products. Association provides guidelines for implementing LonTalk protocol to ensure interoperability through a standard or consistent implementation.
3. LonTalk: An open standard protocol developed by the Echelon Corporation that uses a "Neuron Chip" for communication. LonTalk is a register trademark of Echelon.
4. LonWorks: Network technology developed by Echelon.
5. Node: Device that communicates using CEA-709.1-C protocol and that is connected to a CEA-709.1-C network.
6. Node Address: The logical address of a node on the network, consisting of a Domain number, Subnet number, and Node number. "Node number" portion of an address is a number assigned to device during installation, is unique within a subnet, and is not a factory-set unique Node ID.
7. Node ID: A unique 48-bit identifier assigned at factory to each CEA-709.1-C device. Sometimes called a "Neuron ID."
8. Program ID: An identifier (number) stored in a device (usually EEPROM) that identifies node manufacturer, functionality of device (application and sequence), transceiver used, and intended device usage.
9. Standard Configuration Property Type (SCPT): Pronounced "skip-it." A standard format type maintained by LonMark International for configuration properties.
10. Standard Network Variable Type (SNVT): Pronounced "snivet." A standard format type maintained by LonMark used to define data information transmitted and received by individual nodes. "SNVT" is used in two ways. It is an acronym for "Standard Network Variable Type" and is often used to indicate a network variable itself (i.e., it can mean "a network variable of a standard network variable type").
11. Subnet: Consists of a logical grouping of up to 127 nodes, where logical grouping is defined by node addressing. Each subnet is assigned a number, which is unique within a Domain. See "Node Address."
12. TP/FT-10: Free Topology Twisted Pair network defined by CEA-709.3 and is most common media type for a CEA-709.1-C control network.
13. TP/XF-1250: High-speed, 1.25-Mbps, twisted-pair, doubly terminated bus network defined by "LonMark Interoperability Guidelines" typically used only to connect multiple TP/FT-10 networks.
14. User-Defined Configuration Property Type (UCPT): Pronounced "U-Keep-It." A Configuration Property format type that is defined by device manufacturer.
15. User-Defined Network Variable Type (UNVT): Network variable format defined by device manufacturer. UNVTs create non-standard communications that other vendors' devices may not correctly interpret and may negatively impact system operation. UNVTs are not allowed.

Q. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

R. Mobile Device: A data-enabled phone or tablet computer capable of connecting to a cellular data network and running a native control application or accessing a web interface.

S. Modbus TCP/IP: An open protocol for exchange of process data.

T. MS/TP: Master-slave/token-passing, IEE 8802-3. Datalink protocol LAN option that uses twisted-pair wire for low-speed communication.

U. Network Controller: Digital controller, which supports a family of programmable application controllers and application-specific controllers, that communicates on peer-to-peer network for transmission of global data.

V. Network Repeater: Device that receives data packet from one network and rebroadcasts it to another network. No routing information is added to protocol.

W. Peer to Peer: Networking architecture that treats all network stations as equal partners.

X. POT: Portable operator's terminal.

Y. RAM: Random access memory.

Z. RF: Radio frequency.

AA. Router: Device connecting two or more networks at network layer.

BB. TCP/IP: Transport control protocol/Internet protocol.

CC. UPS: Uninterruptible power supply.

DD. USB: Universal Serial Bus.

EE. User Datagram Protocol (UDP): This protocol assumes that the IP is used as the underlying protocol.

FF. VAV: Variable air volume.

GG. WLED: White light emitting diode.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product include the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.

3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation, operation and maintenance instructions including factors effecting performance.
5. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.

    a. Workstations.
    b. Servers.
    c. Printers.
    d. Gateways.
    e. Routers.
    f. Protocol analyzers.
    g. DDC controllers.
    h. Enclosures.
    i. Electrical power devices.
    j. UPS units.
    k. Accessories.
    l. Instruments.
    m. Control dampers and actuators.
    n. Control valves and actuators.

6. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.
7. Each submitted piece of product literature shall clearly cross reference specification and drawings that submittal is to cover.

B. Software Submittal:

1. Cross-referenced listing of software to be loaded on each operator workstation, server, gateway, and DDC controller.
2. Description and technical data of all software provided and cross-referenced to products in which software will be installed.
3. Operating system software, operator interface and programming software, color graphic software, DDC controller software, maintenance management software, and third-party software.
4. Include a flow diagram and an outline of each subroutine that indicates each program variable name and units of measure.
5. Listing and description of each engineering equation used with reference source.
6. Listing and description of each constant used in engineering equations and a reference source to prove origin of each constant.
7. Description of operator interface to alphanumeric and graphic programming.
8. Description of each network communication protocol.
9. Description of system database, including all data included in database, database capacity and limitations to expand database.
10. Description of each application program and device drivers to be generated, including specific information on data acquisition and control strategies showing their relationship to system timing, speed, processing burden and system throughout.
11. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

C. Sustainable Design Submittals:

D. Shop Drawings:

1. Include plans, elevations, sections, and mounting details where applicable.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail means of vibration isolation and show attachments to rotating equipment.
4. Plan Drawings indicating the following:

    a. Screened backgrounds of walls, structural grid lines, HVAC equipment, ductwork and piping.
    b. Room names and numbers with coordinated placement to avoid interference with control products indicated.
    c. Each desktop workstation, server, gateway, router, DDC controller, control panel instrument connecting to DDC controller, and damper and valve connecting to DDC controller, if included in Project.
    d. Exact placement of products in rooms, ducts, and piping to reflect proposed installed condition.
    e. Network communication cable and raceway routing.
    f. Information, drawn to scale, as directed.
    g. Proposed routing of wiring, cabling, conduit, and tubing coordinated with building services for review before installation.

5. Schematic drawings for each controlled HVAC system indicating the following:

    a. I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.
    b. I/O listed in table format showing point name, type of device, manufacturer, model number, and cross-reference to product data sheet number.
    c. A graphic showing location of control I/O in proper relationship to HVAC system.
    d. Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
    e. Unique identification of each I/O that shall be consistently used between different drawings showing same point.
    f. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays and interface to DDC controllers.
    g. Narrative sequence of operation.
    h. Graphic sequence of operation, showing all inputs and output logical blocks.

6. Control panel drawings indicating the following:

    a. Panel dimensions, materials, size, and location of field cable, raceways, and tubing connections.
    b. Interior subpanel layout, drawn to scale and showing all internal components, cabling and wiring raceways, nameplates and allocated spare space.
    c. Front, rear, and side elevations and nameplate legend.
    d. Unique drawing for each panel.

7. DDC system network riser diagram indicating the following:

    a. Each device connected to network with unique identification for each.
    b. Interconnection of each different network in DDC system.
    c. For each network, indicate communication protocol, speed and physical means of interconnecting network devices, such as copper cable type, or optical fiber cable type. Indicate raceway type and size for each.
    d. Each network port for connection of an operator workstation or other type of operator interface with unique identification for each.

8. DDC system electrical power riser diagram indicating the following:

    a. Each point of connection to field power with requirements (volts/phase//hertz/amperes/connection type) listed for each.
    b. Each control power supply including, as applicable, transformers, power-line conditioners, transient voltage suppression and high filter noise units, DC power supplies, and UPS units with unique identification for each.
    c. Each product requiring power with requirements (volts/phase//hertz/amperes/connection type) listed for each.
    d. Power wiring type and size, race type, and size for each.

9. Monitoring and control signal diagrams indicating the following:

    a. Control signal cable and wiring between controllers and I/O.
    b. Point-to-point schematic wiring diagrams for each product.
    c. Control signal tubing to sensors, switches and transmitters.
    d. Process signal tubing to sensors, switches and transmitters.

10. Color graphics indicating the following:

    a. Itemized list of color graphic displays to be provided.
    b. For each display screen to be provided, a true color copy showing layout of pictures, graphics and data displayed.
    c. Intended operator access between related hierarchical display screens.

E. System Description:

1. Full description of DDC system architecture, network configuration, operator interfaces and peripherals, servers, controller types and applications, gateways, routers and other network devices, and power supplies.
2. Complete listing and description of each report, log and trend for format and timing and events which initiate generation.
3. System and product operation under each potential failure condition including, but not limited to, the following:

    a. Loss of power.
    b. Loss of network communication signal.
    c. Loss of controller signals to inputs and outpoints.
    d. Operator workstation failure.
    e. Gateway failure.
    f. Network failure

g. Controller failure.
h. Instrument failure.
i. Control damper and valve actuator failure.

4. Complete bibliography of documentation and media to be delivered to Owner.
5. Description of testing plans and procedures.
6. Description of Owner training.

F. Samples:

1. For each exposed product, installed in finished space for approval of selection of aesthetic characteristics.

G. Delegated-Design Submittal: For DDC system products and installation indicated as being delegated.

1. Supporting documentation showing DDC system design complies with performance requirements indicated, including calculations and other documentation necessary to prove compliance.
2. Schedule and design calculations for control dampers and actuators.

a. Flow at Project design and minimum flow conditions.
b. Face velocity at Project design and minimum airflow conditions.
c. Pressure drop across damper at Project design and minimum airflow conditions.
d. AMCA 500-D damper installation arrangement used to calculate and schedule pressure drop, as applicable to installation.
e. Maximum close-off pressure.
f. Leakage airflow at maximum system pressure differential (fan close-off pressure).
g. Torque required at worst case condition for sizing actuator.
h. Actuator selection indicating torque provided.
i. Actuator signal to control damper (on, close or modulate).
j. Actuator position on loss of power.
k. Actuator position on loss of control signal.

3. Schedule and design calculations for control valves and actuators.

a. Flow at Project design and minimum flow conditions.
b. Pressure-differential drop across valve at Project design flow condition.
c. Maximum system pressure-differential drop (pump close-off pressure) across valve at Project minimum flow condition.
d. Design and minimum control valve coefficient with corresponding valve position.
e. Maximum close-off pressure.
f. Leakage flow at maximum system pressure differential.
g. Torque required at worst case condition for sizing actuator.
h. Actuator selection indicating torque provided.
i. Actuator signal to control damper (on, close or modulate).
j. Actuator position on loss of power.
k. Actuator position on loss of control signal.

4. Schedule and design calculations for selecting flow instruments.

a. Instrument flow range.
b. Project design and minimum flow conditions with corresponding accuracy, control signal to transmitter and output signal for remote control.
c. Extreme points of extended flow range with corresponding accuracy, control signal to transmitter and output signal for remote control.
d. Pressure-differential loss across instrument at Project design flow conditions.
e. Where flow sensors are mated with pressure transmitters, provide information for each instrument separately and as an operating pair.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan drawings, reflected ceiling plan(s), and other details, drawn to scale and coordinated with each other, using input from installers of the items involved.

B. Qualification Data:

1. Systems Provider Qualification Data:

a. Resume of project manager assigned to Project.
b. Resumes of application engineering staff assigned to Project.
c. Resumes of installation and programming technicians assigned to Project.
d. Resumes of service technicians assigned to Project.
e. Brief description of past project including physical address, floor area, number of floors, building system cooling and heating capacity and building's primary function.
f. Description of past project DDC system, noting similarities to Project scope and complexity indicated.
g. Names of staff assigned to past project that will also be assigned to execute work of this Project.
h. Owner contact information for past project including name, phone number, and e-mail address.
i. Contractor contact information for past project including name, phone number, and e-mail address.
j. Architect and Engineer contact information for past project including name, phone number, and e-mail address.

2. Manufacturer's qualification data.
3. Testing agency's qualifications data.

C. Welding certificates.

D. Product Certificates:

1. Data Communications Protocol Certificates: Certifying that each proposed DDC system component complies with ASHRAE 135.
2. Data Communications Protocol Certificates: Certifying that each proposed DDC system component complies with LonWorks.

E. Product Test Reports: For each product that requires testing to be performed as directed.

F. Preconstruction Test Reports: For each separate test performed.

G. Source quality-control reports.

H. Field quality-control reports.

I. Sample Warranty: For manufacturer's warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For DDC system to include in emergency, operation and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.
b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
c. As-built versions of submittal Product Data.
d. Names, addresses, e-mail addresses and 24-hour telephone numbers of Installer and service representatives for DDC system and products.
e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control and changing set points and variables.
f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
g. Engineering, installation, and maintenance manuals that explain how to:

1) Design and install new points, panels, and other hardware.
2) Perform preventive maintenance and calibration.
3) Debug hardware problems.
4) Repair or replace hardware.

h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
i. Backup copy of graphic files, programs, and database on electronic media such as DVDs.
j. List of recommended spare parts with part numbers and suppliers.
k. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
l. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
m. Licenses, guarantees, and warranty documents.
n. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.

o. Owner training materials.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials and parts that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Include product manufacturers' recommended parts lists for proper product operation over four-year period following warranty period. Parts list shall be indicated for each year.

C. Furnish parts, as indicated by manufacturer's recommended parts list, for product operation during one or two-year period following warranty period as directed.

D. Furnish quantity indicated of matching product(s) in Project inventory for each unique size and type of following:

1. Network Controller: One.
2. Programmable Application Controller: One.
3. Application-Specific Controller: One.
4. Room Carbon Dioxide Sensor and Transmitter: One.
5. Room Moisture Sensor and Transmitter: One.
6. Room Pressure Sensor and Transmitter: One.
7. Room Temperature Sensor and Transmitter: One.
8. General-Purpose Relay: One.
9. Multifunction Time-Delay Relay: One.
10. Latching Relay: One.
11. Current-Sensing Relay: One.
12. Combination On-Off Status Sensor and On-Off Relay: One.
13. Transformer: One.
14. DC Power Supply: One.
15. Supply of 20 percent spare optical fiber cable splice organizer cabinets for several re-terminations.

1.8 QUALITY ASSURANCE

A. DDC System Manufacturer Qualifications:

1. Nationally recognized manufacturer of DDC systems and products.
2. DDC systems with similar requirements to those indicated for a continuous period of five or 10 years within time of bid as directed.
3. DDC systems and products that have been successfully tested and in use on at least three or five past projects as directed.
4. Having complete published catalog literature, installation, operation and maintenance manuals for all products intended for use.
5. Having full-time in-house employees for the following:

a. Product research and development.
b. Product and application engineering.
c. Product manufacturing, testing and quality control.

d. Technical support for DDC system installation training, commissioning and troubleshooting of installations.
e. Owner operator training.

B. DDC System Provider Qualifications:

1. Authorized representative of, and trained by, DDC system manufacturer.
2. In-place facility located within as directed of Project.
3. Demonstrated past experience with installation of DDC system products being installed for period within three or five consecutive years before time of bid as directed.
4. Demonstrated past experience on five projects of similar complexity, scope and value.
5. Each person assigned to Project shall have demonstrated past experience.
6. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
7. Service and maintenance staff assigned to support Project during warranty period.
8. Product parts inventory to support on-going DDC system operation for a period of not less than 5 years after Substantial Completion.
9. DDC system manufacturer's backing to take over execution of Work if necessary to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.

C. Testing Agency Qualifications: Member company of NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

D. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
3. AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."
4. AWS D1.4/D1.4M, "Structural Welding Code - Reinforcing Steel."

E. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

1.9 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Owner will engage or Engage a qualified testing agency to perform preconstruction testing on field mockups as directed.

1. Include test assemblies representative of proposed materials and construction.
2. Build mockup at testing agency facility using personnel, materials, and methods of construction that will be used at Project site.
3. Notify Architect seven days in advance of dates and times of tests.

B. Preconstruction Testing: Performed by a qualified testing agency on manufacturer's standard assemblies.

1.10 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace products that fail in materials or workmanship within specified warranty period.

1. Failures shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner.
2. Include updates or upgrades to software and firmware if necessary to resolve deficiencies.

a. Install updates only after receiving Owner's written authorization.

3. Warranty service shall occur during normal business hours and commence within 16 or 24 hours of Owner's warranty service request as directed.
4. Warranty Period: Two year(s) from date of Substantial Completion.

a. For Gateway: Two or Three-year parts and labor warranty for each as directed.

PART 2 - PRODUCTS

2.1 DDC SYSTEM MANUFACTURERS

2.2 DDC SYSTEM DESCRIPTION

A. Microprocessor-based monitoring and control including analog/digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and processed by a microprocessor, and digital control signals are generated based on control algorithms and transmitted to field devices to achieve a set of predefined conditions.

1. DDC system shall consist of a high-speed, peer-to-peer network of distributed DDC controllers, other network devices, operator interfaces, and software.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 WEB ACCESS

A. DDC system shall be web based or web compatible.

1. Web-Based Access to DDC System:

a. DDC system software shall be based on server thin-client architecture, designed around open standards of web technology. DDC system server shall be accessed using a web browser over DDC system network, using Owner's LAN, and remotely over Internet through Owner's LAN.
b. Intent of thin-client architecture is to provide operators complete access to DDC system via a web browser. No special software other than a web browser shall be

required to access graphics, point displays, and trends; to configure trends, points, and controllers; and to edit programming.

c. web access shall be password protected.

2. Web-Compatible Access to DDC System:

a. Workstation and or server shall perform overall system supervision and configuration, graphical user interface, management report generation, and alarm annunciation.
b. DDC system shall support web browser access to building data. Operator using a standard web browser shall be able to access control graphics and change adjustable set points.
c. Web access shall be password protected.

2.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional to design DDC system to satisfy requirements indicated.

1. System Performance Objectives:

a. DDC system shall manage HVAC systems.
b. DDC system control shall operate HVAC systems to achieve optimum operating costs while using least possible energy and maintaining specified performance.
c. DDC system shall respond to power failures, HVAC equipment failures, and adverse and emergency conditions encountered through connected I/O points.
d. DDC system shall operate while unattended by an operator and through operator interaction.
e. DDC system shall record trends and transaction of events and produce report information such as performance, energy, occupancies, and equipment operation.

B. Surface-Burning Characteristics: Products installed in ducts, equipment, and return-air paths shall comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

C. DDC System Speed:

1. Response Time of Connected I/O:

a. AI point values connected to DDC system shall be updated at least every five or two seconds for use by DDC controllers as directed. Points used globally shall also comply with this requirement.
b. BI point values connected to DDC system shall be updated at least every five or two seconds for use by DDC controllers. Points used globally shall also comply with this requirement as directed.

c. AO points connected to DDC system shall begin to respond to controller output commands within two or one second(s). Global commands shall also comply with this requirement as directed.
d. BO point values connected to DDC system shall respond to controller output commands within two or one second(s) as directed. Global commands shall also comply with this requirement.

2. Display of Connected I/O:

a. Analog point COV connected to DDC system shall be updated and displayed at least every 10 or five seconds for use by operator as directed.
b. Binary point COV connected to DDC system shall be updated and displayed at least every 10 or five seconds for use by operator as directed.
c. Alarms of analog and digital points connected to DDC system shall be displayed within seconds of activation or change of state as directed.
d. Graphic display refresh shall update within eight or four seconds as directed.
e. Point change of values and alarms displayed from workstation to workstation when multiple operators are viewing from multiple workstations shall not exceed graphic refresh rate indicated.

D. Network Bandwidth: Design each network of DDC system to include at least 30 percent available spare bandwidth as directed with DDC system operating under normal and heavy load conditions indicated. Calculate bandwidth usage, and apply a safety factor to ensure that requirement is satisfied when subjected to testing under worst case conditions.

E. DDC System Data Storage:

1. Include capability to archive not less than as directed consecutive months of historical data for all I/O points connected to system, including alarms, event histories, transaction logs, trends and other information indicated.
2. Local Storage:

a. Provide server or workstation with data storage indicated as directed. Server(s) shall use IT industry standard database platforms and be capable of functions described in "DDC Data Access" Paragraph.

3. Cloud Storage:

a. Provide application-based and web browser interfaces to configure, upload, download, and manage data, and service plan with storage adequate to store all data for term indicated. Cloud storage shall use IT industry standard database platforms and be capable of functions described in "DDC Data Access" Paragraph.

F. DDC Data Access:

1. When logged into the system, operator shall be able to also interact with any DDC controller connected to DDC system as required for functional operation of DDC system.
2. System(s) shall be used for application configuration; for archiving, reporting and trending of data; for operator transaction archiving and reporting; for network information management; for alarm annunciation; and for operator interface tasks and controls application management.

G. Future Expandability:

1. DDC system size shall be expandable to an ultimate capacity of at least as directed times total I/O points indicated.
2. Additional DDC controllers, I/O and associated wiring shall be all that is needed to achieve ultimate capacity. Initial network infrastructure shall be designed and installed to support ultimate capacity.
3. Operator interfaces installed initially shall not require hardware and software additions and revisions for ultimate capacity.

H. Input Point Displayed Accuracy: Input point displayed values shall meet following end-to-end overall system accuracy, including errors associated with meter, sensor, transmitter, lead wire or cable, and analog to digital conversion.

1. Energy:

   a. Thermal: Within as directed percent of reading.
   b. Electric Power: Within 1 percent of reading.
   c. Requirements indicated on Drawings for meters not supplied by utility.

2. Flow:

   a. Air: Within 5 or 2 percent of design flow rate as directed.
   b. Air (Terminal Units): Within 10 or 5 percent of design flow rate as directed.
   c. Water: Within 2 or 5 percent of design flow rate as directed.
   d. Steam: Within 5 percent of design flow rate.

3. Gas:

   a. Carbon Dioxide: Within 50 ppm.
   b. Carbon Monoxide: Within 5 percent of reading.
   c. Oxygen: Within 5 percent of reading.
   d. Refrigerant: Within 50 ppm.

4. Moisture (Relative Humidity):

   a. Air: Within 5 or 2 percent RH as directed.
   b. Space: Within 5 or 2 percent RH as directed.
   c. Outdoor: Within 5 or 2 percent RH as directed.

5. Level: Within 5 or 2 percent of reading as directed.
6. Pressure:

   a. Air, Ducts and Equipment: 1 or 0.5 percent of instrument range or span.
   b. Space: As directed.
   c. Water: As directed.
   d. Steam: As directed.

7. Speed: Within 10 or 5 percent of reading as directed.
8. Temperature, Dew Point:

a. Air: Within 1 deg F (0.5 deg C) or 0.5 deg F (0.2 deg C) as directed.
b. Space: Within 1 deg F (0.5 deg C) or 0.5 deg F (0.2 deg C) as directed.
c. Outdoor: Within 3 deg F (1.5 deg C) or 2 deg F (1 deg C) as directed.

9. Temperature, Dry Bulb:

a. Air: Within 1 deg F (0.5 deg C) or 0.5 deg F (0.2 deg C) as directed.
b. Space: Within 1 deg F (0.5 deg C) or 0.5 deg F (0.2 deg C) as directed.
c. Outdoor: Within 2 deg F (1 deg C) or 1 deg F (0.5 deg C) as directed.
d. Chilled Water: Within 1 deg F (0.5 deg C) or 0.5 deg F (0.2 deg C) as directed.
e. Condenser Water: Within 1 deg F (0.5 deg C) or 0.5 deg F (0.2 deg C) as directed.
f. Heating Hot Water: Within 1 deg F (0.5 deg C) or 0.5 deg F (0.2 deg C) as directed.
g. Energy Recovery Runaround Liquid: Within 1 deg F (0.5 deg C) or 0.5 deg F (0.2 deg C) as directed.
h. Steam: Within 2 deg F (1 deg C) or 1 deg F (0.5 deg C) as directed.
i. Temperature Difference: Within 0.25 deg F (0.15 deg C).
j. Other Temperatures Not Indicated: Within 1 deg F (0.5 deg C) or 0.5 deg F (0.2 deg C) as directed.

10. Temperature, Wet Bulb:

a. Air: Within 1 deg F (0.5 deg C) or 0.5 deg F (0.2 deg C) as directed.
b. Space: Within 1 deg F (0.5 deg C) or 0.5 deg F (0.2 deg C) as directed.
c. Outdoor: Within 2 deg F (1 deg C) or 1 deg F (0.5 deg C) as directed.

11. Vibration: Within 5 or 10 percent of reading as directed.

I. Precision of I/O Reported Values: Values reported in database and displayed shall have following precision:

1. Current:

a. Milliamperes: Nearest 1/100th of a milliampere.
b. Amperes: Nearest 1/10th of an ampere up to 100 A; nearest ampere for 100 A and more.

2. Energy:

a. Electric Power:

1) Rate (Watts): Nearest 1/10th of a watt through 1000 W.
2) Rate (Kilowatts): Nearest 1/10th of a kilowatt through 1000 kW; nearest kilowatt above 1000 kW.
3) Usage (Kilowatt-Hours): Nearest kilowatt through 10,000 kW; nearest 10 kW between 10,000 and 100,000 kW; nearest 100 kW for above 100,000 kW.

b. Thermal, Rate:

1) Heating: For Btu/h, nearest Btu/h up to 1000 Btu/h; nearest 10 Btu/h between 1000 and 10,000 Btu/h; nearest 100 Btu/h for above 10,000 Btu/h. For Mbh, round to nearest Mbh up to 1000 Mbh; nearest 10 Mbh between 1000 and 10,000 Mbh; nearest 100 Mbh above 10,000 Mbh (For watts, nearest watt up to 1000 W; for kilowatts, round to nearest kilowatt up to 1000 kW; nearest 10 kW between 1000 and 10,000 kW; nearest 100 kW for above 10,000 kW).
2) Cooling: For tons, nearest ton up to 1000 tons; nearest 10 tons between 1000 and 10,000 tons; nearest 100 tons above 10,000 tons (For watts, nearest watt up to 1000 W; for kilowatts, round to nearest kilowatt up to 1000 kW; nearest 10 kW between 1000 and 10,000 kW; nearest 100 kW for above 10,000 kW).

c. Thermal, Usage:

1) Heating: For Btu, nearest Btu up to 1000 Btu; nearest 10 Btu between 1000 and 10,000 Btu; nearest 100 Btu for above 10,000 Btu. For Mbtu, round to nearest Mbtu up to 1000 Mbtu; nearest 10 Mbtu between 1000 and 10,000 Mbtu; nearest 100 Mbtu above 10,000 Mbtu (For watt-hours, nearest watt-hour up to 1000 Wh; for kilowatts-hours, round to nearest kilowatt-hour up to 1000 kWh; nearest 10 kWh between 1000 and 10,000 kWh; nearest 100 kWh for above 10,000 kWh).
2) Cooling: For ton-hours, nearest ton-hours up to 1000 tons-hours; nearest 10 ton-hours between 1000 and 10,000 ton-hours; nearest 100 tons above 10,000 tons (For watt-hours, nearest watt-hour up to 1000 Wh; for kilowatt-hours, round to nearest kilowatt-hour up to 1000 kWh; nearest 10 kWh between 1000 and 10,000 kWh; nearest 100 kWh for above 10,000 kWh).

3. Flow:

a. Air: Nearest 1/10th of a cfm through 100 cfm; nearest cfm between 100 and 1000 cfm; nearest 10 cfm between 1000 and 10,000 cfm; nearest 100 cfm above 10,000 cfm (Nearest 1/10th of a L/s through 100 L/s; nearest L/s between 100 and 1000 L/s; nearest 10 L/s between 1000 and 10,000 L/s; nearest 100 L/s above 10,000 L/s).
b. Water: Nearest 1/10th gpm through 100 gpm; nearest gpm between 100 and 1000 gpm; nearest 10 gpm between 1000 and 10,000 gpm; nearest 100 gpm above 10,000 gpm (Nearest 1/10th of a L/s through 100 L/s; nearest L/s between 100 and 1000 L/s; nearest 10 L/s between 1000 and 10,000 L/s; nearest 100 L/s above 10,000 L/s).
c. Steam: Nearest 1/10th lb/hr through 100 lbs/hr; nearest lbs/hr between 100 and 1000 lbs/hr; nearest 10 lbs/hr above 1000 lbs/hr (Nearest 1/10th of a L/s through 100 L/s; nearest L/s between 100 and 1000 L/s; nearest 10 L/s between 1000 and 10,000 L/s; nearest 100 L/s above 10,000 L/s).

4. Gas:

a. Carbon Dioxide (ppm): Nearest ppm.
b. Carbon Monoxide (ppm): Nearest ppm.
c. Oxygen (Percentage): Nearest 1/10th of 1 percent.
d. Refrigerant (ppm): Nearest ppm.

5. Moisture (Relative Humidity):

    a. Relative Humidity (Percentage): Nearest 1 percent.

6. Level: Nearest 1/100th of an inch through 10 inches, nearest 1/10 of an inch between 10 and 100 inches, nearest inch above 100 inches (Nearest 1/100th of a mm through 10 mm, nearest 1/10th of a mm between 10 and 100 mm, nearest mm above 100 mm).
7. Speed:

    a. Rotation (rpm): Nearest 1 rpm.
    b. Velocity: Nearest 1/10th fpm through 100 fpm; nearest fpm between 100 and 1000 fpm; nearest 10 fpm above 1000 fpm (Nearest 1/100th of a M/s through 10 M/s; nearest 1/10th of a M/s above 10 M/s).

8. Position, Dampers and Valves (Percentage Open): Nearest 1 percent.
9. Pressure:

    a. Air, Ducts and Equipment: Nearest 1/10th in. w.c. (Nearest Pa up to 1000 Pa, nearest 10 Pa above 1000 Pa).
    b. Space: Nearest 1/100th in. w.c. (Nearest 1/10th Pa).
    c. Steam: Nearest 1/10th psig through 100 psig, nearest psig above 100 psig (Nearest kPa through 1000 kPa, nearest 10 kPa above 1000 kPa).
    d. Water: Nearest 1/10 psig through 100 psig, nearest psig above 100 psig (Nearest kPa through 1000 kPa, nearest 10 kPa above 1000 kPa).

10. Temperature:

    a. Air, Ducts and Equipment: Nearest 1/10th of a degree.
    b. Outdoor: Nearest degree.
    c. Space: Nearest 1/10th of a degree.
    d. Chilled Water: Nearest 1/10th of a degree.
    e. Condenser Water: Nearest 1/10th of a degree.
    f. Heating Hot Water: Nearest degree.
    g. Heat Recovery Runaround: Nearest 1/10th of a degree.
    h. Steam: Nearest degree.

11. Vibration: Nearest 1/10th in/s (Nearest 1/10th mm/s).
12. Voltage: Nearest 1/10 volt up to 100 V; nearest volt above 100 V.

J. Control Stability: Control variables indicated within the following limits:

1. Flow:

    a. Air, Ducts and Equipment, except Terminal Units: Within 5 or 2 percent of design flow rate as directed.
    b. Air, Terminal Units: Within 10 or 5 percent of design flow rate as directed.
    c. Water: Within 2 or 5 percent of design flow rate as directed.
    d. Steam: Within 5 percent of design flow rate.

2. Gas:

a. Carbon Dioxide: Within 50 ppm.
b. Carbon Monoxide: Within 5 percent of reading.
c. Oxygen: Within 5 percent of reading.

3. Moisture (Relative Humidity):

a. Air: Within 5 or 2 percent RH as directed.
b. Space: Within 5 or 2 percent RH as directed.
c. Outdoor: Within 5 or 2 percent RH as directed.

4. Level: Within 5 or 2 percent of reading as directed.
5. Pressure:

a. Air, Ducts and Equipment: 1 or 0.5 percent of instrument range or span as directed.
b. Space: As directed.
c. Water: As directed.
d. Steam: As directed.

6. Temperature, Dew Point:

a. Air: Within 1 deg F (0.5 deg C) or 0.5 deg F (0.2 deg C) as directed.
b. Space: Within 1 deg F (0.5 deg C) or 0.5 deg F (0.2 deg C) as directed.

7. Temperature, Dry Bulb:

a. Air: Within As directed.
b. Space: Within As directed.
c. Chilled Water: Within 1 deg F (0.5 deg C) or 0.5 deg F (0.2 deg C) as directed.
d. Condenser Water: Within 1 deg F (0.5 deg C) or 0.5 deg F (0.2 deg C) as directed.
e. Heating Hot Water: Within As directed.
f. Energy Recovery Runaround Liquid: Within 1 deg F (0.5 deg C) or 0.5 deg F (0.2 deg C) as directed.

8. Temperature, Wet Bulb:

a. Air: Within 1 deg F (0.5 deg C) or 0.5 deg F (0.2 deg C) as directed.
b. Space: Within 1 deg F (0.5 deg C) or 0.5 deg F (0.2 deg C).

K. Environmental Conditions for Controllers, Gateways, and Routers:

1. Products shall operate without performance degradation under ambient environmental temperature, pressure and humidity conditions encountered for installed location.

a. If product alone cannot comply with requirement, install product in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by product and application.

2. Products shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Products not available with integral enclosures complying with requirements indicated shall be housed in

protective secondary enclosures. Installed location shall dictate the following NEMA 250 enclosure requirements:

a. Outdoors, Protected: As directed.
b. Outdoors, Unprotected: Type 4 or Type 4X as directed.
c. Indoors, Heated with Filtered Ventilation: Type 1 or Type 2 as directed.
d. Indoors, Heated with Non-Filtered Ventilation: Type 2 or Type 12 as directed.
e. Indoors, Heated and Air Conditioned: Type 1.
f. Mechanical Equipment Rooms:

1) Chiller and Boiler Rooms: As directed.
2) Air-Moving Equipment Rooms: As directed.

g. Localized Areas Exposed to Washdown: Type 4 or Type 4X as directed.
h. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: As directed.
i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4 or Type 4X as directed.
j. Hazardous Locations: Explosion-proof rating for condition.

L. Environmental Conditions for Instruments and Actuators:

1. Instruments and actuators shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.

a. If instruments and actuators alone cannot comply with requirement, install instruments and actuators in protective enclosures that are isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by instrument and application.

2. Instruments, actuators and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments and actuators not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Installed location shall dictate the following NEMA 250 enclosure requirements:

a. Outdoors, Protected: As directed.
b. Outdoors, Unprotected: Type 4 or Type 4X as directed.
c. Indoors, Heated with Filtered Ventilation: Type 1 or Type 2 as directed.
d. Indoors, Heated with Non-Filtered Ventilation: Type 2 or Type 12 as directed.
e. Indoors, Heated and Air-conditioned: Type 1.
f. Mechanical Equipment Rooms:

1) Chiller and Boiler Rooms: As directed.
2) Air-Moving Equipment Rooms: As directed.

g. Localized Areas Exposed to Washdown: Type 4 or Type 4X as directed.
h. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: As directed.

i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4 or Type 4X as directed.
j. Hazardous Locations: Explosion-proof rating for condition.

M. Electric Power Quality:

1. Power-Line Surges:

a. Protect susceptible DDC system products connected to ac power circuits from power-line surges to comply with requirements of IEEE C62.41.
b. Do not use fuses for surge protection.
c. Test protection in the normal mode and in the common mode, using the following two waveforms:

1) 10-by-1000-mic.sec. waveform with a peak voltage of 1500 V and a peak current of 60 A.
2) 8-by-20-mic.sec. waveform with a peak voltage of 1000 V and a peak current of 500 A.

2. Power Conditioning:

a. Protect susceptible DDC system products connected to ac power circuits from irregularities and noise rejection. Characteristics of power-line conditioner shall be as follows:

1) At 85 percent load, output voltage shall not deviate by more than plus or minus 1 percent of nominal when input voltage fluctuates between minus 20 percent to plus 10 percent of nominal.
2) During load changes from zero to full load, output voltage shall not deviate by more than plus or minus 3 percent of nominal.
3) Accomplish full correction of load switching disturbances within five cycles, and 95 percent correction within two cycles of onset of disturbance.
4) Total harmonic distortion shall not exceed 3-1/2 percent at full load.

3. Ground Fault: Protect products from ground fault by providing suitable grounding. Products shall not fail due to ground fault condition.

N. Backup Power Source:

1. HVAC systems and equipment served by a backup power source shall have associated DDC system products that control such systems and equipment also served from a backup power source.

O. UPS:

1. DDC system products powered by UPS units shall include the following:

a. Desktop workstations.
b. Printers.
c. Servers.
d. Gateways.

e. DDC controllers, except application-specific controllers.

2. DDC system instruments and actuators powered by UPS units shall include the following:

a. Instruments associated with the following systems controlled by DDC system:

b. Dampers and actuators associated with the following systems controlled by DDC system:

c. Valves and actuators associated with the following systems controlled by DDC system:

P. Continuity of Operation after Electric Power Interruption:

1. Equipment and associated factory-installed controls, field-installed controls, electrical equipment, and power supply connected to building normal and backup power systems shall automatically return equipment and associated controls to operating state occurring immediately before loss of normal power, without need for manual intervention by operator when power is restored either through backup power source or through normal power if restored before backup power is brought online.

2.5 SYSTEM ARCHITECTURE

A. System architecture shall consist of no more than two or three levels of LANs.

1. Level one LAN shall connect network controllers and operator workstations.
2. Level one or Level two LAN shall connect programmable application controllers to other programmable application controllers, and to network controllers.
3. Level two or Level three LAN shall connect application-specific controllers to programmable application controllers and network controllers.
4. Level two or Level three LAN shall connect application-specific controllers to application-specific controllers.

B. Minimum Data Transfer and Communication Speed:

1. LAN Connecting Operator Workstations and Network Controllers: As directed.
2. LAN Connecting Programmable Application Controllers: As directed.
3. LAN Connecting Application-Specific Controllers: As directed

C. DDC system shall consist of dedicated LANs that are not shared with other building systems and tenant data and communication networks.

D. System architecture shall be modular and have inherent ability to expand to not less than two or three times system size indicated with no impact to performance indicated.

E. System architecture shall perform modifications without having to remove and replace existing network equipment.

F. Number of LANs and associated communication shall be transparent to operator. All I/O points residing on any LAN shall be capable of global sharing between all system LANs.

G. System design shall eliminate dependence on any single device for system alarm reporting and control execution. Each controller shall operate independently by performing its' own control, alarm management and historical data collection.

H. Special Network Architecture Requirements:

1. Air-Handling Systems: For control applications of an air-handling system that consists of air-handling unit(s) and VAV terminal units, include a dedicated LAN of application-specific controllers serving VAV terminal units connected directly to controller that is controlling air-handling system air-handling unit(s). Basically, create a DDC system LAN that aligns with air-handling system being controlled.

2.6 DDC SYSTEM OPERATOR INTERFACES

A. Operator Means of System Access: Operator shall be able to access entire DDC system through any of multiple means, including, but not limited to, the following:

1. Desktop and portable workstation with hardwired connection through LAN port.
2. Portable operator terminal with hardwired connection through LAN port.
3. Portable operator workstation with wireless connection through LAN router.
4. Mobile device and application with secured wireless connection through LAN router or cellular data service.
5. Remote connection through web access.

B. Access to system, regardless of operator means used, shall be transparent to operator.

C. Network Ports: For hardwired connection of desktop or portable workstation. Network port shall be easily accessible, properly protected, clearly labeled, and installed at the following locations:

1. Each mechanical equipment room.
2. Each boiler room.
3. Each chiller room or outdoor chiller yard.
4. Each cooling tower location.
5. Each different roof level with roof-mounted air-handling units or rooftop units.
6. Security system command center.
7. Fire-alarm system command center.

D. Desktop Workstations:

1. Connect to DDC system Level one LAN through a communications port directly on LAN or through a communications port on a DDC controller.
2. Able to communicate with any device located on any DDC system LAN.

E. Portable Workstations:

1. Connect to DDC system Level one LAN through a communications port directly on LAN or through a communications port on a DDC controller.
2. Able to communicate with any device located on any DDC system LAN.

3. Connect to DDC system Level two or Level three LAN through a communications port on an application-specific controller, or a room temperature sensor connected to an application-specific controller.
4. Connect to system through a wireless router connected to Level one LAN.
5. Connect to system through a cellular data service.
6. Portable workstation shall be able to communicate with any device connected to any system LAN regardless of point of physical connection to system.
7. Monitor, program, schedule, adjust set points, and report capabilities of I/O connected anywhere in system.
8. Have dynamic graphic displays that are identical to desktop workstations.

F. POT:

1. Connect DDC controller through a communications port local to controller.
2. Able to communicate with any DDC system controller that is directly connected or with LAN or connected to DDC system as directed.

G. Mobile Device:

1. Connect to system through a wireless router connected to LAN and cellular data service.
2. Able to communicate with any DDC controller connected to DDC system using a dedicated application and secure web access.

H. Telephone Communications:

1. Through use of a standard modem, operator shall be able to communicate with any device connected to any system LAN.
2. Have auto-dial and auto-answer communications to allow desktop and portable workstations and DDC controllers to communicate with remote workstations and remote DDC controllers via telephone lines.

    a. Desktop and Portable Workstations:

        1) Operators shall be able to perform all control functions, report functions, and database generation and modification functions as if directly connected to system LAN.
        2) Have routines to automatically answer calls, and either file or display information sent remotely.
        3) Communications taking place over telephone lines shall be completely transparent to operator.
        4) Dial-up program shall maintain a user-definable cross-reference and associated telephone numbers so it is not required to remember or manually dial telephone numbers.

    b. DDC Controllers:

        1) Not have modems unless specifically indicated for a unique controller.
        2) Controllers with modems shall automatically place calls to report critical alarms, or to upload trend and historical information for archiving.
        3) Analyze and prioritize alarms to minimize initiation of calls.

4) Buffer noncritical alarms in memory and report them as a group of alarms, or until an operator manually requests an upload.
5) Make provisions for handling busy signals, no-answers, and incomplete data transfers.
6) Call default devices when communications cannot be established with primary devices.

I. Critical Alarm Reporting:

1. Operator-selected critical alarms shall be sent by DDC system to notify operator of critical alarms that require immediate attention.
2. DDC system shall send alarm notification to multiple recipients that are assigned for each alarm.
3. DDC system shall notify recipients by any or all means, including e-mail, text message, and prerecorded phone message to mobile and landline phone numbers.

J. Simultaneous Operator Use: Capable of accommodating up to as directed simultaneous operators that are accessing DDC system through any one of operator interfaces indicated.

2.7 NETWORKS

A. Acceptable networks for connecting workstations, mobile devices, and network controllers include the following:

1. ATA 878.1, ARCNET.
2. CEA-709.1-C.
3. IP.
4. IEEE 8802-3, Ethernet.

B. Acceptable networks for connecting programmable application controllers include the following:

1. ATA 878.1, ARCNET.
2. CEA-709.1-C.
3. IP.
4. IEEE 8802-3, Ethernet.

C. Acceptable networks for connecting application-specific controllers include the following:

1. ATA 878.1, ARCNET.
2. CEA-709.1-C.
3. EIA-485A.
4. IP.
5. IEEE 8802-3, Ethernet.

2.8 NETWORK COMMUNICATION PROTOCOL

A. Network communication protocol(s) used throughout entire DDC system shall be open to Owner and available to other companies for use in making future modifications to DDC system.

B. ASHRAE 135 Protocol:

1. ASHRAE 135 communication protocol shall be sole and native protocol used throughout entire DDC system.
2. DDC system shall not require use of gateways except to integrate HVAC equipment and other building systems and equipment, not required to use ASHRAE 135 communication protocol.
3. If used, gateways shall connect to DDC system using ASHRAE 135 communication protocol and Project object properties and read/write services indicated by interoperability schedule.
4. Operator workstations, controllers and other network devices shall be tested and listed by BACnet Testing Laboratories.

C. CEA-709.1-C Protocol:

1. DDC system shall be an open implementation of LonWorks technology using CEA 709.1-C communication protocol and using LonMark SNVTs as defined in LonMark SNVT list exclusively for communication throughout DDC system.
2. LNS shall be used for all network management including addressing and binding of network variables.

    a. Final LNS database shall be submitted with Project closeout submittals.
    b. All devices shall be online and commissioned into LNS database.

3. All devices connected to DDC system network(s) shall use CEA-709.1-C protocol and be installed so SCPT output from any node on network can be bound to any other node in the domain.

D. Industry Standard Protocols:

1. DDC system shall use any one or a combination of the following industry standard protocols for network communication while complying with other DDC system requirements indicated:

    a. ASHRAE 135.
    b. CEA-709.1-C.
    c. Modbus Application Protocol Specification V1.1b.

2. Operator workstations and network controllers shall communicate through ASHRAE 135 or CEA-709.1-C protocol.
3. Portions of DDC system networks using ASHRAE 135 communication protocol shall be an open implementation of network devices complying with ASHRAE 135. Network devices shall be tested and listed by BACnet Testing Laboratories.
4. Portions of DDC system networks using CEA-709.1-C communication protocol shall be an open implementation of LonWorks technology using CEA-709.1-C communication protocol and using LonMark SNVTs as defined in LonMark SNVT list exclusively for DDC system.
5. Portions of DDC system networks using Modbus Application Protocol Specification V1.1b communication protocol shall be an open implementation of network devices and technology complying with Modbus Application Protocol Specification V1.1b.

6. Gateways shall be used to connect networks and network devices using different protocols.

2.9 DESKTOP WORKSTATIONS

A. Description: A tower or all-in-one computer designed for normal use at a single, semi-permanent location.

B. Performance Requirements:

1. Performance requirements may dictate equipment exceeding minimum requirements indicated.
2. Energy Star compliant.

C. Personal Computer:

1. Minimum Processor Speed: As directed.
2. RAM:

    a. Capacity: As directed.
    b. Speed and Type: 1333 MHz

3. Hard Drive:

    a. Media: As directed.
    b. Number of Hard Drives: One or Two as directed.
    c. Capacity: As directed.
    d. Minimum Average Seek Time: As directed.
    e. Cache Buffer Size: As directed.

4. Optical Drive:

    a. Type: As directed.
    b. Minimum Average Access Time: As directed.
    c. Data Transfer Speed: As directed.
    d. Reading Formats: Data, audio, recordable, and rewritable as directed.

5. Optical Read and Write Drive:

    a. Include with at least 2 MB of data buffer.
    b. Type: As directed.
    c. Minimum Data Buffer Capacity: As directed.
    d. Minimum Average Access Time: As directed.
    e. Nominal Data Transfer Rates:

        1) Reading: As directed.
        2) Writing: As directed.

    f. Average access time of 150 ms or less.
    g. MTBF of at least 100,000 power-on hours.

6. At least four expansion slots of 32 or 64 bit As directed. .
7. Video Card:

    a. Resolution: 1920 by 1200 pixels.
    b. RAM: As directed.
    c. Controller Speed: MHz or GHz as directed.
    d. On-Board Memory Speed: MHz or GHz as directed.
    e. On-Board Memory Data Width: As directed.

8. Sound Card:

    a. At least 128 voice wavetable synthesis.
    b. Capable of delivering three-dimensional sound effects.
    c. High-resolution 16-bit stereo digital audio recording and playback with user-selectable sample rates up to 48,000 Hz.

9. Network Interface Card: Include card with connection, as applicable.

    a. 10-100-1000 base TX Ethernet with RJ45 connector port.
    b. 100 base FX Ethernet with SC or ST port.

D. Wireless Ethernet, 802.11 a/b/g/n.

1. Optical Modem: Full duplex link for connection to optical fiber cable provided.
2. I/O Ports:

    a. Two USB 3.0 ports on front panel, six on back panel, and three internal on motherboard.
    b. One serial port.
    c. One parallel port.
    d. Two PS/2 ports.
    e. One RJ-45.
    f. One stereo line-in and headphone/line-out on back panel.
    g. One microphone and headphone connector on front panel.
    h. One IEEE 1394 on front and back panel with PCI-e card.
    i. One ESATA port on back panel.

3. Battery: Life of at least three years to maintain system clock/calendar and ROM, as a minimum.

E. Keyboard:

1. 101 enhanced keyboard.
2. Full upper- and lowercase ASCII keyset, numeric keypad, dedicated cursor control keypad, and 12 programmable function keys.
3. Wireless operation within up to 72 inches (1800 mm) in front of workstation.

F. Pointing Device:

1. Either a two- or three-button mouse.
2. Wireless operation within up to 72 inches (1800 mm) in front of workstation.

G. Flat Panel Display Monitor:

1. Display:

a. Color display with diagonal viewable area as directed.
b. Digital or analog input signal.
c. Aspect Ratio: 16 to 9.
d. Antiglare display.
e. Response Time: As directed.
f. Dynamic Contrast Ratio: 50000 to 1.
g. Brightness: 250 cd/sq. m.
h. Tilt adjustable base.
i. Energy Star compliant.
j. Resolution: 1920 by 1080 pixels at 60 Hz with pixel size of 0.277 mm or smaller.
k. Number of Displays: One or Two as directed.

H. Speakers:

1. Two, with individual controls for volume, bass and treble.
2. Signal to Noise Ratio: At least 65 dB.
3. Power: At least 4 W per speaker/channel.
4. Magnetic shielding to prevent distortion on the video monitor.

I. I/O Cabling: Include applicable cabling to connect I/O devices.

2.10 PORTABLE WORKSTATIONS

A. Description: A self-contained computer designed to allow for normal use in different locations and conditions.

B. Performance Requirements:

1. Performance requirements may dictate equipment exceeding minimum requirements indicated.
2. Energy Star compliant.
3. Hardware and software shall support local down-loading to DDC controllers.
4. Data transfer rate to DDC controller shall be at network speed.

C. Processor:

1. Minimum Processor Speed: As directed.
2. RAM:

a. Capacity: As directed.
b. Speed and Type: As directed.

3. Hard Drive:

a. Media: As directed.
b. Number of Hard Drives: One or Two as directed.

c. Capacity: As directed.
d. Minimum Average Seek Time: As directed.
e. Cache Buffer Size: As directed.

4. Video Card: As directed.

D. Input and Output Ports:

1. Serial port.
2. Shared port for external keyboard or mouse.
3. Four USB 3.0 ports.
4. HDMI port.
5. Ethernet port.
6. IEEE 1394 port.

E. Battery:

1. Capable of supporting operation of portable workstation for a minimum of 8 hours.
2. Battery life of at least three years.
3. Battery charge time of less than three hours.
4. Spare Battery(ies). One or Two as directed.

F. Keyboard:

1. 85-key backlit keyboard.
2. Full upper- and lowercase ASCII keyset.

G. Integral Pointing Device: Touchpad with two buttons or equivalent pointing device.

H. Display:

1. Diagonal or larger high-definition WLED color display as directed.
2. Antiglare screen.
3. 1920 by 1080 pixel resolution.
4. Brightness: 300 nits.

I. Network Interface Card: Include card with connection, as application.

1. 10-100-1000 base TX Ethernet with RJ45 connector port.
2. 100 base FX Ethernet with SC or ST port.

J. Digital Video Disc Rewrite Recorder (DVD+/-RW):

1. Compatible with DVD disks and data, audio, recordable and rewritable compact disks.
2. Nominal Data Transfer Rates:

a. Reading: As directed.
b. Writing: As directed.

3. 160-ms access time.

K. Accessories:

1. Nylon carrying case.
2. Docking station.
3. Mobile broadband card.
4. Wireless optical mouse.
5. Light-sensitive web cam and noise-cancelling digital array microphone.
6. Category 6a patch cable. Minimum cable length shall be as directed.
7. HDMI cable. Minimum cable length shall be as directed.

2.11 PORTABLE OPERATOR TERMINAL

A. Description: Handheld device with integral keypad or touch screen operator interface.

B. Display: Multiple lines of text display for use in operator interaction with DDC system.

C. Cable: Flexible coiling cable, at least 36 inches (900 mm) long, with a plug-in jack for connection to DDC controllers, network ports or instruments with an integral LAN port. As an alternative to hardwired connection, POT shall be accessible to DDC controllers through a wireless network connection.

D. POT shall be powered through network connection.

E. Connection of POT to DDC system shall not interrupt or interfere with normal network operation in any way, prevent alarms from being transmitted, or preclude central initiated commands and system modification.

F. POT shall give operator the ability to do the following:

1. Display and monitor BI point status.
2. Change BO point set point (on or off, open or closed).
3. Display and monitor analog point values.
4. Change analog control set points.
5. Command a setting of AO point.
6. Display and monitor I/O point in alarm.
7. Add a new or delete an existing I/O point.
8. Enable and disable I/O points, initiators, and programs.
9. Display and change time and date.
10. Display and change time schedules.
11. Display and change run-time counters and run-time limits.
12. Display and change time and event initiation.
13. Display and change control application and DDC parameters.
14. Display and change programmable offset values.
15. Access DDC controller initialization routines and diagnostics.

2.12 PRINTERS

A. Color Inkjet Printer:
1. Inkjet technology with true four-color printing (black, cyan, magenta, and yellow).
2. Print quality of 1200 by 600 dots per inch with black on inkjet paper and 4800 by 1200 dots per inch color printing on premium photo paper.

3. Rated speed as directed pages per minute printing black and white in normal mode and as directed pages per minute printing color in normal mode.
4. Two paper trays; one tray with as directed sheet capacity, and one tray with as directed sheet capacity.
5. Capable of handling letter- and legal-size paper and overhead transparencies.
6. As directed MB of RAM.
7. Duplex printing (printing on both sides of paper).

2.13 SYSTEM SOFTWARE

A. System Software Minimum Requirements:

1. Real-time multitasking and multiuser 32- or 64-bit operating system that allows concurrent multiple operator workstations operating and concurrent execution of multiple real-time programs and custom program development.
2. Operating system shall be capable of operating DOS and Microsoft Windows applications.
3. Database management software shall manage all data on an integrated and non-redundant basis. Additions and deletions to database shall be without detriment to existing data. Include cross linkages so no data required by a program can be deleted by an operator until that data have been deleted from respective programs.
4. Network communications software shall manage and control multiple-network communications to provide exchange of global information and execution of global programs.
5. Operator interface software shall include day-to-day operator transaction processing, alarm and report handling, operator privilege level and data segregation control, custom programming, and online data modification capability.
6. Scheduling software shall schedule centrally based time and event, temporary, and exception day programs.

B. Operator Interface Software:

1. Minimize operator training through use of English language prorating and English language point identification.
2. Minimize use of a typewriter-style keyboard through use of a pointing device similar to a mouse.
3. Operator sign-off shall be a manual operation or, if no keyboard or mouse activity takes place, an automatic sign-off.
4. Automatic sign-off period shall be programmable from one to 60 minutes in one-minute increments on a per operator basis.
5. Operator sign-on and sign-off activity shall be recorded and sent to printer.
6. Security Access:

    a. Operator access to DDC system shall be under password control.
    b. An alphanumeric password shall be field assignable to each operator.
    c. Operators shall be able to access DDC system by entry of proper password.
    d. Operator password shall be same regardless of which computer or other interface means is used.
    e. Additions or changes made to passwords shall be updated automatically.

f. Each operator shall be assigned an access level to restrict access to data and functions the operator is cable of performing.
g. Software shall have at least five access levels.
h. Each menu item shall be assigned an access level so that a one-for-one correspondence between operator assigned access level(s) and menu item access level(s) is required to gain access to menu item.
i. Display menu items to operator with those capable of access highlighted. Menu and operator access level assignments shall be online programmable and under password control.

7. Data Segregation:

a. Include data segregation for control of specific data routed to a workstation, to an operator or to a specific output device, such as a printer.
b. Include at least 32 segregation groups.
c. Segregation groups shall be selectable such as "fire points," "fire points on second floor," "space temperature points," "HVAC points," and so on.
d. Points shall be assignable to multiple segregation groups. Display and output of data to printer or monitor shall occur where there is a match of operator or peripheral segregation group assignment and point segregations.
e. Alarms shall be displayed and printed at each peripheral to which segregation allows, but only those operators assigned to peripheral and having proper authorization level will be allowed to acknowledge alarms.
f. Operators and peripherals shall be assignable to multiple segregation groups and all assignments are to be online programmable and under password control.

8. Operators shall be able to perform commands including, but not limited to, the following:

a. Start or stop selected equipment.
b. Adjust set points.
c. Add, modify, and delete time programming.
d. Enable and disable process execution.
e. Lock and unlock alarm reporting for each point.
f. Enable and disable totalization for each point.
g. Enable and disable trending for each point.
h. Override control loop set points.
i. Enter temporary override schedules.
j. Define holiday schedules.
k. Change time and date.
l. Enter and modify analog alarm limits.
m. Enter and modify analog warning limits.
n. View limits.
o. Enable and disable demand limiting.
p. Enable and disable duty cycle.
q. Display logic programming for each control sequence.

9. Reporting:

a. Generated automatically and manually.
b. Sent to displays, printers and disk files.
c. Types of Reporting:

1) General listing of points.
2) List points currently in alarm.
3) List of off-line points.
4) List points currently in override status.
5) List of disabled points.
6) List points currently locked out.
7) List of items defined in a "Follow-Up" file.
8) List weekly schedules.
9) List holiday programming.
10) List of limits and deadbands.

10. Summaries: For specific points, for a logical point group, for an operator selected group(s), or for entire system without restriction due to hardware configuration.

C. Graphic Interface Software:

1. Include a full interactive graphical selection means of accessing and displaying system data to operator. Include at least five levels with the penetration path operator assignable (for example, site, building, floor, air-handling unit, and supply temperature loop). Native language descriptors assigned to menu items are to be operator defined and modifiable under password control.
2. Include a hierarchical-linked dynamic graphic operator interface for accessing and displaying system data and commanding and modifying equipment operation. Interface shall use a pointing device with pull-down or penetrating menus, color and animation to facilitate operator understanding of system.
3. Include at least 10 levels of graphic penetration with the hierarchy operator assignable.
4. Descriptors for graphics, points, alarms and such shall be modified through operator's workstation under password control.
5. Graphic displays shall be online user definable and modifiable using the hardware and software provided.
6. Data to be displayed within a graphic shall be assignable regardless of physical hardware address, communication or point type.
7. Graphics are to be online programmable and under password control.
8. Points may be assignable to multiple graphics where necessary to facilitate operator understanding of system operation.
9. Graphics shall also contain software points.
10. Penetration within a graphic hierarchy shall display each graphic name as graphics are selected to facilitate operator understanding.
11. Back-trace feature shall permit operator to move upward in the hierarchy using a pointing device. Back trace shall show all previous penetration levels. Include operator with option of showing each graphic full screen size with back trace as horizontal header or by showing a "stack" of graphics, each with a back trace.
12. Display operator accessed data on the monitor.
13. Operator shall select further penetration using pointing device to click on a site, building, floor, area, equipment, and so on. Defined and linked graphic below that selection shall then be displayed.
14. Include operator with means to directly access graphics without going through penetration path.
15. Dynamic data shall be assignable to graphics.
16. Display points (physical and software) with dynamic data provided by DDC system with appropriate text descriptors, status or value, and engineering unit.

17. Use color, rotation, or other highly visible means, to denote status and alarm states. Color shall be variable for each class of points, as chosen by operator.
18. Points shall be dynamic with operator adjustable update rates on a per point basis from one second to over a minute.
19. For operators with appropriate privilege, points shall be commanded directly from display using pointing device.

    a. For an analog command point such as set point, current conditions and limits shall be displayed and operator can position new set point using pointing device.
    b. For a digital command point such as valve position, valve shall show its current state such as open or closed and operator could select alternative position using pointing device.
    c. Keyboard equivalent shall be available for those operators with that preference.

20. Operator shall be able to split or resize viewing screen into quadrants to show one graphic on one quadrant of screen and other graphics or spreadsheet, bar chart, word processing, curve plot and other information on other quadrants on screen. This feature shall allow real-time monitoring of one part of system while displaying other parts of system or data to better facilitate overall system operation.
21. Help Features:

    a. On-line context-sensitive help utility to facilitate operator training and understanding.
    b. Bridge to further explanation of selected keywords. Document shall contain text and graphics to clarify system operation.

        1) If help feature does not have ability to bridge on keywords for more information, a complete set of user manuals shall be provided in an indexed word-processing program, which shall run concurrently with operating system software.

    c. Available for Every Menu Item:

        1) Index items for each system menu item.

22. Graphic generation software shall allow operator to add, modify, or delete system graphic displays.

    a. Include libraries of symbols depicting HVAC symbols such as fans, coils, filters, dampers, valves pumps, and electrical symbols similar to those indicated.
    b. Graphic development package shall use a pointing device in conjunction with a drawing program to allow operator to perform the following:

        1) Define background screens.
        2) Define connecting lines and curves.
        3) Locate, orient and size descriptive text.
        4) Define and display colors for all elements.
        5) Establish correlation between symbols or text and associated system points or other displays.

D. Project-Specific Graphics: Graphics documentation including, but not limited to, the following:

1. Site plan showing each building, and additional site elements, which are being controlled or monitored by DDC system.
2. Plan for each building floor, including interstitial floors, and each roof level of each building, showing the following:

    a. Room layouts with room identification and name.
    b. Locations and identification of all monitored and controlled HVAC equipment and other equipment being monitored and controlled by DDC system.
    c. Location and identification of each hardware point being controlled or monitored by DDC system.

3. Control schematic for each of following, including a graphic system schematic representation, similar to that indicated on Drawings, with point identification, set point and dynamic value indication, sequence of operation and control logic diagram.

    a. Chilled-water system.
    b. Condenser-water system.
    c. Energy-recovery system and unit.
    d. Fuel system.
    e. Heating hot-water system.
    f. Steam system.
    g. Air-handling system and unit.
    h. Fan.
    i. Pump.
    j. Rooftop unit.
    k. Terminal unit.

4. Graphic display for each piece of equipment connected to DDC system through a data communications link. Include dynamic indication of all points associated with equipment.
5. DDC system network riser diagram that shows schematic layout for entire system including all networks and all controllers, gateways, operator workstations and other network devices.

E. Customizing Software:

1. Software to modify and tailor DDC system to specific and unique requirements of equipment installed, to programs implemented and to staffing and operational practices planned.
2. Online modification of DDC system configuration, program parameters, and database using menu selection and keyboard entry of data into preformatted display templates.
3. As a minimum, include the following modification capability:

    a. Operator assignment shall include designation of operator passwords, access levels, point segregation and auto sign-off.
    b. Peripheral assignment capability shall include assignment of segregation groups and operators to consoles and printers, designation of backup workstations and printers, designation of workstation header points and enabling and disabling of print-out of operator changes.
    c. System configuration and diagnostic capability shall include communications and peripheral port assignments, DDC controller assignments to network, DDC

controller enable and disable, assignment of command trace to points and application programs and initiation of diagnostics.

d. System text addition and change capability shall include English or native language descriptors for points, segregation groups and access levels and action messages for alarms, run time and trouble condition.

e. Time and schedule change capability shall include time and date set, time and occupancy schedules, exception and holiday schedules and daylight savings time schedules.

f. Point related change capability shall include the following:

1) System and point enable and disable.
2) Run-time enable and disable.
3) Assignment of points to segregation groups, calibration tables, lockout, and run time and to a fixed I/O value.
4) Assignment of alarm and warning limits.

g. Application program change capability shall include the following:

1) Enable and disable of software programs.
2) Programming changes.
3) Assignment of comfort limits, global points, time and event initiators, time and event schedules and enable and disable time and event programs.

4. Software shall allow operator to add points, or groups of points, to DDC system and to link them to energy optimization and management programs. Additions and modifications shall be online programmable using operator workstation, downloaded to other network devices and entered into their databases. After verification of point additions and associated program operation, database shall be uploaded and recorded on hard drive and disk for archived record.

5. Include high-level language programming software capability for implementation of custom DDC programs. Software shall include a compiler, linker, and up- and down-load capability.

6. Include a library of DDC algorithms, intrinsic control operators, arithmetic, logic and relational operators for implementation of control sequences. Also include, as a minimum, the following:

a. Proportional control (P).
b. Proportional plus integral (PI).
c. Proportional plus integral plus derivative (PID).
d. Adaptive and intelligent self-learning control.

1) Algorithm shall monitor loop response to output corrections and adjust loop response characteristics according to time constant changes imposed.
2) Algorithm shall operate in a continuous self-learning manner and shall retain in memory a stored record of system dynamics so that on system shut down and restart, learning process starts from where it left off.

7. Fully implemented intrinsic control operators including sequence, reversing, ratio, time delay, time of day, highest select AO, lowest select AO, analog controlled digital output, analog control AO, and digitally controlled AO.

8. Logic operators such as "And," "Or," "Not," and others that are part of a standard set available with a high-level language.
9. Arithmetic operators such as "Add," "Subtract," "Multiply," "Divide," and others that are part of a standard set available with a high-level language.
10. Relational operators such as "Equal To," "Not Equal To," "Less Than," "Greater Than," and others that are part of a standard set available with a high-level language.

F. Alarm Handling Software:

1. Include alarm handling software to report all alarm conditions monitored and transmitted through DDC controllers, gateways and other network devices.
2. Include first in, first out handling of alarms according to alarm priority ranking, with most critical alarms first, and with buffer storage in case of simultaneous and multiple alarms.
3. Alarm handling shall be active at all times to ensure that alarms are processed even if an operator is not currently signed on to DDC system.
4. Alarms display shall include the following:

    a. Indication of alarm condition such as "Abnormal Off," "Hi Alarm," and "Low Alarm."
    b. "Analog Value" or "Status" group and point identification with native language point descriptor such as "Space Temperature, Building 110, 2nd Floor, Room 212."
    c. Discrete per point alarm action message, such as "Call Maintenance Dept. Ext-5561."
    d. Include extended message capability to allow assignment and printing of extended action messages. Capability shall be operator programmable and assignable on a per point basis.

5. Alarms shall be directed to appropriate operator workstations, printers, and individual operators by privilege level and segregation assignments.
6. Send e-mail alarm messages to designated operators.
7. Send e-mail, page, text and voice messages to designated operators for critical alarms.
8. Alarms shall be categorized and processed by class.

    a. Class 1:

        1) Associated with fire, security and other extremely critical equipment monitoring functions; have alarm, trouble, return to normal, and acknowledge conditions printed and displayed.
        2) Unacknowledged alarms to be placed in unacknowledged alarm buffer.
        3) All conditions shall cause an audible sound and shall require individual acknowledgment to silence audible sound.

    b. Class 2:

        1) Critical, but not life-safety related, and processed same as Class 1 alarms, except do not require individual acknowledgment.
        2) Acknowledgement may be through a multiple alarm acknowledgment.

    c. Class 3:

1) General alarms; printed, displayed and placed in unacknowledged alarm buffer queues.
2) Each new alarm received shall cause an audible sound. Audible sound shall be silenced by "acknowledging" alarm or by pressing a "silence" key.
3) Acknowledgement of queued alarms shall be either on an individual basis or through a multiple alarm acknowledgement.
4) Alarms returning to normal condition shall be printed and not cause an audible sound or require acknowledgment.

d. Class 4:

1) Routine maintenance or other types of warning alarms.
2) Alarms to be printed only, with no display, no audible sound and no acknowledgment required.

9. Include an unacknowledged alarm indicator on display to alert operator that there are unacknowledged alarms in system. Operator shall be able to acknowledge alarms on an individual basis or through a multiple alarm acknowledge key, depending on alarm class.
10. To ensure that no alarm records are lost, it shall be possible to assign a backup printer to accept alarms in case of failure of primary printer.

G. Reports and Logs:

1. Include reporting software package that allows operator to select, modify, or create reports using DDC system I/O point data available.
2. Each report shall be definable as to data content, format, interval and date.
3. Report data shall be sampled and stored on DDC controller, within storage limits of DDC controller, and then uploaded to archive on workstation or server for historical reporting as directed.
4. Operator shall be able to obtain real-time logs of all I/O points by type or status, such as alarm, point lockout, or normal.
5. Reports and logs shall be stored on workstation and server hard drives in a format that is readily accessible by other standard software applications, including spreadsheets and word processing.
6. Reports and logs shall be readily printed and set to be printed either on operator command or at a specific time each day.

H. Standard Reports: Standard DDC system reports shall be provided and operator shall be able to customize reports later.

1. All I/O: With current status and values.
2. Alarm: All current alarms, except those in alarm lockout.
3. Disabled I/O: All I/O points that are disabled.
4. Alarm Lockout I/O: All I/O points in alarm lockout, whether manual or automatic.
5. Alarm Lockout I/O in Alarm: All I/O in alarm lockout that are currently in alarm.
6. Logs:

a. Alarm history.
b. System messages.
c. System events.
d. Trends.

I. Custom Reports: Operator shall be able to easily define any system data into a daily, weekly, monthly, or annual report. Reports shall be time and date stamped and shall contain a report title.

J. Standard Trends:

1. Trend all I/O point present values, set points, and other parameters indicated for trending.
2. Trends shall be associated into groups, and a trend report shall be set up for each group.
3. Trends shall be stored within DDC controller and uploaded to hard drives automatically on reaching 75 of DDC controller buffer limit, or by operator request, or by archiving time schedule.
4. Preset trend intervals for each I/O point after review with Owner.
5. Trend intervals shall be operator selectable from 10 seconds up to 60 minutes. Minimum number of consecutive trend values stored at one time shall be 100 per variable.
6. When drive storage memory is full, most recent data shall overwrite oldest data.
7. Archived and real-time trend data shall be available for viewing numerically and graphically by operators.

K. Custom Trends: Operator shall be able to define a custom trend log for any I/O point in DDC system.

1. Each trend shall include interval, start time, and stop time.
2. Data shall be sampled and stored on DDC controller, within storage limits of DDC controller, and then uploaded to archive on workstation or server hard drives.
3. Data shall be retrievable for use in spreadsheets and standard database programs.

L. Programming Software:

1. Include programming software to execute sequences of operation indicated.
2. Include programming routines in simple and easy to follow logic with detailed text comments describing what the logic does and how it corresponds to sequence of operation.
3. Programming software shall be as directed:

    a. Graphic Based: Programming shall use a library of function blocks made from preprogrammed code designed for DDC control systems.

        1) Function blocks shall be assembled with interconnection lines that represent to control sequence in a flowchart.
        2) Programming tools shall be viewable in real time to show present values and logical results of each function block.

    b. Menu Based: Programming shall be done by entering parameters, definitions, conditions, requirements and constraints.
    c. Line by Line and Text Based: Programming shall declare variable types such as local, global, real, integer, and so on, at the beginning of the program. Use descriptive comments frequently to describe programming code.

4. Include means for detecting programming errors and testing software control strategies with a simulation tool before implementing in actual control. Simulation tool may be inherent with programming software or as a separate product.

M. Database Management Software:

1. Where a separate SQL database is used for information storage, DDC system shall include database management software that separates database monitoring and managing functions by supporting multiple separate windows.
2. Database secure access shall be accomplished using standard SQL authentication including ability to access data for use outside of DDC system applications.
3. Database management function shall include summarized information on trend, alarm, event, and audit for the following database management actions:

    a. Backup.
    b. Purge.
    c. Restore.

4. Database management software shall support the following:

    a. Statistics: Display database server information and trend, alarm, event, and audit information on database.
    b. Maintenance: Include method of purging records from trend, alarm, event and audit databases by supporting separate screens for creating a backup before purging, selecting database, and allowing for retention of a selected number of day's data.
    c. Backup: Include means to create a database backup file and select a storage location.
    d. Restore: Include a restricted means of restoring a database by requiring operator to have proper security level.

5. Database management software shall include information of current database activity, including the following:

    a. Ready.
    b. Purging record from a database.
    c. Action failed.
    d. Refreshing statistics.
    e. Restoring database.
    f. Shrinking a database.
    g. Backing up a database.
    h. Resetting Internet information services.
    i. Starting network device manager.
    j. Shutting down the network device manager.
    k. Action successful.

6. Database management software monitoring functions shall continuously read database information once operator has logged on.
7. Include operator notification through on-screen pop-up display and e-mail message when database value has exceeded a warning or alarm limit.
8. Monitoring settings window shall have the following sections:

    a. Allow operator to set and review scan intervals and start times.
    b. E-mail: Allow operator to create and review e-mail and phone text messages to be delivered when a warning or an alarm is generated.

c. Warning: Allow operator to define warning limit parameters, set reminder frequency and link e-mail message.
d. Alarm: Allow operator to define alarm limit parameters, set reminder frequency and link e-mail message.
e. Database Login: Protect system from unauthorized database manipulation by creating a read access and a write access for each of trend, alarm, event and audit databases as well as operator proper security access to restore a database.

9. Monitoring settings taskbar shall include the following informational icons:

a. Normal: Indicates by color and size, or other easily identifiable means that all databases are within their limits.
b. Warning: Indicates by color and size, or other easily identifiable means that one or more databases have exceeded their warning limit.
c. Alarm: Indicates by color and size, or other easily identifiable means that one or more databases have exceeded their alarm limit.

2.14 OFFICE APPLICATION SOFTWARE

A. Include current version of office application software at time of Substantial Completion.

B. Office application software package shall include multiple separate applications and use a common platform for all applications, similar to Microsoft's "Office Professional."

1. Database.
2. E-mail.
3. Presentation.
4. Publisher.
5. Spreadsheet.
6. Word processing.

2.15 ASHRAE 135 GATEWAYS

A. Include BACnet communication ports, whenever available as an equipment OEM standard option, for integration via a single communication cable. BACnet-controlled plant equipment includes, but is not limited to, boilers, chillers, and variable-speed drives.

B. Include gateways to connect BACnet to legacy systems, existing non-BACnet devices, and existing non-BACnet DDC-controlled equipment, only when specifically requested and approved by Owner.

C. Include with each gateway an interoperability schedule showing each point or event on legacy side that BACnet "client" will read, and each parameter that BACnet network will write to. Describe this interoperability of BACnet services, or BIBBs, defined in ASHRAE 135, Annex K.

D. Gateway Minimum Requirements:

1. Read and view all readable object properties on non-BACnet network to BACnet network and vice versa where applicable.
2. Write to all writeable object properties on non-BACnet network from BACnet network and vice versa where applicable.
3. Include single-pass (only one protocol to BACnet without intermediary protocols) translation from non-BACnet protocol to BACnet and vice versa.
4. Comply with requirements of Data Sharing Read Property, Data Sharing Write Property, Device Management Dynamic Device Binding-B, and Device Management Communication Control BIBBs according to ASHRAE 135.
5. Hardware, software, software licenses, and configuration tools for operator-to-gateway communications.
6. Backup programming and parameters on CD media and the ability to modify, download, backup, and restore gateway configuration.

2.16 CEA-709.1-C NETWORK HARDWARE

A. Routers:

1. Network routers, including routers configured as repeaters, shall comply with requirements of CEA-709.1-C and include connection between two or more CEA-709.3 TP/FT-10 channels or between two or more CEA-709.3 TP/FT-10 channels and a TP/XF-1250 channel.
2. IP Routers:

    a. Perform layer three routing of CEA-709.1-C packets over an IP network according to CEA-852-B.
    b. Include appropriate connection to the IP network and connections to CEA-709.3 TP/FT-10 or TP/XF-1250 network.
    c. Support the Dynamic Host Configuration Protocol for IP configuration and use of an CEA-852-B Configuration Server (for CEA-852-B configuration), but shall not rely on these services for configuration.
    d. Capable of manual configuration via a console RS-232 port.

B. Gateways:

1. Perform bidirectional protocol translation from one non-CEA-709.1-C protocol to CEA-709.1-C.
2. Incorporate a network connection to a TP/FT-10 network according to CEA-709.3 and a connection for a non-CEA-709.1-C network.

2.17 DDC CONTROLLERS

A. DDC system shall consist of a combination of network controllers, programmable application controllers and application-specific controllers to satisfy performance requirements indicated.

B. DDC controllers shall perform monitoring, control, energy optimization and other requirements indicated.

C. DDC controllers shall use a multitasking, multiuser, real-time digital control microprocessor with a distributed network database and intelligence.

D. Each DDC controller shall be capable of full and complete operation as a completely independent unit and as a part of a DDC system wide distributed network.

E. Environment Requirements:

1. Controller hardware shall be suitable for the anticipated ambient conditions.
2. Controllers located in conditioned space shall be rated for operation at 32 to 120 deg F (Zero to 50 deg C).
3. Controllers located outdoors shall be rated for operation at 40 to 150 deg F (40 to 65 deg C).

F. Power and Noise Immunity:

1. Controller shall operate at 90 to 110 percent of nominal voltage rating and shall perform an orderly shutdown below 80 percent of nominal voltage.
2. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios with up to 5 W of power located within36 inches (900 mm) of enclosure.

G. DDC Controller Spare Processing Capacity:

1. Include spare processing memory for each controller. RAM, PROM, or EEPROM will implement requirements indicated with the following spare memory:

   a. Network Controllers: Percent as directed.
   b. Programmable Application Controllers: Not less than percent as directed.
   c. Application-Specific Controllers: Not less than percent as directed.

2. Memory shall support DDC controller's operating system and database and shall include the following:

   a. Monitoring and control.
   b. Energy management, operation and optimization applications.
   c. Alarm management.
   d. Historical trend data of all connected I/O points.
   e. Maintenance applications.
   f. Operator interfaces.
   g. Monitoring of manual overrides.

H. DDC Controller Spare I/O Point Capacity: Include spare I/O point capacity for each controller as follows:

1. Network Controllers:

   a. 10 or 20 percent of each AI, AO, BI, and BO point connected to controller as directed.
   b. Minimum Spare I/O Points per Controller:

      1) AIs: Two or Three as directed.

2) AOs: Two or Three as directed.
3) BIs: Three or Five as directed.
4) BOs: Three or Five as directed.

2. Programmable Application Controllers:

a. 10 or 20 percent of each AI, AO, BI, and BO point connected to controller as directed.
b. Minimum Spare I/O Points per Controller:

1) AIs: Two or Three as directed.
2) AOs: Two or Three as directed.
3) BIs: Three or Five as directed.
4) BOs: Three or Five as directed.

3. Application-Specific Controllers:

a. 10 percent of each AI, AO, BI, and BO point connected to controller.
b. Minimum Spare I/O Points per Controller:

1) AIs: One or Two as directed.
2) AOs: One or Two as directed.
3) BIs: One or Two as directed.
4) BOs: One or Two as directed.

I. Maintenance and Support: Include the following features to facilitate maintenance and support:

1. Mount microprocessor components on circuit cards for ease of removal and replacement.
2. Means to quickly and easily disconnect controller from network.
3. Means to quickly and easily access connect to field test equipment.
4. Visual indication that controller electric power is on, of communication fault or trouble, and that controller is receiving and sending signals to network.

J. General Requirements for CEA-709.1-C DDC Controllers:

1. Controllers shall be LonMark certified.
2. Distinguishable and accessible switch, button, or pin, when pressed shall broadcast its 48-bit Node ID and Program ID over network.
3. TP/FT-10 transceiver according to CEA-709.3 and connections for TP/FT-10 control network wiring.
4. TP/XF-1250 transceiver according to CEA-709.3 and connections for TP/XF-1250 control network wiring.
5. Communicate using CEA-709.1-C protocol.
6. Controllers configured into subnets, as required, to comply with performance requirements indicated.
7. Network communication through LNS network management and database standard for CEA-709.1-C network devices.
8. Locally powered, not powered through network connection.
9. Functionality required to support applications indicated, including, but not limited to, the following:

a. Input and outputs indicated and as required to support sequence of operation and application in which it is used. SNVTs shall have meaningful names identifying the value represented by an SNVT. Unless an SNVT of an appropriate engineering type is unavailable, all network variables shall be of an SNVT with engineering units appropriate to value the variable represents.
b. Configurable through SCPTs defined in LonMark SCPT List, operator-defined UCPTs, network configuration inputs (NCIs) of an SNVT type defined in LonMark SNVT List, NCIs of an operator-defined network variable type, or hardware settings on controller itself for all settings and parameters used by application in which it is used.

10. Programmable controllers shall conform to LonMark Interoperability Guidelines and have LonMark certification.

K. Input and Output Point Interface:

1. Hardwired input and output points shall connect to network, programmable application and application-specific controllers.
2. Input and output points shall be protected so shorting of point to itself, to another point, or to ground will not damage controller.
3. Input and output points shall be protected from voltage up to 24 V of any duration so that contact will not damage controller.
4. AIs:

a. AIs shall include monitoring of low-voltage (zero- to 10-V dc), current (4 to 20 mA) and resistance signals from thermistor and RTD sensors.
b. AIs shall be compatible with, and field configurable to, sensor and transmitters installed.
c. Controller AIs shall perform analog-to-digital (A-to-D) conversion with a minimum resolution of 8 or 12 bits or better to comply with accuracy requirements indicated as directed.
d. Signal conditioning including transient rejection shall be provided for each AI.
e. Capable of being individually calibrated for zero and span.
f. Incorporate common-mode noise rejection of at least 50 dB from zero to 100 Hz for differential inputs, and normal-mode noise rejection of at least 20 dB at 60 Hz from a source impedance of 10000 ohms.

5. AOs:

a. Controller AOs shall perform analog-to-digital (A-to-D) conversion with a minimum resolution of 8 or 12 bits or better to comply with accuracy requirements indicated.
b. Output signals shall have a range of 4 to 20 mA dc or zero- to 10-V dc as required to include proper control of output device.
c. Capable of being individually calibrated for zero and span.
d. AOs shall not exhibit a drift of greater than 0.4 percent of range per year.

6. BIs:

a. Controller BIs shall accept contact closures and shall ignore transients of less than 5-ms duration.

b. Isolation and protection against an applied steady-state voltage of up to 180-V ac peak.
c. BIs shall include a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against effects of contact bounce and noise.
d. BIs shall sense "dry contact" closure without external power (other than that provided by the controller) being applied.
e. Pulse accumulation input points shall comply with all requirements of BIs and accept up to 10 pulses per second for pulse accumulation. Buffer shall be provided to totalize pulses. Pulse accumulator shall accept rates of at least 20 pulses per second. The totalized value shall be reset to zero on operator's command.

7. BOs:

a. Controller BOs shall include relay contact closures or triac outputs for momentary and maintained operation of output devices.

1) Relay contact closures shall have a minimum duration of 0.1 second. Relays shall include at least 180 V of isolation. Electromagnetic interference suppression shall be provided on all output lines to limit transients to non-damaging levels. Minimum contact rating shall be 1 A at 24-V ac.
2) Triac outputs shall include at least 180 V of isolation. Minimum contact rating shall be 1 A at 24-V ac.

b. BOs shall include for two-state operation or a pulsed low-voltage signal for pulse-width modulation control.
c. BOs shall be selectable for either normally open or normally closed operation.
d. Include tristate outputs (two coordinated BOs) for control of three-point floating-type electronic actuators without feedback.
e. Limit use of three-point floating devices to VAV terminal unit control applications, and other applications indicated on Drawings. Control algorithms shall operate actuator to one end of its stroke once every 12 or 24 hours for verification of operator tracking as directed.

2.18 NETWORK CONTROLLERS

A. General Network Controller Requirements:

1. Include adequate number of controllers to achieve performance indicated.
2. System shall consist of one or more independent, standalone, microprocessor-based network controllers to manage global strategies indicated.
3. Controller shall have enough memory to support its operating system, database, and programming requirements.
4. Data shall be shared between networked controllers and other network devices.
5. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
6. Controllers that perform scheduling shall have a real-time clock.

7. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
8. Controllers shall be fully programmable.

B. Communication:

1. Network controllers shall communicate with other devices on DDC system Level one network.
2. Network controller also shall perform routing if connected to a network of programmable application and application-specific controllers.

C. Operator Interface:

1. Controller shall be equipped with a service communications port for connection to a portable operator's workstation or mobile device.
2. Local Keypad and Display:

   a. Equip controller with local keypad and digital display for interrogating and editing data.
   b. Use of keypad and display shall require security password.

D. Serviceability:

1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall maintain BIOS and programming information in event of a power loss for at least 72 or 96 hours as directed.

2.19 PROGRAMMABLE APPLICATION CONTROLLERS

A. General Programmable Application Controller Requirements:

1. Include adequate number of controllers to achieve performance indicated.
2. Controller shall have enough memory to support its operating system, database, and programming requirements.
3. Data shall be shared between networked controllers and other network devices.
4. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
5. Controllers that perform scheduling shall have a real-time clock.
6. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
7. Controllers shall be fully programmable.

B. Communication:

1. Programmable application controllers shall communicate with other devices on network.

C. Operator Interface:

1. Controller shall be equipped with a service communications port for connection to a portable operator's workstation or mobile device.
2. Local Keypad and Display:

a. Equip controller with local keypad and digital display for interrogating and editing data.
b. Use of keypad and display shall require security password.

D. Serviceability:

1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall maintain BIOS and programming information in event of a power loss for at least 72 hours.

2.20 APPLICATION-SPECIFIC CONTROLLERS

A. Description: Microprocessor-based controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment. Controllers are not fully user-programmable but are configurable and customizable for operation of equipment they are designed to control.

1. Capable of standalone operation and shall continue to include control functions without being connected to network.
2. Data shall be shared between networked controllers and other network devices.

B. Communication: Application-specific controllers shall communicate with other application-specific controller and devices on network, and to programmable application and network controllers.

C. Operator Interface: Controller shall be equipped with a service communications port for connection to a portable operator's workstation. Connection shall extend to port on space temperature sensor that is connected to controller.

D. Serviceability:

1. Controller shall be equipped with diagnostic LEDs or other form of local visual indication of power, communication, and processor.
2. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
3. Controller shall use nonvolatile memory and maintain all BIOS and programming information in event of power loss.

2.21 CONTROLLER SOFTWARE

A. General Controller Software Requirements:

1. Software applications shall reside and operate in controllers. Editing of applications shall occur at operator workstations.
2. I/O points shall be identified by up to 30-character point name and up to 16-character point descriptor. Same names shall be used at operator workstations.
3. Control functions shall be executed within controllers using DDC algorithms.
4. Controllers shall be configured to use stored default values to ensure fail-safe operation. Default values shall be used when there is a failure of a connected input instrument or loss of communication of a global point value.

B. Security:

1. Operator access shall be secured using individual security passwords and user names.
2. Passwords shall restrict operator to points, applications, and system functions as assigned by system manager.
3. Operator log-on and log-off attempts shall be recorded.
4. System shall protect itself from unauthorized use by automatically logging off after last keystroke. The delay time shall be operator-definable.

C. Scheduling: Include capability to schedule each point or group of points in system. Each schedule shall consist of the following:

1. Weekly Schedule:

   a. Include separate schedules for each day of week.
   b. Each schedule should include the capability for start, stop, optimal start, optimal stop, and night economizer.
   c. Each schedule may consist of up to 10 events.
   d. When a group of objects are scheduled together, include capability to adjust start and stop times for each member.

2. Exception Schedules:

   a. Include ability for operator to designate any day of the year as an exception schedule.
   b. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by regular schedule for that day of week.

3. Holiday Schedules:

   a. Include capability for operator to define up to 99 special or holiday schedules.
   b. Schedules may be placed on scheduling calendar and will be repeated each year.
   c. Operator shall be able to define length of each holiday period.

D. System Coordination:

1. Include standard application for proper coordination of equipment.

2. Application shall include operator with a method of grouping together equipment based on function and location.
3. Group may then be used for scheduling and other applications.

E. Binary Alarms:

1. Each binary point shall be set to alarm based on operator-specified state.
2. Include capability to automatically and manually disable alarming.

F. Analog Alarms:

1. Each analog object shall have both high and low alarm limits.
2. Alarming shall be able to be automatically and manually disabled.

G. Alarm Reporting:

1. Operator shall be able to determine action to be taken in event of an alarm.
2. Alarms shall be routed to appropriate operator workstations based on time and other conditions.
3. Alarm shall be able to start programs, print, be logged in event log, generate custom messages, and display graphics.

H. Remote Communication:

1. System shall have ability to dial out in the event of an alarm.

I. Electric Power Demand Limiting:

1. Demand-limiting program shall monitor building or other operator-defined electric power consumption from signals connected to electric power meter or from a watt transducer or current transformer.
2. Demand-limiting program shall predict probable power demand such that action can be taken to prevent exceeding demand limit. When demand prediction exceeds demand limit, action will be taken to reduce loads in a predetermined manner. When demand prediction indicates demand limit will not be exceeded, action will be taken to restore loads in a predetermined manner.
3. Demand reduction shall be accomplished by the following means:

    a. Reset air-handling unit supply temperature set points.
    b. Reset space temperature set points.
    c. De-energize equipment based on priority.

4. Demand-limiting parameters, frequency of calculations, time intervals, and other relevant variables shall be based on the means by which electric power service provider computes demand charges.
5. Include demand-limiting prediction and control for any individual meter monitored by system or for total of any combination of meters.
6. Include means operator to make the following changes online:

    a. Addition and deletion of loads controlled.
    b. Changes in demand intervals.

c. Changes in demand limit for meter(s).
d. Maximum shutoff time for equipment.
e. Minimum shutoff time for equipment.
f. Select rotational or sequential shedding and restoring.
g. Shed and restore priority.

7. Include the following information and reports, to be available on an hourly, daily, weekly, monthly and annual basis:

a. Total electric consumption.
b. Peak demand.
c. Date and time of peak demand.
d. Daily peak demand.

J. Maintenance Management: System shall monitor equipment status and generate maintenance messages based on operator-designated run-time, starts, and calendar date limits.

K. Sequencing: Include application software based on sequences of operation indicated to properly sequence chillers, boilers, and other applicable HVAC equipment.

L. Control Loops:

1. Support any of the following control loops, as applicable to control required:

a. Two-position (on/off, open/close, slow/fast) control.
b. Proportional control.
c. Proportional plus integral (PI) control.
d. Proportional plus integral plus derivative (PID) control.

1) Include PID algorithms with direct or reverse action and anti-windup.
2) Algorithm shall calculate a time-varying analog value used to position an output or stage a series of outputs.
3) Controlled variable, set point, and PID gains shall be operator-selectable.

e. Adaptive (automatic tuning).

M. Staggered Start: Application shall prevent all controlled equipment from simultaneously restarting after a power outage. Order which equipment (or groups of equipment) is started, along with the time delay between starts, shall be operator-selectable.

N. Energy Calculations:

1. Include software to allow instantaneous power or flow rates to be accumulated and converted to energy usage data.
2. Include an algorithm that calculates a sliding-window average (rolling average). Algorithm shall be flexible to allow window intervals to be operator specified (such as 15, 30, or 60 minutes).
3. Include an algorithm that calculates a fixed-window average. A digital input signal shall define start of window period (such as signal from utility meter) to synchronize fixed-window average with that used by utility.

O. Anti-Short Cycling:

1. BO points shall be protected from short cycling.
2. Feature shall allow minimum on-time and off-time to be selected.

P. On and Off Control with Differential:

1. Include an algorithm that allows a BO to be cycled based on a controlled variable and set point.
2. Algorithm shall be direct- or reverse-acting and incorporate an adjustable differential.

Q. Run-Time Totalization:

1. Include software to totalize run-times for all BI and BO points.
2. A high run-time alarm shall be assigned, if required, by operator.

2.22 ENCLOSURES

A. General Enclosure Requirements:

1. House each controller and associated control accessories in a single enclosure. Enclosure shall serve as central tie-in point for control devices such as switches, transmitters, transducers, power supplies and transformers.
2. Do not house more than one controller in a single enclosure.
3. Include enclosure door with key locking mechanism. Key locks alike for all enclosures and include one pair of keys per enclosure.
4. Equip doors of enclosures housing controllers and components with analog or digital displays with windows to allow visual observation of displays without opening enclosure door.
5. Individual wall-mounted single-door enclosures shall not exceed 36 inches (900 mm) wide and high as directed.
6. Individual wall-mounted double-door enclosures shall not exceed 60 inches (1500 mm) wide and 36 inches (900 mm) high.
7. Include wall-mounted enclosures with brackets suitable for mounting enclosures to wall or freestanding support stand as indicated.
8. Supply each enclosure with a complete set of as-built schematics, tubing, and wiring diagrams and product literature located in a pocket on inside of door. For enclosures with windows, include pocket on bottom of enclosure.

B. Internal Arrangement:

1. Internal layout of enclosure shall group and protect pneumatic, electric, and electronic components associated with a controller, but not an integral part of controller.
2. Arrange layout to group similar products together.
3. Include a barrier between line-voltage and low-voltage electrical and electronic products.
4. Factory or shop install products, tubing, cabling and wiring complying with requirements and standards indicated.
5. Terminate field cable and wire using heavy-duty terminal blocks.
6. Include spare terminals, equal to not less than 10 or 20 percent of used terminals as directed.

7. Include spade lugs for stranded cable and wire.
8. Install a maximum of two wires on each side of a terminal.
9. Include enclosure field power supply with a toggle-type switch located at entrance inside enclosure to disconnect power.
10. Include enclosure with a line-voltage nominal 20-A GFCI duplex receptacle for service and testing tools. Wire receptacle on hot side of enclosure disconnect switch and include with a 5-A circuit breaker.
11. Mount products within enclosure on removable internal panel(s).
12. Include products mounted in enclosures with engraved, laminated phenolic nameplates (black letters on a white background). The nameplates shall have at least 1/4-inch- (6-mm-) high lettering.
13. Route tubing cable and wire located inside enclosure within a raceway with a continuous removable cover.
14. Label each end of cable, wire and tubing in enclosure following an approved identification system that extends from field I/O connection and all intermediate connections throughout length to controller connection.
15. Size enclosure internal panel to include at least 25 percent spare area on face of panel.

C. Environmental Requirements:

1. Evaluate temperature and humidity requirements of each product to be installed within each enclosure.
2. Calculate enclosure internal operating temperature considering heat dissipation of all products installed within enclosure and ambient effects (solar, conduction and wind) on enclosure.
3. Where required by application, include temperature-controlled electrical heat to maintain inside of enclosure above minimum operating temperature of product with most stringent requirement.
4. Where required by application, include temperature-controlled ventilation fans with filtered louver(s) to maintain inside of enclosure below maximum operating temperature of product with most stringent requirement.

D. Wall-Mounted, NEMA 250, Type 1:

1. Enclosure shall be NRTL listed according to UL 50 or UL 50E.
2. Construct enclosure of steel, not less than:

    a. Enclosure size less than 24 in. (600 mm): 0.053 in. (1.35 mm) or 0.067 in. (1.7 mm) thick as directed.
    b. Enclosure size 24 in. (600 mm) and larger: 0.067 in. (1.7 mm) or 0.093 in. (2.36 mm) thick.

3. Finish enclosure inside and out with polyester powder coating that is electrostatically applied and then baked to bond to substrate.

    a. Exterior color as directed.
    b. Interior color shall be as directed.

4. Hinged door full size of front face of enclosure and supported using:

    a. Enclosures sizes less than 36 in. (900 mm) tall: Multiple butt hinges.
    b. Enclosures sizes 36 in. (900 mm) tall and larger: Continuous piano hinges.

5. Removable internal panel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.

    a. Size less than 24 in. (600 mm): Solid or Perforated steel, 0.053 in. (1.35 mm) thick.
    b. Size 24 in. (600 mm) and larger: Solid aluminum, 0.10 in. (3 mm) or steel, 0.093 in. (2.36 mm) thick.

6. Internal panel mounting hardware, grounding hardware and sealing washers.
7. Grounding stud on enclosure body.
8. Thermoplastic pocket on inside of door for record Drawings and Product Data.

E. Wall Mounted NEMA 250, Types 4 and 12:
1. Enclosure shall be NRTL listed according to UL 508A.
2. Seam and joints are continuously welded and ground smooth.
3. Where recessed enclosures are indicated, include enclosures with face flange for flush mounting.
4. Externally formed body flange around perimeter of enclosure face for continuous perimeter seamless gasket door seal.
5. Single-door enclosure sizes up to 60 inches tall by 36 inches wide (1500 mm tall by 900 mm wide).
6. Double-door enclosure sizes up to 36 inches tall by 60 inches wide (900 mm tall by 1500 mm wide).
7. Construct enclosure of steel, not less than the following:

    a. Size Less Than 24 Inches (600 mm): 0.053 inch (1.35 mm) or 0.067 inch (1.7 mm) thick.
    b. Size 24 Inches (600 mm) and Larger: 0.067 inch (1.7 mm) thick.

8. Finish enclosure with polyester powder coating that is electrostatically applied and then baked to bond to substrate.

    a. Exterior color as directed.
    b. Interior color shall be as directed.

9. Corner-formed door, full size of enclosure face, supported using multiple concealed hinges with easily removable hinge pins.

    a. Sizes through 24 Inches (600 mm) Tall: Two hinges.
    b. Sizes between 24 Inches (600 mm) through 48 Inches (1200 mm) Tall: Three hinges.
    c. Sizes Larger 48 Inches (1200 mm) Tall: Four hinges.

10. Double-door enclosures with overlapping door design to include unobstructed full-width access.

    a. Single-door enclosures 48 inches (1200 mm) and taller, and all double-door enclosures, with three-point (top, middle and bottom) latch system.

11. Removable internal panel with a white polyester powder coating that is electrostatically applied and then baked to bond to substrate.

a. Size Less Than 24 Inches (600 mm): Solid or perforated steel, 0.053 inch (1.35 mm) thick.
b. Size 24 Inches (600 mm) and Larger: Solid aluminum, 0.10 inch (3 mm) or steel, 0.093 inch (2.36 mm) thick.

12. Internal panel mounting studs with hardware, grounding hardware, and sealing washers.
13. Grounding stud on enclosure body.
14. Thermoplastic pocket on inside of door for record Drawings and Product Data.

F. Accessories:

1. Electric Heater:

a. Aluminum housing with brushed finish.
b. Thermostatic control with adjustable set point from zero to 100 deg F (Minus 18 to 38 deg C).
c. Capacity: 100, 200, 400, and 800 W as required by application.
d. Fan draws cool air from bottom of enclosure and passes air across thermostat and heating elements before being released into enclosure cavity. Heated air is discharged through the top of heater.

2. Ventilation Fans, Filtered Intake and Exhaust Grilles:

a. Number and size of fans, filters and grilles as required by application.
b. Compact cooling fans engineered for 50,000 hours of continuous operation without lubrication or service.
c. Fans capable of being installed on any surface and in any position within enclosure for spot cooling or air circulation.
d. Thermostatic control with adjustable set point from 32 to 140 deg F (Zero to 60 deg C).
e. Airflow Capacity at Zero Pressure:

1) 4-Inch (100-mm) Fan: 100 cfm (47 L/s).
2) 6-Inch (150-mm) Fan: 240 cfm (113 L/s).
3) 10-Inch (250-mm) Fan: 560 cfm (264 L/s).

f. Maximum operating temperature of 158 deg F (70 deg C).
g. 4-inch (100-mm) fan thermally protected and provided with permanently lubricated ball-bearings.
h. 6- and 10-inch (150- and 250-mm) fans with ball-bearing construction and split capacitor motors thermally protected to avoid premature failure.
i. Dynamically balanced impellers molded from polycarbonate material.
j. Fan furnished with power cord and polarized plug for power connection.
k. Fan brackets, finger guards and mounting hardware provided with fans to complete installation.
l. Removable Intake and Exhaust Grilles: ABS plastic or stainless steel of size to match fan size and suitable for NEMA 250, Types 1 and 12 enclosures.
m. Filters for NEMA 250, Type 1 Enclosures: Washable foam or aluminum, of a size to match intake grille.
n. Filters for NEMA 250, Type 12 Enclosures: Disposable, of a size to match intake grille.

3. Framed Fixed Window Kit for NEMA 250, Types 4, 4X, and 12 Enclosures:

   a. 0.25-inch- (6-mm-) thick, scratch-resistant acrylic or polycarbonate window mounted in a metal frame matching adjacent door material.
   b. Enclosure types, except NEMA 250 Type 1, shall have a continuous gasket material around perimeter of window and frame to provide watertight seal.
   c. Window kit shall be factory or shop installed before shipment to Project.

4. Frameless Fixed Window Kit for NEMA 250, Type 1 Enclosures:

   a. 0.125-inch- (3-mm-) thick, polycarbonate window mounted in enclosure door material.
   b. Window attached to door with screw fasteners and continuous strip of high-strength double-sided tape around window perimeter.
   c. Window kit shall be factory or shop installed before shipment to Project.

5. Frame Fixed or Hinged Window Kit for NEMA 250, Types 1 and 12 Enclosures:

   a. 0.25-inch- (6-mm-) thick, scratch-resistant acrylic or polycarbonate window mounted in a metal frame matching adjacent door material.
   b. Enclosure types, except NEMA 250 Type 1, shall have a continuous gasket material around perimeter of window and frame to provide watertight seal.
   c. Window kit shall be factory or shop installed before shipment to Project.

6. Bar handle with keyed cylinder lock set.

2.23 RELAYS

A. General-Purpose Relays:
   1. Relays shall be heavy duty and rated for at least 10 A at 250-V ac and 60 Hz.
   2. Relays shall be either double pole double throw (DPDT) or three-pole double throw, depending on the control application.
   3. Use a plug-in-style relay with an eight-pin octal plug for DPDT relays and an 11-pin octal plug for three-pole double-throw relays.
   4. Construct the contacts of either silver cadmium oxide or gold.
   5. Enclose the relay in a clear transparent polycarbonate dust-tight cover.
   6. Relays shall have LED indication and a manual reset and push-to-test button.
   7. Performance:

      a. Mechanical Life: At least 10 million cycles.
      b. Electrical Life: At least 100,000 cycles at rated load.
      c. Pickup Time: 15 ms or less.
      d. Dropout Time: 10 ms or less.
      e. Pull-in Voltage: 85 percent of rated voltage.
      f. Dropout Voltage: 50 percent of nominal rated voltage.
      g. Power Consumption: 2 VA.
      h. Ambient Operating Temperatures: Minus 40 to 115 deg F (Minus 40 to 46 deg C).

   8. Equip relays with coil transient suppression to limit transients to non-damaging levels.

9. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
10. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

B. Multifunction Time-Delay Relays:
1. Relays shall be continuous duty and rated for at least 10 A at 240-V ac and 60 Hz.
2. Relays shall be DPDT relay with up to eight programmable functions to provide on/off delay, interval and recycle timing functions.
3. Use a plug-in-style relay with either an 8- or 11-pin octal plug.
4. Construct the contacts of either silver cadmium oxide or gold.
5. Enclose the relay in a dust-tight cover.
6. Include knob and dial scale for setting delay time.
7. Performance:

    a. Mechanical Life: At least 10 million cycles.
    b. Electrical Life: At least 100,000 cycles at rated load.
    c. Timing Ranges: Multiple ranges from 0.1 seconds to 100 minutes.
    d. Repeatability: Within 2 percent.
    e. Recycle Time: 45 ms.
    f. Minimum Pulse Width Control: 50 ms.
    g. Power Consumption: 5 VA or less at 120-V ac.
    h. Ambient Operating Temperatures: Minus 40 to 115 deg F (Minus 40 to 46 deg C).

8. Equip relays with coil transient suppression to limit transients to non-damaging levels.
9. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
10. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

C. Latching Relays:
1. Relays shall be continuous duty and rated for at least 10 A at 250-V ac and 60 Hz.
2. Relays shall be either DPDT or three-pole double throw, depending on the control application.
3. Use a plug-in-style relay with a multibladed plug.
4. Construct the contacts of either silver cadmium oxide or gold.
5. Enclose the relay in a clear transparent polycarbonate dust-tight cover.
6. Performance:

    a. Mechanical Life: At least 10 million cycles.
    b. Electrical Life: At least 100,000 cycles at rated load.
    c. Pickup Time: 15 ms or less.
    d. Dropout Time: 10 ms or less.
    e. Pull-in Voltage: 85 percent of rated voltage.
    f. Dropout Voltage: 50 percent of nominal rated voltage.
    g. Power Consumption: 2 VA.
    h. Ambient Operating Temperatures: Minus 40 to 115 deg F (Minus 40 to 46 deg C).

7. Equip relays with coil transient suppression to limit transients to non-damaging levels.
8. Plug each relay into an industry-standard, 35-mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.

9. Relay socket shall have screw terminals. Mold into the socket the coincident screw terminal numbers and associated octal pin numbers.

D. Current Sensing Relay:
1. Monitors ac current.
2. Independent adjustable controls for pickup and dropout current.
3. Energized when supply voltage is present and current is above pickup setting.
4. De-energizes when monitored current is below dropout current.
5. Dropout current is adjustable from 50 to 95 percent of pickup current.
6. Include a current transformer, if required for application.
7. House current sensing relay and current transformer in its own enclosure. Use NEMA 250, Type 12 enclosure for indoors and NEMA 250, Type 4 for outdoors.

E. Combination On-Off Status Sensor and On-Off Relay:
1. Description:

a. On-off control and status indication in a single device.
b. LED status indication of activated relay and current trigger.
c. Closed-Open-Auto override switch located on the load side of the relay.

2. Performance:

a. Ambient Temperature: Minus 30 to 140 deg F (Minus 34 to 60 deg C).
b. Voltage Rating: Single-phase loads rated for 300-V ac. Three-phase loads rated for 600-V ac.

3. Status Indication:

a. Current Sensor: Integral sensing for single-phase loads up to 20 A and external solid or split sensing ring for three-phase loads up to 150 A.
b. Current Sensor Range: As required by application.
c. Current Set Point: As directed.
d. Current Sensor Output:

1) Solid-state, single-pole double-throw contact rated for 30-V ac and dc and for 0.4 A.
2) Solid-state, single-pole double-throw contact rated for 120-V ac and 1.0 A.
3) Analog, zero- to 5- or 10-V dc.
4) Analog, 4 to 20 mA, loop powered.

4. Relay: Single-pole double-throw, continuous-duty coil; rated for 10-million mechanical cycles.
5. Enclosure: NEMA 250, Type 1 enclosure.

2.24 ELECTRICAL POWER DEVICES

A. Transformers:

1. Transformer shall be sized for the total connected load, plus an additional 25 percent of connected load.

2. Transformer shall be at least 40 or 100 VA as directed.
3. Transformer shall have both primary and secondary fuses.

B. DC Power Supply:
1. Plug-in style suitable for mating with a standard eight-pin octal socket. Include the power supply with a mating mounting socket.
2. Enclose circuitry in a housing.
3. Include both line and load regulation to ensure a stable output. To protect both the power supply and the load, power supply shall have an automatic current limiting circuit.
4. Performance:

a. Output voltage nominally 25-V dc within 5 percent.
b. Output current up to 100 mA.
c. Input voltage nominally 120-V ac, 60 Hz.
d. Load regulation within 0.5 percent from zero- to 100-mA load.
e. Line regulation within 0.5 percent at a 100-mA load for a 10 percent line change.
f. Stability within 0.1 percent of rated volts for 24 hours after a 20-minute warmup.

2.25 UNINTERRUPTABLE POWER SUPPLY (UPS) UNITS FOR WORKSTATIONS

A. 250 through 1000 VA:
1. UPS units shall provide continuous, regulated output power without using their batteries during brown-out, surge, and spike conditions.
2. Load served shall not exceed 75 percent of UPS rated capacity, including power factor of connected loads.

a. Larger-capacity units shall be provided for systems with larger connected loads.
b. UPS shall provide five minutes of battery power.

3. Performance:

a. Input Voltage: Single phase, 120- or 230-V ac, compatible with field power source.
b. Load Power Factor Range (Crest Factor): 0.65 to 1.0.
c. Output Voltage: 101- to 132-V ac, while input voltage varies between 89 and 152-V ac.
d. On Battery Output Voltage: Sine wave.
e. Inverter overload capacity shall be minimum 150 percent for 30 seconds.
f. Recharge time shall be a maximum of six hours to 90 percent capacity after full discharge to cutoff.
g. Transfer Time: 6 ms.
h. Surge Voltage Withstand Capacity: IEEE C62.41, Categories A and B; 6 kV/200 and 500 A; 100-kHz ringwave.

4. UPS shall be automatic during fault or overload conditions.
5. Unit with integral line-interactive, power condition topology to eliminate all power contaminants.
6. Include front panel with power switch and visual indication of power, battery, fault and temperature.
7. Unit shall include an audible alarm of faults and front panel silence feature.

8. Unit with four NEMA WD 1, NEMA WD 6 Configuration 5-15R receptacles.
9. UPS shall include dry contacts (digital output points) for low battery condition and battery-on (primary utility power failure) and connect the points to the DDC system.
10. Batteries shall be sealed lead-acid type and be maintenance free. Battery replacement shall be front accessible by user without dropping load.
11. Include tower models installed in ventilated cabinets to the particular installation location.

B. 1000 through 3000 VA:
1. UPS units shall provide continuous, regulated output power without using their batteries during brown-out, surge, and spike conditions.
2. Load served shall not exceed 75 percent of UPS rated capacity, including power factor of connected loads.

    a. Larger-capacity units, or multiple units, shall be provided for systems with larger connected loads.
    b. UPS shall provide five or 10 minutes of battery power as directed.

3. Performance:

    a. Input Voltage: Single phase, 120-V ac, plus 20 to minus 30 percent.
    b. Power Factor: Minimum 0.97 at full load.
    c. Output Voltage: Single phase, 120-V ac, within 3 percent, steady state with rated output current of 10.0 A, 30.0-A peak.
    d. Inverter overload capacity shall be minimum 150 percent for 30 seconds.
    e. Recharge time shall be a maximum of eight hours to 90 percent capacity.

4. UPS bypass shall be automatic during fault or overload conditions.
5. UPS shall include dry contacts (digital output points) for low battery condition and battery-on (primary utility power failure) and connect the points to the DDC system.
6. Batteries shall be sealed lead-acid type and be maintenance free.
7. Include tower models installed in ventilated cabinets or rack models installed on matching racks, as applicable to the particular installation location and space availability/configuration.

2.26 PIPING AND TUBING

A. Pneumatic, and Pressure Instrument Signal Air, Tubing and Piping:

1. Products in this paragraph are intended for use with the following:

    a. Main air and signal air to pneumatically controlled instruments, actuators and other control devices and accessories.
    b. Signal air between pressure instruments, such as sensors, switches, transmitters, controllers, and accessories.

2. Copper Tubing:

a. Seamless phosphor deoxidized copper, soft annealed or drawn tempered, with chemical and physical properties according to ASTM B75.
b. Performance, dimensions, weight and tolerance according to ASTM B280.
c. Diameter, as required by application, not less than nominal 0.25 inch (6 mm).
d. Wall thickness, as required by the application, but not less than 0.030 inch (0.8 mm).

3. Copper Tubing Connectors and Fittings:

a. Brass, compression type.

b. Brass, solder-joint type.

4. Polyethylene Tubing:

a. Fire-resistant black virgin polyethylene according to ASTM D1248, Type 1, Class C and Grade 5.
b. Tubing shall comply with stress crack test according to ASTM D1693.
c. Diameter, as required by application, of not less than nominal 0.25 inch (6 mm).

5. Polyethylene Tubing Connectors and Fittings:

a. Brass, barbered fittings.

b. Brass, compression type.

B. Process Tubing:

1. Products in this paragraph are intended for signals to instruments connected to liquid and steam systems.
2. Copper Tubing:

a. Seamless phosphor deoxidized copper, soft annealed or drawn tempered with chemical and physical properties according to ASTM B75.
b. Performance, dimensions, weight and tolerance according to ASTM B280.
c. Diameter, as required by application, of not less than nominal 0.25 inch (6 mm).
d. Wall thickness, as required by application, but not less than 0.030 inch (0.8 mm).

3. Copper Tubing Connectors and Fittings:

a. Brass, compression type.

b. Brass, solder-joint type.

2.27 CONTROL WIRE AND CABLE

A. Wire: Single conductor control wiring above 24 V.

1. Wire size as directed.

2. Conductor shall be 7/24 soft annealed copper strand with 2- to 2.5-inch (50- to 65-mm) lay.
3. Conductor insulation shall be 600 V, Type THWN or Type THHN, and 90 deg C according to UL 83.
4. Conductor colors shall be black (hot), white (neutral), and green (ground).
5. Furnish wire on spools.

B. Single Twisted Shielded Instrumentation Cable above 24 V:

1. Wire size minimum as directed.
2. Conductors shall be a twisted, 7/24 soft annealed copper strand with a 2- to 2.5-inch (50- to 65-mm) lay.
3. Conductor insulation shall have a Type THHN/THWN or Type TFN rating.
4. Shielding shall be 100 percent type, 0.35/0.5-mil aluminum/Mylar tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
5. Outer jacket insulation shall have a 600-V, 90-deg C rating and shall be Type TC cable.
6. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.
7. Furnish wire on spools.

C. Single Twisted Shielded Instrumentation Cable 24 V and Less:

1. Wire size minimum as directed.
2. Conductors shall be a twisted, 7/24 soft annealed copper stranding with a 2- to 2.5-inch (50- to 65-mm) lay.
3. Conductor insulation shall have a nominal 15-mil thickness, constructed from flame-retardant PVC.
4. Shielding shall be 100 percent type, 1.35-mil aluminum/polymer tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
5. Outer jacket insulation shall have a 300-V, 105-deg C rating and shall be Type PLTC cable.
6. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.
7. Furnish wire on spools.

D. LAN and Communication Cable: Comply with DDC system manufacturer requirements for network being installed.

1. Cable shall be balanced twisted pair.
2. Comply with the following requirements and for balanced twisted pair cable described in Section 260523 "Control-Voltage Electrical Power Cables" or Section 271513 "Communications Copper Horizontal Cabling" as directed.
3. Cable shall be plenum rated.
4. Cable shall comply with NFPA 70.
5. Cable shall have a unique color that is different from other cables used on Project.

2.28 CONTROL POWER WIRING AND RACEWAYS

A. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" electrical power conductors and cables.

B. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for electrical power raceways and boxes.

2.29 ACCESSORIES

A. Damper Blade Limit Switches:

1. Sense positive open and/or closed position of the damper blades.
2. NEMA 250, Type 13, oil-tight construction.
3. Arrange for the mounting application.
4. Additional waterproof enclosure when required by its environment.
5. Arrange to prevent "over-center" operation.

B. Manual Valves:

1. Needle Type:
   a. PTFE packing.
   b. Construct of brass for use with copper and polyethylene tubing and of stainless steel for use with stainless-steel tubing.
   c. Aluminum T-bar handle.
   d. Include tubing connections.

2. Ball Type:
   a. Body: Bronze ASTM B62 or ASTM B61.
   b. Ball: Type 316 stainless steel.
   c. Stem: Type 316 stainless steel.
   d. Seats: Reinforced PTFE.
   e. Packing Ring: Reinforced PTFE.
   f. Lever: Stainless steel with a vinyl grip.
   g. 600 WOG.
   h. Threaded end connections.

2.30 IDENTIFICATION

A. Instrument Air Pipe and Tubing:

1. Engraved tag shall bear the following information:

   a. Service (Example): "Instrument Air."
   b. Pressure Range (Example): 0 to 30 psig (0 to 200 kPa).

2. Letter size shall be a minimum of 0.25 inch (6 mm) high.
3. Tag shall consist of white lettering on blue background.
4. Tag shall be engraved phenolic consisting of three layers of rigid laminate. Top and bottom layers are color-coded blue with contrasting white center exposed by engraving through outer layer.
5. Include tag with a brass grommet, chain and S-hook.

B. Control Equipment, Instruments, and Control Devices:

1. Engraved tag bearing unique identification.

    a. Include instruments with unique identification identified by equipment being controlled or monitored, followed by point identification.

2. Letter size shall be as follows:

    a. Operator Workstations: Minimum of 0.5 inch (13 mm) high.
    b. Printers: Minimum of 0.5 inch (13 mm) high.
    c. DDC Controllers: Minimum of 0.5 inch (13 mm) high.
    d. Gateways: Minimum of 0.5 inch (13 mm) high.
    e. Repeaters: Minimum of 0.5 inch (13 mm) high.
    f. Enclosures: Minimum of 0.5 inch (13 mm) high.
    g. Electrical Power Devices: Minimum of 0.25 inch (6 mm) high.
    h. UPS units: Minimum of 0.5 inch (13 mm).
    i. Accessories: Minimum of 0.25 inch (6 mm) high.
    j. Instruments: Minimum of 0.25 inch (6 mm) high.
    k. Control Damper and Valve Actuators: Minimum of 0.25 inch (6 mm) high.

3. Tag shall consist of white lettering on black background.
4. Tag shall be engraved phenolic consisting of three layers of rigid laminate. Top and bottom layers are color-coded black with contrasting white center exposed by engraving through outer layer.
5. Tag shall be fastened with drive pins.
6. Instruments, control devices and actuators with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require an additional tag.

C. Valve Tags:

1. Brass tags and brass chains attached to valve.
2. Tags shall be at least 1.5 inches (38 mm) in diameter.
3. Include tag with unique valve identification indicating control influence such as flow, level, pressure, or temperature; followed by location of valve, and followed by three-digit sequential number. For example: TV-1.001.
4. Valves with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require an additional tag.

D. Raceway and Boxes:

1. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
2. Paint cover plates on junction boxes and conduit same color as the tape banding for conduits. After painting, label cover plate "HVAC Controls," using an engraved phenolic tag.
3. For raceways housing pneumatic tubing, add a phenolic tag labeled "HVAC Instrument Air Tubing."
4. For raceways housing air signal tubing, add a phenolic tag labeled "HVAC Air Signal Tubing."

E. Equipment Warning Labels:

1. Acrylic label with pressure-sensitive adhesive back and peel-off protective jacket.
2. Lettering size shall be at least 14-point type with white lettering on red background.
3. Warning label shall read "CAUTION-Equipment operated under remote automatic control and may start or stop at any time without warning. Switch electric power disconnecting means to OFF position before servicing."
4. Lettering shall be enclosed in a white line border. Edge of label shall extend at least 0.25 inch (6 mm) beyond white border.

2.31 SOURCE QUALITY CONTROL

A. Product(s) and material(s) will be considered defective if it does or they do not pass tests and inspections as directed.

B. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

1. Verify compatibility with and suitability of substrates.

B. Examine roughing-in for products to verify actual locations of connections before installation.

1. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
2. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

C. Examine walls, floors, roofs, and ceilings for suitable conditions where product will be installed.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 DDC SYSTEM INTERFACE WITH OTHER SYSTEMS AND EQUIPMENT

A. Communication Interface to Equipment with Integral Controls:

1. DDC system shall have communication interface with equipment having integral controls and having a communication interface for remote monitoring or control.

2. Equipment to Be Connected:

   a. Domestic water booster pumps specified in Section 221123.13 "Domestic-Water Packaged Booster Pumps."
   b. Air-terminal units specified in Section 233600 "Air Terminal Units."
   c. Kitchen hoods specified in Section 233813 "Commercial-Kitchen Hoods."
   d. Boilers specified in Section 235213 "Electric Boilers."
   e. Boilers specified in Section 235216 "Condensing Boilers."
   f. Boilers specified in Section 235223 "Cast-Iron Boilers."
   g. Boilers specified in Section 235233 "Water-Tube Boilers."
   h. Boilers specified in Section 235239 "Fire-Tube Boilers."
   i. Feedwater equipment specified in Section 235313 "Boiler Feedwater Pumps."
   j. Deaerators specified in Section 235316 "Deaerators."
   k. Chillers specified in Section 236413.13 "Direct-Fired Absorption Water Chillers."
   l. Chillers specified in Section 236413.16 "Indirect-Fired Absorption Water Chillers."
   m. Chillers specified in Section 236416 "Centrifugal Water Chillers."
   n. Chillers specified in Section 236423.13 "Air-Cooled, Scroll Water Chillers."
   o. Chillers specified in Section 236423.16 "Water-Cooled, Scroll Water Chillers."
   p. Chillers specified in Section 236426.13 "Air-Cooled, Rotary-Screw Water Chillers."
   q. Chillers specified in Section 236426.16 "Water-Cooled, Rotary-Screw Water Chillers."
   r. Cooling towers specified in Section 236513.13 "Open-Circuit, Forced-Draft Cooling Towers."
   s. Cooling towers specified in Section 236513.16 "Closed-Circuit, Forced-Draft Cooling Towers."
   t. Cooling towers specified in Section 236514.13 "Open-Circuit, Induced-Draft, Counterflow Cooling Towers."
   u. Cooling towers specified in Section 236514.14 "Open-Circuit, Induced-Draft, Crossflow Cooling Towers."
   v. Cooling towers specified in Section 236514.16 "Closed-Circuit, Induced-Draft, Counterflow Cooling Towers."
   w. Cooling towers specified in Section 236514.17 "Closed-Circuit, Induced-Draft, Combined-Flow Cooling Towers."
   x. Heat wheels and heat exchangers specified in Section 237223 "Air-to-Air Energy Recovery Equipment."
   y. Air-handling units specified in Section 237313 "Modular Indoor Central-Station Air-Handling Units."
   z. Roof-top units specified in Section 237413 "Packaged, Outdoor, Central-Station Air-Handling Units."
   aa. Dedicated outdoor-air units specified in Section 237433 "Dedicated Outdoor-Air Units."
   bb. Packaged terminal air-conditioners specified in Section 238113.11 "Packaged Terminal Air-Conditioners, Through-Wall Units."
   cc. Packaged terminal air-conditioners specified in Section 238113.12 "Packaged Terminal Air-Conditioners, Freestanding Units."
   dd. Packaged terminal air-conditioners specified in Section 238113.13 "Packaged Terminal Air-Conditioners, Outdoor, Wall-Mounted Units."

ee. Computer-room air-conditioning units specified in Section 238123.11 "Small-Capacity (6 Tons (21 kW) and Smaller), Computer-Room Air-Conditioners, Floor Mounted Units."
ff. Computer-room air-conditioning units specified in Section 238123.12 "Large-Capacity (7 Tons (25 kW) and Larger), Computer-Room Air-Conditioners, Floor Mounted Units."
gg. Computer-room air-conditioning units specified in Section 238123.13 "Computer-Room Air Conditioners, Ceiling-Mounted Units."
hh. Computer-room air-conditioning units specified in Section 238123.14 "Computer-Room Air Conditioners, Console Units."
ii. Computer-room, rack-mounted cooling equipment specified in Section 238123.18 "Computer-Room, Rack-Cooling Equipment."
jj. Fan-coil units specified in Section 238219 "Fan Coil Units."
kk. Unit ventilators specified in Section 238223 "Unit Ventilators."
ll. Wetted-element humidifiers specified in Section 238413.16 "Wetted-Element Humidifiers."
mm. Atomizing humidifiers specified in Section 238413.19 "Atomizing Humidifiers."
nn. Direct-steam-injection humidifiers specified in Section 238413.23 "Direct-Steam-Injection Humidifiers."
oo. Self-contained humidifiers specified in Section 238413.29 "Self-Contained Steam Humidifiers."
pp. Heat exchanger humidifiers specified in Section 238413.36 "Heat Exchanger Humidifiers."
qq. Dehumidification units specified in Section 238416 "Mechanical Dehumidification Units."
rr. Switchboards specified in Section 262300 "Low-Voltage Switchgear."
ss. Motor-control centers specified in Section 262419 "Motor-Control Centers."
tt. Variable-frequency controllers specified in Section 262923 "Variable-Frequency Motor Controllers."
uu. Diesel emergency engine generators specified in Section 263213.1 "Diesel Emergency Engine Generators."
vv. Diesel engine generators specified in Section 263213.14 "Diesel Engine Generators."
ww. Gaseous emergency engine generators specified in Section 263213.16 "Gaseous Emergency Engine Generators."
xx. Gaseous engine generators specified in Section 263213.17 "Gaseous Engine Generators."
yy. Bi-fuel emergency engine generators specified in Section 263213.19 "Bi-Fuel Emergency Engine Generators."
zz. Bi-fuel engine generators specified in Section 263213.20 "Bi-Fuel Engine Generators."
aaa. UPS specified in Section 263353 "Static Uninterruptible Power Supply."
bbb. Refrigerant monitoring.

B. Communication Interface to Other Building Systems:

1. DDC system shall have a communication interface with systems having a communication interface.
2. Systems to Be Connected:

a. Elevators specified in Section 142100 "Electric Traction Elevators."

b. Elevators specified in Section 142113 "Electric Traction Freight Elevators."
c. Elevators specified in Section 142400 "Hydraulic Elevators."
d. Elevators specified in Section 142413 "Hydraulic Freight Elevators."
e. Escalators specified in Section 143100 "Escalators."
f. Automated water treatment systems specified in Section 232500 "HVAC Water Treatment."
g. Automated water treatment systems specified in Section 232516 "Water Treatment for Open-Loop Hydronic Systems."
h. Automated water treatment systems specified in Section 232519 "Water Treatment for Steam System Feedwater."
i. Power monitoring specified in Section 260913 "Electrical Power Monitoring and Control."
j. Lighting controls specified in Section 260926 "Lighting Control Panelboards."
k. Lighting controls specified in Section 260943.16 "Addressable-Luminaire Lighting Controls."
l. Lighting controls specified in Section 260943.23 "Relay-Based Lighting Controls."
m. Fire-alarm system specified in Section 284621.11 "Addressable Fire-Alarm Systems."
n. Fire-alarm system specified in Section 284621.13 "Conventional Fire-Alarm Systems."
o. Access controls specified in Section 281300 "Access Control System Software and Database Management."
p. Intrusion detection specified in Section 283100 "Intrusion Detection."
q. Perimeter security specified in Section 283121 "Area and Perimeter Intrusion Detection."

3.3 CONTROL DEVICES FOR INSTALLATION BY INSTALLERS

A. Deliver selected control devices, specified in indicated HVAC instrumentation and control device Sections, to identified equipment and systems manufacturers for factory installation and to identified installers for field installation.

B. Deliver the following to duct fabricator and Installer for installation in ductwork. Include installation instructions to Installer and supervise installation for compliance with requirements.

1. DDC control dampers, which are specified in Section 230923.12 "DDC Control Dampers."
2. Airflow sensors and switches, which are specified in Section 230923.14 "Flow Instruments."
3. Pressure sensors, which are specified in Section 230923.23 "Pressure Instruments."

C. Deliver the following to plumbing and HVAC piping installers for installation in piping. Include installation instructions to Installer and supervise installation for compliance with requirements.

1. DDC control valves, which are specified in Section 230923.11 "Control Valves."
2. Pipe-mounted flow meters, which are specified in Section 230923.14 "Flow Instruments."

3. Pipe-mounted sensors, switches and transmitters. Flow meters are specified in Section 230923.14 "Flow Instruments." Liquid and steam temperature sensors, switches, and transmitters are specified in Section 230923.27 "Temperature Instruments."
4. Tank-mounted sensors, switches and transmitters. Pressure sensors, switches, and transmitters are specified in Section 230923.23 "Pressure Instruments." Liquid and steam temperature sensors, switches, and transmitters are specified in Section 230923.27 "Temperature Instruments."
5. Pipe- and tank-mounted thermowells. Liquid and steam thermowells are specified in Section 230923.27 "Temperature Instruments."

3.4 CONTROL DEVICES FOR EQUIPMENT MANUFACTURER FACTORY INSTALLATION

A. Deliver the following to air-handling unit manufacturer for factory installation. Include installation instructions to air-handling unit manufacturer and supervise installation for compliance with requirements.

1. Programmable application or application-specific controller.
2. Unit-mounted DDC control dampers and actuators, which are specified in Section 230923.12 "Control Dampers."
3. Unit-mounted airflow sensors, switches and transmitters, which are specified in Section 230923.14 "Flow Instruments."
4. Unit-mounted gas sensors and transmitters, which are specified in Section 230923.16 "Gas Instruments."
5. Unit-mounted leak-detection switches, which are specified in Section 230923.18 "Leak-Detection Instruments."
6. Unit-mounted speed sensors, switches and transmitters, which are specified in Section 230923.24 "DDC Speed Instruments."
7. Unit-mounted pressure sensors, switches and transmitters, which are specified in Section 230923.23 "Pressure Instruments."
8. Unit-mounted temperature sensors, switches and transmitters. Air-temperature sensors, switches, and transmitters are specified in Section 230923.27 "Temperature Instruments."
9. Relays.

B. Deliver the following to terminal unit manufacturer for factory installation. Include installation instructions to terminal unit manufacturer.

1. Programmable application or application-specific controller.
2. Electric damper actuator. Dampers actuators are specified in Section 230923.12 "Control Dampers."
3. Unit-mounted flow and pressure sensors, transmitters and transducers. Flow sensors, transmitters, and transducers are specified in Section 230923.14 "Flow Instruments." Pressure sensors, switches, and transmitters are specified in Section 230923.23 "Pressure Instruments."
4. Unit-mounted temperature sensors. Air-temperature sensors, switches, and transmitters are specified in Section 230923.27 "Temperature Instruments."
5. Relays.

C. Deliver the following to fan-coil unit manufacturer for factory installation. Include installation instructions to fan-coil unit manufacturer.

1. Programmable application or application-specific controller.
2. Unit-mounted temperature sensors. Air-temperature sensors, switches, and transmitters are specified in Section 230923.27 "Temperature Instruments."
3. Flow and pressure switches. Air and liquid flow sensors, transmitters, and transducers are specified in Section 230923.14 "Flow Instruments." Pressure sensors, switches, and transmitters are specified in Section 230923.23 "Pressure Instruments."
4. Leak-detection switches, which are specified in Section 230923.18 "Leak-Detection Instruments."
5. Relays.

3.5 GENERAL INSTALLATION REQUIREMENTS

A. Install products to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Support products, tubing, piping wiring and raceways. Brace products to prevent lateral movement and sway or a break in attachment when subjected to a force as directed.

D. If codes and referenced standards are more stringent than requirements indicated, comply with requirements in codes and referenced standards.

E. Fabricate openings and install sleeves in ceilings, floors, roof, and walls required by installation of products. Before proceeding with drilling, punching, and cutting, check for concealed work to avoid damage. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

F. Firestop Penetrations Made in Fire-Rated Assemblies: Comply with requirements in Section 078413 "Penetration Firestopping."

G. Seal penetrations made in acoustically rated assemblies. Comply with requirements in Section 079200 "Joint Sealants."

H. Welding Requirements:

1. Restrict welding and burning to supports and bracing.
2. No equipment shall be cut or welded without approval. Welding or cutting will not be approved if there is risk of damage to adjacent Work.
3. Welding, where approved, shall be by inert-gas electric arc process and shall be performed by qualified welders according to applicable welding codes.
4. If requested on-site, show satisfactory evidence of welder certificates indicating ability to perform welding work intended.

I. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that damage surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening fasteners.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts and screws with graphite and oil before assembly.

J. If product locations are not indicated, install products in locations that are accessible and that will permit service and maintenance from floor, equipment platforms, or catwalks without removal of permanently installed furniture and equipment.

K. Corrosive Environments:

1. Avoid or limit use of materials in corrosive airstreams and environments, including, but not limited to, the following:

   a. Laboratory exhaust-air streams.
   b. Process exhaust-air streams.

2. When conduit is in contact with a corrosive airstream and environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment. Comply with requirements for installation of raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."
3. Where instruments are located in a corrosive airstream and are not corrosive resistant from manufacturer, field install products in NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.6 OPERATOR WORKSTATION INSTALLATION

A. Desktop Workstations Installation:

1. Install workstation(s) at location(s) directed by Owner.
2. Install multiple-receptacle power strip with cord for use in connecting multiple workstation components to a single duplex electrical power receptacle.
3. Install software on workstation(s) and verify software functions properly.
4. Develop Project-specific graphics, trends, reports, logs and historical database.
5. Power each workstation through a dedicated UPS unit. Locate UPS adjacent to workstation.

B. Portable Workstations Installation:

1. Turn over portable workstations to Owner at Substantial Completion.
2. Install software on workstation(s) and verify software functions properly.

C. Color Graphics Application:

1. Use system schematics indicated as starting point to create graphics.
2. Develop Project-specific library of symbols for representing system equipment and products.
3. Incorporate digital images of Project-completed installation into graphics where beneficial to enhance effect.
4. Submit sketch of graphic layout with description of all text for each graphic for Owner's and Architect's review before creating graphic using graphics software.
5. Seek Owner input in graphics development once using graphics software.
6. Final editing shall be done on-site with Owner's and Architect's review and feedback.
7. Refine graphics as necessary for Owner acceptance.

8. On receiving Owner acceptance, print a hard copy for inclusion in operation and maintenance manual. Prepare a scanned copy PDF file of each graphic and include with softcopy of DDC system operation and maintenance manual.

3.7 POT INSTALLATION

A. Install one or two portable operator terminal(s) as directed.

B. Turn over POTs to Owner at Substantial Completion.

C. Install software on each POT and verify that software functions properly.

3.8 PRINTER INSTALLATION

A. Provide the following printer(s) at location(s) directed by Owner:

1. Color Inkjet: Quantity, one or one per desktop workstation as directed.
2. Dot Matrix: Quantity, one or one per desktop workstation as directed.

B. Install printer software on workstations and verify that software functions properly.

3.9 GATEWAY INSTALLATION

A. Install gateways if required for DDC system communication interface requirements indicated.

1. Install gateway(s) required to suit indicated requirements.

B. Test gateway to verify that communication interface functions properly.

3.10 ROUTER INSTALLATION

A. Install routers if required for DDC system communication interface requirements indicated.

1. Install router(s) required to suit indicated requirements.

B. Test router to verify that communication interface functions properly.

3.11 CONTROLLER INSTALLATION

A. Install controllers in enclosures to comply with indicated requirements.

B. Connect controllers to field power supply and to UPS units where indicated.

C. Install controller with latest version of applicable software and configure to execute requirements indicated.

D. Test and adjust controllers to verify operation of connected I/O to achieve performance indicated requirements while executing sequences of operation.

E. Installation of Network Controllers:

1. Quantity and location of network controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
2. Install controllers in a protected location that is easily accessible by operators.
3. Top of controller shall be within 72 inches (1800 mm) or 84 inches (2100 mm) as directed.

F. Installation of Programmable Application Controllers:

1. Quantity and location of programmable application controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
2. Install controllers in a protected location that is easily accessible by operators.
3. Top of controller shall be within 72 inches (1800 mm) or 84 inches (2100 mm) of finished floor as directed.

G. Application-Specific Controllers:

1. Quantity and location of application-specific controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
2. For controllers not mounted directly on equipment being controlled, install controllers in a protected location that is easily accessible by operators.

3.12 ENCLOSURES INSTALLATION

A. Install the following items in enclosures, to comply with indicated requirements:

1. Gateways.
2. Routers.
3. Controllers.
4. Electrical power devices.
5. UPS units.
6. Relays.
7. Accessories.
8. Instruments.
9. Actuators

B. Attach wall-mounted enclosures to wall using the following types of steel struts:

1. For NEMA 250, Type 1 Enclosures: Strut and hardware as directed.
2. For NEMA 250, Type 4 or Type 4X Enclosures and Enclosures Located Outdoors as directed: Use stainless-steel strut and hardware.
3. Install plastic caps on exposed cut edges of strut.

C. Align top or bottom of adjacent enclosures of like size.

D. Install floor-mounted enclosures located in mechanical equipment rooms on concrete housekeeping pads. Attach enclosure legs using galvanized- or stainless-steel anchors.

E. Install continuous and fully accessible wireways to connect conduit, wire, and cable to multiple adjacent enclosures. Wireway used for application shall have protection equal to NEMA 250 rating of connected enclosures.

3.13 ELECTRIC POWER CONNECTIONS

A. Connect electrical power to DDC system products requiring electrical power connections.

B. Design of electrical power to products not indicated with electric power is delegated to DDC system provider and installing trade. Work shall comply with NFPA 70 and other requirements indicated.

C. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers" for electrical power circuit breakers.

D. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power conductors and cables.

E. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for electrical power raceways and boxes.

3.14 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements in Section 260553 "Identification for Electrical Systems" for identification products and installation.

B. Install self-adhesive labels or laminated acrylic or melamine plastic signs with unique identification on face for each of the following as directed:

1. Operator workstation.
2. Printer.
3. Gateway.
4. Router.
5. DDC controller.
6. Enclosure.
7. Electrical power device.
8. UPS unit.
9. Accessory.

C. Install unique instrument identification on face of each instrument connected to a DDC controller.

D. Install unique identification on face of each control damper and valve actuator connected to a DDC controller.

E. Where product is installed above accessible tile ceiling, also install matching identification on face of ceiling grid located directly below.

F. Where product is installed above an inaccessible ceiling, also install identification on face of access door directly below.

G. Warning Labels and Signs:

1. Shall be permanently attached to equipment that can be automatically started by DDC control system.
2. Shall be located in highly visible location near power service entry points.

3.15 NETWORK INSTALLATION

A. Install balanced twisted pair cable when connecting between the following network devices located in same building:

1. Operator workstations.
2. Operator workstations and network controllers.
3. Network controllers.

B. Install balanced twisted pair cable when connecting between the following:

1. Gateways.
2. Gateways and network controllers or programmable application controllers.
3. Routers.
4. Routers and network controllers or programmable application controllers.
5. Network controllers and programmable application controllers.
6. Programmable application controllers.
7. Programmable application controllers and application-specific controllers.
8. Application-specific controllers.

C. Install cable in continuous raceway.

1. Where indicated on Drawings, cable trays may be used for copper cable in lieu of conduit.

3.16 NETWORK NAMING AND NUMBERING

A. Coordinate with Owner and provide unique naming and addressing for networks and devices.

B. ASHRAE 135 Networks:

1. MAC Address:

a. Every network device shall have an assigned and documented MAC address unique to its network.
b. Ethernet Networks: Document MAC address assigned at its creation.
c. ARCNET or MS/TP networks: Assign from 00 to 64.

2. Network Numbering:

   a. Assign unique numbers to each new network.
   b. Provide ability for changing network number through device switches or operator interface.
   c. DDC system, with all possible connected LANs, can contain up to 65,534 unique networks.

3. Device Object Identifier Property Number:

   a. Assign unique device object identifier property numbers or device instances for each device network.
   b. Provide for future modification of device instance number by device switches or operator interface.
   c. LAN shall support up to 4,194,302 unique devices.

4. Device Object Name Property Text:

   a. Device object name property field shall support 32 minimum printable characters.
   b. Assign unique device "Object Name" property names with plain-English descriptive names for each device.

      1) Example 1: Device object name for device controlling boiler plant at Building 1000 would be "HW System B1000."
      2) Example 2: Device object name for a VAV terminal unit controller could be "VAV unit 102".

5. Object Name Property Text for Other Than Device Objects:

   a. Object name property field shall support 32 minimum printable characters.
   b. Assign object name properties with plain-English names descriptive of application.

      1) Example 1: "Zone 1 Temperature."
      2) Example 2 "Fan Start and Stop."

6. Object Identifier Property Number for Other Than Device Objects:

   a. Assign object identifier property numbers according to Drawings or tables indicated.
   b. If not indicated, object identifier property numbers may be assigned at Installer's discretion but must be approved by Owner in advance, be documented and be unique for like object types within device.

3.17 PIPING AND TUBING INSTALLATION

A. Above-Grade Pneumatic and Air Signal Piping and Tubing Installation:

1. Material Application:

   a. Install copper tubing, except as follows:

1) Tubing Exposed to View: Polyethylene tubing installed in raceways may be used in lieu of copper tubing.
2) Concealed Tubing: Polyethylene tubing may be used in lieu of copper tubing when concealed behind accessible ceilings and concealed in walls and connecting wall-mounted instruments with recessed connections.

b. Install copper tubing, unless other accessible materials are indicated, for air signals to instruments including, but not limited to, the following:

1) Sensors.
2) Switches.
3) Transmitters.

c. Install drawn-temper copper tubing, except within 36 inches (900 mm) of device terminations tubing shall be annealed-tempered copper tubing.
d. Install compression fittings to connect copper tubing to instruments, control devices, and accessories.
e. Install barbed or compression fittings to connect polyethylene tubing to instruments, control devices, and accessories.

2. Routing:

a. Do not expose tubing in finished spaces, such as spaces with ceilings; occupied spaces, offices, and conference rooms, unless expressly approved in writing by Architect. Tubing may be exposed in areas without ceilings.
b. Where tubing is installed in finished occupied spaces, install the tubing in surface metal raceway with appropriate fittings only where not feasible to conceal in wall, above ceiling or behind architectural enclosures or covers.
c. Install piping and tubing plumb and parallel to and at right angles with building construction.
d. Install multiple runs of tubing or piping in equally spaced parallel lines.
e. Piping and tubing shall not interfere with access to valves, equipment, duct and equipment access doors, or obstruct personnel access and passageways of any kind.
f. Coordinate with other trades before installation to prevent proposed piping and tubing from interfering with pipe, duct, terminal equipment, light fixtures, conduit and cable tray space. If changes to Shop Drawings are necessary due to field coordination, document changes on record Drawings.
g. Install vibration loops in copper tubing when connecting to instrument and actuators that vibrate.

3. Support:

a. According to MSS SP-69, Table 3, except support spacing shall not exceed 60 inches (1500 mm).
b. Support copper tubing with copper hangers, clips, and tube trays.
c. Do not use tape for support or dielectric isolation.
d. Install supports at each change in direction and at each branch take off.
e. Attached supports to building structure independent of work of other trades. Support from ducts, pipes, cable trays, and conduits is prohibited.

f. Attached support from building structure with threaded rods, structural shapes, or channel strut.
g. Install and brace supports to carry static load plus a safety margin, which will allow tubing to be serviced.
h. Brace supports to prevent lateral movement.
i. Paint steel support members that are not galvanized or zinc coated.
j. Support polyethylene tubing same as copper tubing.

4. Do not attach piping and tubing to equipment that may be removed frequently for maintenance or that may impart vibration and expansion from temperature change.
5. Protect exposed tubing in mechanical equipment rooms from mechanical damage within inches as directed above floor. Use aluminum channel reversed and secured over tubing to protect tubing from damage.
6. Joining and Makeup:

a. Where joining and mating dissimilar metals where galvanic action could occur, install dielectric isolation.
b. Install a dirt leg with an isolation valve and threaded plug at each main air, connection to a panel, pneumatic pilot positioner and PRV station.
c. Make threaded joints for connecting to instrument equipment with connectors with a compression tubing connector on one end and threaded connection on other end.
d. Make tubing bends with a tube-bending tool. Hard bends, wrinkled or flattened bends are unacceptable.
e. Install tube fittings according to manufacturer's written instructions.
f. Do not make tubing connections to a fitting before completing makeup of the connection.
g. Align tubing with the fitting. Avoid springing tube into position, as this may result in excessive stress on both tubing and fitting with possible resulting leaks.
h. Do not install fittings close to a bend. A length of straight tubing, not deformed by bending, is required for a proper connection.
i. Check tubing for correct diameter and wall thickness.
j. Tube ends shall be cut square and deburred. Exercise care during cutting to keep tubing round.
k. Thread pipe on a threading machine. Ream inner edges of pipe ends, file and grind to remove burrs.
l. Wrap pipe threads of fittings on pneumatic lines with a single wrap of PTFE tape.
m. Protect piping and tubing from entrance of foreign matter.

7. Conduit in which nonmetallic tubing is installed shall not exceed 50 percent fill. Support conduit according to NFPA 70 unless otherwise indicated.

B. Identify piping and tubing as follows:

1. Every 50 feet (15 m) of straight run.
2. At least once for each branch within 36 inches (900 mm) of main tee.
3. At each change in direction.
4. Within 36 inches (900 mm) of each ceiling, floor, roof and wall penetration.
5. Where exposed to and where concealed from view, including above ceiling plenums, shafts, and chases.
6. At each valve.

7. Mark each instrument tube connection with a number-coded identification. Each unique tube shall have same unique number at instrument connection and termination at opposite end of tube.

C. Isolation Valves Installation:

1. Install valves full size of piping and tubing.
2. Install at the following locations:

   a. At each branch.
   b. Before and after each PRV.
   c. Before and after each air dryer.
   d. At each control device.

3. Valves shall be located to be readily accessible from floor.

D. Process Tubing Installation:

1. Install process tubing for signal to instruments in liquid and steam systems. Instruments include, but are not limited to, the following:

   a. Meters.
   b. Sensors.
   c. Switches.
   d. Transmitters.

2. Support tubing according to MSS SP-69, Table 3, but at intervals no less than 60 inches (1500 mm).
3. Install NPS 1/2 (DN 15) process tubing for industrial-grade sensors, transmitters, and switches. Install stainless-steel bushings where required.
4. Make tubing bends with a bending tool. Flattened or wrinkled bends are unacceptable.
5. Support tubing independent of other trades.
6. Route tubing parallel to and at right angles to building construction.
7. Install tubing concealed in areas with ceilings.
8. Install a dirt leg with an isolation valve and threaded plug in drain valve at each connection to a transmitter and switch.
9. Insulate process piping connected to hot water and steam systems for personnel protection if the surface temperature exceeds 120 deg F (49 deg C). Only insulate piping within maintenance personnel reach from floor, platform, or catwalk.
10. Wrap pipe threads of fitting in process tubing with service temperatures below 350 deg F (177 deg C) with a single wrap of PTFE tape.
11. Coat pipe threads of fittings on process tubing in services with temperatures exceeding 350 deg F (177 deg C) with pipe compound before being made up to reduce the possibility of galling.
12. Do not make tubing connections to a fitting before completing makeup of the connection.
13. Check tubing for correct diameter and wall thickness. Cut the tube ends square and deburred. Exercise care during cutting to keep tubing round.
14. Do not install fittings close to a bend. A length of straight tubing, not deformed by bending, is required for a proper connection.
15. Align tubing with fitting when installed. Avoid springing tube into position.

16. Install tubing with extreme care exercised to keep foreign matter out of system. Open tubing ends shall be kept plugged to keep out dust, dirt and moisture.
17. Do not attach tubing to equipment that may be removed frequently for maintenance or may impart vibration and expansion from temperature change.
18. Protect exposed tubing in mechanical equipment rooms from inadvertent mechanical damage within inches as directed above floor. Use aluminum channel reversed and secured over tubing to protect tubing from damage.

E. Isolation Valves Installation:

1. Install valves full size of piping and tubing.
2. Install isolation valves at the following locations:

    a. Process connection.
    b. Inlet to each instrument including, sensors, transmitters, switches, gages, and other control devices.

3. Locate valves to be readily accessible from floor.

3.18 CONTROL WIRE, CABLE AND RACEWAYS INSTALLATION

A. Comply with NECA 1.

B. Wire and Cable Installation:

1. Comply with installation requirements in Section 260523 "Control-Voltage Electrical Power Cables."
2. Comply with installation requirements in Section 271313 "Communications Copper Backbone Cabling."
3. Comply with installation requirements in Section 271513 "Communications Copper Horizontal Cabling."
4. Install cables with protective sheathing that is waterproof and capable of withstanding continuous temperatures of 90 deg C with no measurable effect on physical and electrical properties of cable.

    a. Provide shielding to prevent interference and distortion from adjacent cables and equipment.

5. Provide strain relief.
6. Terminate wiring in a junction box.

    a. Clamp cable over jacket in junction box.
    b. Individual conductors in the stripped section of the cable shall be slack between the clamping point and terminal block.

7. Terminate field wiring and cable not directly connected to instruments and control devices having integral wiring terminals using terminal blocks.
8. Install signal transmission components according to IEEE C2, REA Form 511a, NFPA 70, and as indicated.

9. Use shielded cable to transmitters.
10. Use shielded cable to temperature sensors.
11. Perform continuity and meager testing on wire and cable after installation.

C. Conduit Installation:

1. Comply with Section "260533 "Raceways and Boxes for Electrical Systems" for control-voltage conductors.
2. Comply with Section 270528 "Pathways for Communications Systems" for balanced twisted pair cabling and optical fiber installation.

3.19 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage or Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Testing of Pneumatic and Air-Signal Tubing:

    a. Test for leaks and obstructions.
    b. Disconnect each pipe and tubing line before a test is performed, and blowout dust, dirt, trash, condensate and other foreign materials with compressed air. Use commercially pure compressed air or nitrogen as distributed in gas cylinders. Air from an oil-free compressor with an air dryer is an acceptable alternative for the test.
    c. After foreign matter is expelled and line is free from obstructions, plug far end of tubing run.
    d. Connect a pressure source to near end of run with a needle valve between air supply and tubing run.
    e. Connect a pressure gage accurate to within 0.5 percent of test between the shutoff needle valve and tubing run under test.
    f. For system pressures above 30 psig (207 kPa), apply a pressure of 1.5 times operating pressure. Record pressure in tubing run every 10 minutes for one hour. Allowable drop in pressure in one-hour period shall not exceed 1 psig (6.9 kPa).
    g. For system pressures 30 psig (207 kPa) and below, apply a pressure of 2.0 times operating pressure to piping and tubing run. Record pressure in tubing run every 5 minutes for one hour. Allowable drop in pressure in one-hour period shall not exceed 0.5 psig (3.5 kPa).

D. Testing:

1. Perform preinstallation, in-progress, and final tests, supplemented by additional tests, as necessary.
2. Preinstallation Cable Verification: Verify integrity and serviceability for new cable lengths before installation. This assurance may be provided by using vendor verification documents, testing, or other methods. As a minimum, furnish evidence of verification for cable attenuation and bandwidth parameters.
3. In-Progress Testing: Perform standard tests for correct pair identification and termination during installation to ensure proper installation and cable placement. Perform tests in addition to those specified if there is any reason to question condition of material furnished and installed. Testing accomplished is to be documented by agency conducting tests. Submit test results for Project record.
4. Final Testing: Perform final test of installed system to demonstrate acceptability as installed. Testing shall be performed according to a test plan supplied by DDC system manufacturer. Defective Work or material shall be corrected and retested. As a minimum, final testing for cable system, including spare cable, shall verify conformance of attenuation, length, and bandwidth parameters with performance indicated.
5. Test Equipment: Use an optical fiber time domain reflectometer for testing of length and optical connectivity.
6. Test Results: Record test results and submit copy of test results for Project record.

3.20 DDC SYSTEM I/O CHECKOUT PROCEDURES

A. Check installed products before continuity tests, leak tests and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.

D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material and support.

E. For pneumatic products, verify that air supply for each product is properly installed.

F. Control Damper Checkout:

1. Verify that control dampers are installed correctly for flow direction.
2. Verify that proper blade alignment, either parallel or opposed, has been provided.
3. Verify that damper frame attachment is properly secured and sealed.
4. Verify that damper actuator and linkage attachment is secure.
5. Verify that actuator wiring is complete, enclosed and connected to correct power source.
6. Verify that damper blade travel is unobstructed.

G. Control Valve Checkout:

1. For pneumatic valves, verify that pressure gages are provided in each airline to valve actuator and positioner.
2. Verify that control valves are installed correctly for flow direction.
3. Verify that valve body attachment is properly secured and sealed.
4. Verify that valve actuator and linkage attachment is secure.

5. Verify that actuator wiring is complete, enclosed and connected to correct power source.
6. Verify that valve ball, disc or plug travel is unobstructed.
7. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.

H. Instrument Checkout:

1. Verify that instrument is correctly installed for location, orientation, direction and operating clearances.
2. Verify that attachment is properly secured and sealed.
3. Verify that conduit connections are properly secured and sealed.
4. Verify that wiring is properly labeled with unique identification, correct type and size and is securely attached to proper terminals.
5. Inspect instrument tag against approved submittal.
6. For instruments with tubing connections, verify that tubing attachment is secure and isolation valves have been provided.
7. For flow instruments, verify that recommended upstream and downstream distances have been maintained.
8. For temperature instruments:

a. Verify sensing element type and proper material.
b. Verify length and insertion.

3.21 DDC SYSTEM I/O ADJUSTMENT, CALIBRATION AND TESTING:

A. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.

B. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.

C. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.

D. Equipment and procedures used for calibration shall comply with instrument manufacturer's written instructions.

E. Provide diagnostic and test equipment for calibration and adjustment.

F. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. An installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.

G. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.

H. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.

I. Comply with field testing requirements and procedures indicated by ASHRAE's Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

J. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

K. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact making or breaking.

L. Control Dampers:

1. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
2. Stroke control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed and 100 percent open at proper air pressure.
3. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.
4. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

M. Control Valves:

1. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
2. Stroke control valves with pilot positioners. Adjust valve and positioner following manufacturer's recommended procedure, so valve is 100 percent closed, 50 percent closed and 100 percent open at proper air pressures.
3. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.
4. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

N. Meters: Check sensors at zero, 50, and 100 percent of Project design values.

O. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

P. Switches: Calibrate switches to make or break contact at set points indicated.

Q. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.

2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistant source.

3.22 DDC SYSTEM CONTROLLER CHECKOUT

A. Verify power supply.

1. Verify voltage, phase and hertz.
2. Verify that protection from power surges is installed and functioning.
3. Verify that ground fault protection is installed.
4. If applicable, verify if connected to UPS unit.
5. If applicable, verify if connected to a backup power source.
6. If applicable, verify that power conditioning units, transient voltage suppression and high-frequency noise filter units are installed.

B. Verify that wire and cabling is properly secured to terminals and labeled with unique identification.

C. Verify that spare I/O capacity is provided.

3.23 DDC CONTROLLER I/O CONTROL LOOP TESTS

A. Testing:

1. Test every I/O point connected to DDC controller to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.
2. Test every I/O point throughout its full operating range.
3. Test every control loop to verify operation is stable and accurate.
4. Adjust control loop proportional, integral and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.
5. Test and adjust every control loop for proper operation according to sequence of operation.
6. Test software and hardware interlocks for proper operation. Correct deficiencies.
7. Operate each analog point at the following:

    a. Upper quarter of range.
    b. Lower quarter of range.
    c. At midpoint of range.

8. Exercise each binary point.
9. For every I/O point in DDC system, read and record each value at operator workstation, at DDC controller and at field instrument simultaneously. Value displayed at operator workstation, at DDC controller and at field instrument shall match.
10. Prepare and submit a report documenting results for each I/O point in DDC system and include in each I/O point a description of corrective measures and adjustments made to achieve desire results.

3.24 DDC SYSTEM VALIDATION TESTS

A. Perform validation tests before requesting final review of system. Before beginning testing, first submit Pretest Checklist and Test Plan.

B. After approval of Test Plan, execute all tests and procedures indicated in plan.

C. After testing is complete, submit completed test checklist.

D. Pretest Checklist: Submit the following list with items checked off once verified:

1. Detailed explanation for any items that are not completed or verified.
2. Required mechanical installation work is successfully completed and HVAC equipment is working correctly.
3. HVAC equipment motors operate below full-load amperage ratings.
4. Required DDC system components, wiring, and accessories are installed.
5. Installed DDC system architecture matches approved Drawings.
6. Control electric power circuits operate at proper voltage and are free from faults.
7. Required surge protection is installed.
8. DDC system network communications function properly, including uploading and downloading programming changes.
9. Using BACnet protocol analyzer, verify that communications are error free.
10. Each controller's programming is backed up.
11. Equipment, products, tubing, wiring cable and conduits are properly labeled.
12. All I/O points are programmed into controllers.
13. Testing, adjusting and balancing work affecting controls is complete.
14. Dampers and actuators zero and span adjustments are set properly.
15. Each control damper and actuator goes to failed position on loss of power.
16. Valves and actuators zero and span adjustments are set properly.
17. Each control valve and actuator goes to failed position on loss of power.
18. Meter, sensor and transmitter readings are accurate and calibrated.
19. Control loops are tuned for smooth and stable operation.
20. View trend data where applicable.
21. Each controller works properly in standalone mode.
22. Safety controls and devices function properly.
23. Interfaces with fire-alarm system function properly.
24. Electrical interlocks function properly.
25. Operator workstations and other interfaces are delivered, all system and database software is installed, and graphic are created.
26. Record Drawings are completed.

E. Test Plan:

1. Prepare and submit a validation test plan including test procedures for performance validation tests.
2. Test plan shall address all specified functions of DDC system and sequences of operation.
3. Explain detailed actions and expected results to demonstrate compliance with requirements indicated.
4. Explain method for simulating necessary conditions of operation used to demonstrate performance.

5. Include a test checklist to be used to check and initial that each test has been successfully completed.
6. Submit test plan documentation 10 or 20 business days as directed before start of tests.

F. Validation Test:

1. Verify operating performance of each I/O point in DDC system.

    a. Verify analog I/O points at operating value.
    b. Make adjustments to out-of-tolerance I/O points.

        1) Identify I/O points for future reference.
        2) Simulate abnormal conditions to demonstrate proper function of safety devices.
        3) Replace instruments and controllers that cannot maintain performance indicated after adjustments.

2. Simulate conditions to demonstrate proper sequence of control.
3. Readjust settings to design values and observe ability of DDC system to establish desired conditions.
4. After 24 Hours following Initial Validation Test:

    a. Re-check I/O points that required corrections during initial test.
    b. Identify I/O points that still require additional correction and make corrections necessary to achieve desired results.

5. After 24 Hours of Second Validation Test:

    a. Re-check I/O points that required corrections during second test.
    b. Continue validation testing until I/O point is normal on two consecutive tests.

6. Completely check out, calibrate, and test all connected hardware and software to ensure that DDC system performs according to requirements indicated.
7. After validation testing is complete, prepare and submit a report indicating all I/O points that required correction and how many validation re-tests it took to pass. Identify adjustments made for each test and indicate instruments that were replaced.

G. DDC System Response Time Test:

1. Simulate HLC.

    a. Heavy load shall be an occurrence of 50 percent of total connected binary COV, one-half of which represent an "alarm" condition, and 50 percent of total connected analog COV, one-half of which represent an "alarm" condition, that are initiated simultaneously on a one-time basis.

2. Initiate 10 successive occurrences of HLC and measure response time to typical alarms and status changes.
3. Measure with a timer having at least 0.1-second resolution and 0.01 percent accuracy.
4. Purpose of test is to demonstrate DDC system, as follows:

a. Reaction to COV and alarm conditions during HLC.
b. Ability to update DDC system database during HLC.

5. Passing test is contingent on the following:

a. Alarm reporting at printer beginning no more than two seconds after the initiation (time zero) of HLC.
b. All alarms, both binary and analog, are reported and printed; none are lost.
c. Compliance with response times specified.

6. Prepare and submit a report documenting HLC tested and results of test including time stamp and print out of all alarms.

H. DDC System Network Bandwidth Test:

1. Test network bandwidth usage on all DDC system networks to demonstrate bandwidth usage under DDC system normal operating conditions and under simulated HLC.
2. To pass, none of DDC system networks shall use more than 70 percent of available bandwidth under normal and HLC operation.

3.25 FINAL REVIEW

A. Submit written request to Architect and Construction Manager when DDC system is ready for final review. Written request shall state the following:

1. DDC system has been thoroughly inspected for compliance with contract documents and found to be in full compliance.
2. DDC system has been calibrated, adjusted and tested and found to comply with requirements of operational stability, accuracy, speed and other performance requirements indicated.
3. DDC system monitoring and control of HVAC systems results in operation according to sequences of operation indicated.
4. DDC system is complete and ready for final review.

B. Review by Architect and Construction Manager shall be made after receipt of written request. A field report shall be issued to document observations and deficiencies.

C. Take prompt action to remedy deficiencies indicated in field report and submit a second written request when all deficiencies have been corrected. Repeat process until no deficiencies are reported.

D. Should more than two reviews be required, DDC system manufacturer and Installer shall compensate entity performing review for total costs, labor and expenses, associated with third and subsequent reviews. Estimated cost of each review shall be submitted and approved by DDC system manufacturer and Installer before making the review.

E. Prepare and submit closeout submittals when no deficiencies are reported.

F. A part of DDC system final review shall include a demonstration to parties participating in final review.

1. Provide staff familiar with DDC system installed to demonstrate operation of DDC system during final review.
2. Provide testing equipment to demonstrate accuracy and other performance requirements of DDC system that is requested by reviewers during final review.
3. Demonstration shall include, but not be limited to, the following:

    a. Accuracy and calibration of 10 or 20 I/O points randomly selected by reviewers. If review finds that some I/O points are not properly calibrated and not satisfying performance requirements indicated, additional I/O points may be selected by reviewers until total I/O points being reviewed that satisfy requirements equals quantity indicated.
    b. HVAC equipment and system hardwired and software safeties and life-safety functions are operating according to sequence of operation. Up to 10 or 20 I/O points shall be randomly selected by reviewers. Additional I/O points may be selected by reviewers to discover problems with operation.
    c. Correct sequence of operation after electrical power interruption and resumption after electrical power is restored for randomly selected HVAC systems.
    d. Operation of randomly selected dampers and valves in normal-on, normal-off and failed positions.
    e. Reporting of alarm conditions for randomly selected alarms, including different classes of alarms, to ensure that alarms are properly received by operators and operator workstations.
    f. Trends, summaries, logs and reports set-up for Project.
    g. For up to three HVAC systems randomly selected by reviewers, use graph trends to show that sequence of operation is executed in correct manner and that HVAC systems operate properly through complete sequence of operation including different modes of operations indicated. Show that control loops are stable and operating at set points and respond to changes in set point of 20 percent or more.
    h. Software's ability to communicate with controllers, operator workstations, uploading and downloading of control programs.
    i. Software's ability to edit control programs off-line.
    j. Data entry to show Project-specific customizing capability including parameter changes.
    k. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.
    l. Execution of digital and analog commands in graphic mode.
    m. Spreadsheet and curve plot software and its integration with database.
    n. Online user guide and help functions.
    o. Multitasking by showing different operations occurring simultaneously on four quadrants of split screen.
    p. System speed of response compared to requirements indicated.
    q. For Each Network and Programmable Application Controller:

        1) Memory: Programmed data, parameters, trend and alarm history collected during normal operation is not lost during power failure.
        2) Operator Interface: Ability to connect directly to each type of digital controller with a portable operator workstation and mobile device. Show that maintenance personnel interface tools perform as indicated in manufacturer's technical literature.

3) Standalone Ability: Demonstrate that controllers provide stable and reliable standalone operation using default values or other method for values normally read over network.
4) Electric Power: Ability to disconnect any controller safely from its power source.
5) Wiring Labels: Match control drawings.
6) Network Communication: Ability to locate a controller's location on network and communication architecture matches Shop Drawings.
7) Nameplates and Tags: Accurate and permanently attached to control panel doors, instrument, actuators and devices.

r. For Each Operator Workstation:

1) I/O points lists agree with naming conventions.
2) Graphics are complete.
3) UPS unit, if applicable, operates.

s. Communications and Interoperability: Demonstrate proper interoperability of data sharing, alarm and event management, trending, scheduling, and device and network management. Use ASHRAE 135 protocol analyzer to help identify devices, view network traffic, and verify interoperability. Requirements must be met even if only one manufacturer's equipment is installed.

1) Data Presentation: On each operator workstation, demonstrate graphic display capabilities.
2) Reading of Any Property: Demonstrate ability to read and display any used readable object property of any device on network.
3) Set Point and Parameter Modifications: Show ability to modify set points and tuning parameters indicated. Modifications are made with messages and write services initiated by an operator using workstation graphics, or by completing a field in a menu with instructional text.
4) Peer-to-Peer Data Exchange: Network devices are installed and configured to perform without need for operator intervention to implement Project sequence of operation and to share global data.
5) Alarm and Event Management: Alarms and events are installed and prioritized according to Owner. Demonstrate that time delays and other logic are set up to avoid nuisance tripping. Show that operators with sufficient privileges are permitted.
6) Schedule Lists: Schedules are configured for start and stop, mode change, occupant overrides, and night setback as defined in sequence of operations.
7) Schedule Display and Modification: Ability to display any schedule with start and stop times for calendar year. Show that all calendar entries and schedules are modifiable from any connected operator workstation by an operator with sufficient privilege.
8) Archival Storage of Data: Data archiving is handled by operator workstation and server and local trend archiving and display is accomplished.
9) Modification of Trend Log Object Parameters: Operator with sufficient privilege can change logged data points, sampling rate, and trend duration.
10) Device and Network Management:

a) Display of network device status.

b) Display of BACnet Object Information.
c) Silencing devices transmitting erroneous data.
d) Time synchronization.
e) Remote device re-initialization.
f) Backup and restore network device programming and master database(s).
g) Configuration management of routers.

3.26 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.27 MAINTENANCE SERVICE

A. Maintenance Service: Beginning at Substantial Completion, maintenance service shall include months' full maintenance as directed by DDC system manufacturer's authorized service representative. Include preventive maintenance as directed, repair or replacement of worn or defective components, cleaning, calibration and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.28 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for one or two year(s) as directed.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within one or two year(s) from date of Substantial Completion as directed. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access system and to upgrade computer equipment if necessary.

3.29 DEMONSTRATION

A. Engage a factory-authorized service representative with complete knowledge of Project-specific system installed to train Owner's maintenance personnel to adjust, operate, and maintain DDC system.

B. Extent of Training:

1. Base extent of training on scope and complexity of DDC system indicated and training requirements indicated. Provide extent of training required to satisfy requirements indicated even if more than minimum training requirements are indicated.
2. Inform Owner of anticipated training requirements if more than minimum training requirements are indicated.

3. Minimum Training Requirements:

    a. Provide not less than number of training total days as directed.
    b. Stagger training over multiple training classes to accommodate Owner's requirements. All training shall occur before end of warranty period.
    c. Total days of training shall be broken as directed into not more than separate training classes.
    d. Each training class shall be not less than as directed consecutive day(s).

C. Training Schedule:

1. Schedule training with Owner 20 business days before expected Substantial Completion.
2. Schedule training to provide Owner with at as directed least business days of notice in advance of training.
3. Training shall occur within normal business hours at a mutually agreed on time. Unless otherwise agreed to, training shall occur Monday through Friday, except on U.S. Federal holidays, with two morning sessions and two afternoon sessions. Each morning session and afternoon session shall be split in half with 15 or 30-minute break between sessions as directed. Morning and afternoon sessions shall be separated by 30 or 60-minute lunch period as directed. Training, including breaks and excluding lunch period, shall not exceed eight hours per day.
4. Provide staggered training schedule as requested by Owner.

D. Training Attendee List and Sign-in Sheet:

1. Request from Owner in advance of training a proposed attendee list with name, phone number and e-mail address.
2. Provide a preprinted sign-in sheet for each training session with proposed attendees listed and no fewer than six blank spaces to add additional attendees.
3. Preprinted sign-in sheet shall include training session number, date and time, instructor name, phone number and e-mail address, and brief description of content to be covered during session. List attendees with columns for name, phone number, e-mail address and a column for attendee signature or initials.
4. Circulate sign-in sheet at beginning of each session and solicit attendees to sign or initial in applicable location.
5. At end of each training day, send Owner an e-mail with an attachment of scanned copy (PDF) of circulated sign-in sheet for each session.

E. Training Attendee Headcount:

1. Plan in advance of training for number of attendees as directed.
2. Make allowance for Owner to add up to one or two attendee(s) at time of training as directed.
3. Headcount may vary depending on training content covered in session. Attendee access may be restricted to some training content for purposes of maintaining system security.

F. Training Attendee Prior Knowledge: For guidance in planning required training and instruction, assume attendees have the following:

1. Education and degree as directed.
2. User knowledge of computers and office applications as directed.

3. Knowledge of HVAC systems as directed.
4. Knowledge of DDC systems as directed.
5. Knowledge of DDC system and products installed as directed.

G. Attendee Training Manuals:

1. Provide each attendee with a color hard copy of all training materials and visual presentations.
2. Hard-copy materials shall be organized in a three-ring binder with table of contents and individual divider tabs marked for each logical grouping of subject matter. Organize material to provide space for attendees to take handwritten notes within training manuals.
3. In addition to hard-copy materials included in training manual, provide each binder with a sleeve or pocket that includes a DVD or flash drive with PDF copy of all hard-copy materials.

H. Instructor Requirements:

1. One or multiple qualified instructors, as required, to provide training.
2. Instructors shall have not less than five years of providing instructional training on not less than five past projects with similar DDC system scope and complexity to DDC system installed.

I. Organization of Training Sessions:

1. Organize training sessions into logical groupings of technical content and to reflect different levels of operators having access to system. Plan training sessions to accommodate the following three levels of operators:

   a. Daily operators.
   b. Advanced operators.
   c. System managers and administrators.

2. Plan and organize training sessions to group training content to protect DDC system security. Some attendees may be restricted to some training sessions that cover restricted content for purposes of maintaining DDC system security.

J. Training Outline:

1. Submit training outline for Owner review at least 10 business day before scheduling training.
2. Outline shall include a detailed agenda for each training day that is broken down into each of four training sessions that day, training objectives for each training session and synopses for each lesson planned.

K. On-Site Training:

1. Owner will provide conditioned classroom or workspace with ample desks or tables, chairs, power and data connectivity for instructor and each attendee.
2. Instructor shall provide training materials, projector and other audiovisual equipment used in training.
3. Provide as much of training located on-site as deemed feasible and practical by Owner.

4. On-site training shall include regular walk-through tours, as required, to observe each unique product type installed with hands-on review of operation, calibration and service requirements.
5. Operator workstation provided with DDC system shall be used in training. If operator workstation is not indicated, provide a temporary workstation to convey training content.

L. Off-Site Training:

1. Provide conditioned training rooms and workspace with ample tables desks or tables, chairs, power and data connectivity for each attendee.
2. Provide capability to remotely access to Project DDC system for use in training.
3. Provide a workstation for use by each attendee.

M. Training Content for Daily Operators:

1. Basic operation of system.
2. Understanding DDC system architecture and configuration.
3. Understanding each unique product type installed including performance and service requirements for each.
4. Understanding operation of each system and equipment controlled by DDC system including sequences of operation, each unique control algorithm and each unique optimization routine.
5. Operating operator workstations, printers and other peripherals.
6. Logging on and off system.
7. Accessing graphics, reports and alarms.
8. Adjusting and changing set points and time schedules.
9. Recognizing DDC system malfunctions.
10. Understanding content of operation and maintenance manuals including control drawings.
11. Understanding physical location and placement of DDC controllers and I/O hardware.
12. Accessing data from DDC controllers.
13. Operating portable operator workstations.
14. Review of DDC testing results to establish basic understanding of DDC system operating performance and HVAC system limitations as of Substantial Completion.
15. Running each specified report and log.
16. Displaying and demonstrating each data entry to show Project-specific customizing capability. Demonstrating parameter changes.
17. Stepping through graphics penetration tree, displaying all graphics, demonstrating dynamic updating, and direct access to graphics.
18. Executing digital and analog commands in graphic mode.
19. Demonstrating control loop precision and stability via trend logs of I/O for not less than 10 percent of I/O installed.
20. Demonstrating DDC system performance through trend logs and command tracing.
21. Demonstrating scan, update, and alarm responsiveness.
22. Demonstrating spreadsheet and curve plot software, and its integration with database.
23. Demonstrating on-line user guide, and help function and mail facility.
24. Demonstrating multitasking by showing dynamic curve plot, and graphic construction operating simultaneously via split screen.
25. Demonstrating the following for HVAC systems and equipment controlled by DDC system:

a. Operation of HVAC equipment in normal-off, -on and failed conditions while observing individual equipment, dampers and valves for correct position under each condition.
b. For HVAC equipment with factory-installed software, show that integration into DDC system is able to communicate with DDC controllers or gateways, as applicable.
c. Using graphed trends, show that sequence of operation is executed in correct manner, and HVAC systems operate properly through complete sequence of operation including seasonal change, occupied and unoccupied modes, warm-up and cool-down cycles and other modes of operation indicated.
d. Hardware interlocks and safeties function properly and DDC system performs correct sequence of operation after electrical power interruption and resumption after power is restored.
e. Reporting of alarm conditions for each alarm, and confirm that alarms are received at assigned locations, including operator workstations.
f. Each control loop responds to set point adjustment and stabilizes within time period indicated.
g. Sharing of previously graphed trends of all control loops to demonstrate that each control loop is stable and set points are being maintained.

N. Training Content for Advanced Operators:

1. Making and changing workstation graphics.
2. Creating, deleting and modifying alarms including annunciation and routing.
3. Creating, deleting and modifying point trend logs including graphing and printing on an ad-hoc basis and operator-defined time intervals.
4. Creating, deleting and modifying reports.
5. Creating, deleting and modifying points.
6. Creating, deleting and modifying programming including ability to edit control programs off-line.
7. Creating, deleting and modifying system graphics and other types of displays.
8. Adding DDC controllers and other network communication devices such as gateways and routers.
9. Adding operator workstations.
10. Performing DDC system checkout and diagnostic procedures.
11. Performing DDC controllers operation and maintenance procedures.
12. Performing operator workstation operation and maintenance procedures.
13. Configuring DDC system hardware including controllers, workstations, communication devices and I/O points.
14. Maintaining, calibrating, troubleshooting, diagnosing and repairing hardware.
15. Adjusting, calibrating and replacing DDC system components.

O. Training Content for System Managers and Administrators:

1. DDC system software maintenance and backups.
2. Uploading, downloading and off-line archiving of all DDC system software and databases.
3. Interface with Project-specific, third-party operator software.
4. Understanding password and security procedures.
5. Adding new operators and making modifications to existing operators.
6. Operator password assignments and modification.

7. Operator authority assignment and modification.
8. Workstation data segregation and modification.

P. Video of Training Sessions:

1. Provide a digital video and audio recording of each training session. Create a separate recording file for each session.
2. Stamp each recording file with training session number, session name and date.
3. Provide Owner with two copies of digital files on DVDs or flash drives for later reference and for use in future training.
4. Owner retains right to make additional copies for intended training purposes without having to pay royalties.

END OF SECTION 230923

SECTION 230923.11 - CONTROL VALVES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes control valves and actuators for DDC systems.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.11.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include diagrams for power, signal, and control wiring.
2. Include diagrams for pneumatic signal and main air tubing.

C. Delegated-Design Submittal:

1. Schedule and design calculations for control valves and actuators, including the following:

a. Flow at project design and minimum flow conditions.
b. Pressure differential drop across valve at project design flow condition.
c. Maximum system pressure differential drop (pump close-off pressure) across valve at project minimum flow condition.
d. Design and minimum control valve coefficient with corresponding valve position.
e. Maximum close-off pressure.
f. Leakage flow at maximum system pressure differential.
g. Torque required at worst case condition for sizing actuator.
h. Actuator selection indicating torque provided.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.

C. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to size products where indicated as delegated design.

D. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.

E. Determine control valve sizes and flow coefficients by ISA 75.01.01.

F. Control valve characteristics and rangeability shall comply with ISA 75.11.01.

G. Selection Criteria:

1. Control valves shall be suitable for operation at following conditions:

    a. Chilled Water: As directed.
    b. Condenser Water: As directed.
    c. Heat Recovery: As directed.
    d. Heating Hot Water: As directed.
    e. Steam: As directed.

2. Fail positions unless otherwise indicated:

    a. Chilled Water: As directed.
    b. Condenser Water: As directed.
    c. Heat Recovery: As directed.
    d. Heating Hot Water: As directed.
    e. Steam: As directed.

3. Minimum Cv shall be calculated at 10 percent of design flow, with a coincident pressure differential equal to the system design pump head.
4. In water systems, select modulating control valves at terminal equipment for a design Cv based on a pressure drop of 5 psig (34 kPa) or 7 psig (48 kPa) at design flow unless otherwise indicated.
5. Modulating valve sizes for steam service shall provide a pressure drop at design flow equal to lesser of the following:

    a. 50 percent of the valve inlet pressure.
    b. 50 percent of the absolute steam pressure at the valve inlet.

2.2 BALL-STYLE CONTROL VALVES

A. Ball Valves with Single Port and Characterized Disk:
1. Pressure Rating for NPS 1 (DN 25) and Smaller: Nominal 600 WOG.
2. Pressure Rating for NPS 1-1/2 (DN 38) through NPS 2 (DN 50): Nominal 400 WOG.
3. Close-off Pressure: 200 psig (1379 kPa).
4. Process Temperature Range: Zero to 212 deg F (Minus 18 to plus 100 deg C).
5. Body and Tail Piece: Cast bronze ASTM B61, ASTM B62, ASTM B584, or forged brass with nickel plating.
6. End Connections: Threaded (NPT) ends.
7. Ball: Chrome-plated brass or bronze or 300 series stainless steel.
8. Stem and Stem Extension:

    a. Material to match ball.
    b. Blowout-proof design.
    c. Sleeve or other approved means to allow valve to be opened and closed without damaging the insulation or the vapor barrier seal.

9. Ball Seats: Reinforced PTFE.
10. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.
11. Flow Characteristic: Equal percentage.

B. Ball Valves with Two Ports and Characterized Disk:
1. Pressure Rating for NPS 1 (DN 25) and Smaller: Nominal 600 WOG.
2. Pressure Rating for NPS 1-1/2 (DN 38) through NPS 2 (DN 50): Nominal 400 WOG.
3. Close-off Pressure: 200 psig (1379 kPa).
4. Process Temperature Range: Zero to 212 deg F (Minus 18 to plus 100 deg C).
5. Body and Tail Piece: Cast bronze ASTM B61, ASTM B62, ASTM B584, or forged brass with nickel plating.
6. End Connections: Threaded (NPT) ends.
7. Ball: Chrome-plated brass or bronze or 300 series stainless steel.
8. Stem and Stem Extension:

    a. Material to match ball.
    b. Blowout-proof design.
    c. Sleeve or other approved means to allow valve to be opened and closed without damaging the insulation or the vapor barrier seal.

9. Ball Seats: Reinforced PTFE.
10. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.
11. Flow Characteristics for A-Port: Equal percentage.
12. Flow Characteristics for B-Port: Modified for constant common port flow.

C. Pressure-Independent Ball Valves NPS 2 (DN 50) and Smaller:
1. Performance:

a. Pressure Rating: 600 psig (4137 kPa) for NPS 1 (DN 25) and 400 psig (2528 kPa) for NPS 1-1/2 and NPS 2 (DN 38 and DN 50).
b. Close-off pressure of 200 psig (1379 kPa).
c. Process Temperature Range: Between zero to 212 deg F (minus 18 to plus 100 deg C).
d. Rangeability: 100 to 1.

2. Integral Pressure Regulator: Located upstream of ball to regulate pressure, to maintain a constant pressure differential while operating within a pressure differential range of 5 to 50 psig (34 to 345 kPa).
3. Body: Forged brass, nickel plated, and with threaded ends.
4. Ball: Chrome-plated brass.
5. Stem and Stem Extension: Chrome-plated brass, blowout-proof design.
6. Stem sleeve or other approved means to allow valve to be opened and closed without damaging field-applied insulation and insulation vapor barrier seal.
7. Ball Seats: Reinforced PTFE.
8. Stem Seal: Reinforced PTFE packing ring stem seal with threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if equivalent cycle endurance can be achieved.
9. Flow Characteristic: Equal percentage.

2.3 BUTTERFLY-STYLE CONTROL VALVES

A. Commercial-Grade, Two-Way Butterfly Valves:
1. Performance:

a. Bi-directional bubble tight shutoff at 250 psig (1724 kPa).
b. Comply with MSS SP-67 or MSS SP-68.
c. Rotation: Zero to 90 degrees.
d. Linear or modified equal percentage flow characteristic.

2. Body: Cast iron ASTM A126, Class B, ductile iron ASTM A536 or cast steel ASTM A216/A216M WCB fully lugged, suitable for mating to ASME B16.5 flanges.
3. Disc: 316 stainless steel.
4. Shaft: 316 or 17-4 PH stainless steel.
5. Seat: Reinforced EPDM or reinforced PTFE with retaining ring.
6. Shaft Bushings: Reinforced PTFE or stainless steel.
7. Replaceable seat, disc, and shaft bushings.
8. Corrosion-resistant nameplate indicating:

a. Manufacturer's name, model number, and serial number.
b. Body size.
c. Body and trim materials.
d. Flow arrow.

B. Commercial-Grade, Three-Way Butterfly Valves:
1. Arrangement: Two valves mated to a fabricated tee with interconnecting mechanical linkage.
2. Performance:

a. Bi-directional bubble tight shutoff at 250 psig (1724 kPa).
b. Comply with MSS SP-67 or MSS SP-68.
c. Rotation: Zero to 90 degrees.
d. Linear or modified equal percentage flow characteristic.

3. Body: Cast iron ASTM A126, Class B, ductile iron ASTM A536 or cast steel ASTM A216/A216M WCB fully lugged, suitable for mating to ASME B16.5 flanges.
4. Disc: 316 stainless steel.
5. Shaft: 316 or 17-4 PH stainless steel.
6. Seat: Reinforced EPDM or reinforced PTFE seat with retaining ring.
7. Shaft Bushings: Reinforced PTFE or stainless steel.
8. Replaceable seat, disc, and shaft bushings.
9. Corrosion-resistant nameplate indicating:

a. Manufacturer's name, model number, and serial number.
b. Body size.
c. Body and trim materials.
d. Flow arrow.

2.4 GLOBE-STYLE CONTROL VALVES

A. General Globe-Style Valve Requirements:

1. Globe-style control valve body dimensions shall comply with ISA 75.08.01.
2. Construct the valves to be serviceable from the top.
3. For cage guided valves, trim shall be field interchangeable for different valve flow characteristics, such as equal percentage, linear, and quick opening.
4. Reduced trim for one nominal size smaller shall be available for industrial valves NPS 1 (DN 25) and larger.
5. Replaceable seats and plugs.
6. Furnish each control valve with a corrosion-resistant nameplate indicating the following:

a. Manufacturer's name, model number, and serial number.
b. Body and trim size.
c. Arrow indicating direction of flow.

B. Two-Way Globe Valves NPS 2 (DN 50) and Smaller:
1. Globe Style: Single port.
2. Body: Cast bronze or forged brass with ASME B16.5, Class 250 rating.
3. End Connections: Threaded.
4. Bonnet: Screwed.
5. Packing: PTFE V-ring.
6. Plug: Top guided.
7. Plug, Seat, and Stem: Brass or stainless steel.
8. Process Temperature Range: 35 to 248 deg F (2 to 120 deg C).
9. Ambient Operating Temperature: 35 to 150 deg F (2 to 65 deg C).
10. Leakage: FCI 70-2, Class IV.
11. Rangeability: 25 to 1.
12. Equal percentage flow characteristic.

C. Three-Way Globe Valves NPS 2 (DN 50) and Smaller:
1. Globe Style: Mix flow pattern.
2. Body: Cast bronze or forged brass with ASME B16.5, Class 250 rating.
3. End Connections: Threaded.
4. Bonnet: Screwed.
5. Packing: PTFE V-ring.
6. Plug: Top guided.
7. Plug, Seat, and Stem: Brass or stainless steel.
8. Process Temperature Range: 35 to 248 deg F (2 to 120 deg C).
9. Ambient Operating Temperature: 35 to 150 deg F (2 to 65 deg C).
10. Leakage: FCI 70-2, Class IV.
11. Rangeability: 25 to 1.
12. Linear flow characteristic.

D. Two-Way Globe Valves NPS 2-1/2 to NPS 6 (DN 65 to DN 150):
1. Globe Style: Single port.
2. Body: Cast iron complying with ASME B61.1, Class 125.
3. End Connections: Flanged, suitable for mating to ASME B16.5, Class 150 flanges.
4. Bonnet: Bolted.
5. Packing: PTFE cone-ring.
6. Plug: Top or bottom guided.
7. Plug, Seat, and Stem: Brass or stainless steel.
8. Process Temperature Rating: 35 to 281 deg F (2 to 138 deg C).
9. Leakage: 0.1 percent of maximum flow.
10. Rangeability: Varies with valve size between 6 and 10 to 1.
11. Modified linear flow characteristic.

E. Industrial-Grade Straight-Through Globe Valves NPS 1 (DN 25) and Larger:
1. Globe Style: Single port.
2. Body: Cast iron or cast steel.
3. End Connections for NPS 2 (DN 50): Threaded.
4. End Connections for NPS 2-1/2 (DN 65) and Larger: Raised face flanged.
5. Bonnet: Bolted.
6. Packing: PTFE V-ring.
7. Plug: Cage guided and unbalanced.
8. Plug, Seat, and Stem: 416 stainless-steel plug and seat, 17-4 PH stainless-steel cage and 316 stainless-steel stem.
9. Valve Stem: Thread and pin stem to plug.
10. Valve Stem Finish: Polished to 5 microinches rms or less.
11. Plug and Seat Surfaces: Hardened facing.
12. Process Temperature Range: Zero to 450 deg F (Minus 18 to plus 232 deg C).
13. Ambient Operating Temperature: Minus 20 to plus 150 deg F (Minus 29 to plus 71 deg C).
14. Leakage: FCI 70-2, as directed.
15. Flow Characteristic: As directed.

2.5 SOLENOID VALVES

A. Description:

1. Action: Either normally open or normally closed in the event of electrical power failure as required by the application.
2. Size to close against the system pressure.
3. Manual override capable.
4. Heavy-duty assembly.
5. Body: Brass or stainless steel.
6. Seats and Discs: NBR or PTFE.
7. Solenoid Enclosure: NEMA 250, Type 4.

2.6 ELECTRIC AND ELECTRONIC CONTROL VALVE ACTUATORS

A. Actuators for Hydronic Control Valves: Capable of closing valve against system pump shutoff head.

B. Actuators for Steam Control Valves: Shutoff against 1.2 or 1.5 times steam design pressure as directed.

C. Position indicator and graduated scale on each actuator.

D. Type: Motor operated, with or without gears, electric and electronic.

E. Voltage: As directed.

F. Deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.

G. Function properly within a range of 85 to 120 percent of nameplate voltage.

H. Construction:

1. For Actuators Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
2. For Actuators from 100 to 400 W: Gears ground steel, oil immersed, shaft hardened steel running in bronze, copper alloy or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel or cast-aluminum housing.
3. For Actuators Larger Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.

I. Field Adjustment:

1. Spring Return Actuators: Easily switchable from fail open to fail closed in the field without replacement.
2. Gear Type Actuators: External manual adjustment mechanism to allow manual positioning when the actuator is not powered.

J. Two-Position Actuators: Single direction, spring return or reversing type.

K. Modulating Actuators:

1. Operation: Capable of stopping at all points across full range, and starting in either direction from any point in range.

2. Control Input Signal:

    a. Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position and other input drives actuator to close position. No signal of either input remains in last position.
    b. Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for zero- to 10- or 2- to 10-V dc and 4- to 20-mA signals.
    c. Pulse Width Modulation (PWM): Actuator drives to a specified position according to pulse duration (length) of signal from a dry contact closure, triac sink, or source controller.
    d. Programmable Multi-Function:

        1) Control Input, Position Feedback, and Running Time: Factory or field programmable.
        2) Diagnostic: Feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.
        3) Service Data: Include, at a minimum, number of hours powered and number of hours in motion.

L. Position Feedback:

1. Equip or Where indicated, equip two-position actuators with limits switches or other positive means of a position indication signal for remote monitoring of open and close position.
2. Equip or Where indicated, equip modulating actuators with a position feedback through current or voltage signal for remote monitoring.
3. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.

M. Fail-Safe:

1. Where indicated, provide actuator to fail to an end position.
2. Internal spring return mechanism to drive controlled device to an end position (open or close) on loss of power.
3. Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.

N. Integral Overload Protection:

1. Provide against overload throughout the entire operating range in both directions.
2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

O. Valve Attachment:

1. Unless otherwise required for valve interface, provide an actuator designed to be directly coupled to valve shaft without the need for connecting linkages.
2. Attach actuator to valve drive shaft in a way that ensures maximum transfer of power and torque without slippage.

3. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.

P. Temperature and Humidity:

1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F (minus 29 to plus 49 deg C).
2. Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from 5 to 95 percent relative humidity, non-condensing.

Q. Enclosure:

1. Suitable for ambient conditions encountered by application.
2. NEMA 250, Type 2 for indoor and protected applications.
3. NEMA 250, Type 4 or Type 4X for outdoor and unprotected applications.
4. Provide actuator enclosure with heater and control where required by application.

R. Stroke Time:

1. Operate valve from fully closed to fully open as directed.
2. Operate valve from fully open to fully closed as directed.
3. Move valve to failed position within seconds as directed.
4. Select operating speed to be compatible with equipment and system operation.

S. Sound:

1. Spring Return: 62 dBA.
2. Non-Spring Return: 45 dBA.

PART 3 - EXECUTION

3.1 CONTROL VALVE APPLICATIONS

A. Control Valves:

1. Select from valves specified in "Control Valves" Article to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.
2. System as directed, Two-Way Applications Controlled by Flow: As directed.
3. System as directed, Two-Way Applications Controlled by Pressure: As directed.
4. System as directed, Two-Way Applications Controlled by Temperature: As directed
5. System as directed, Three Way, Controlled by Temperature: As directed.

3.2 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy most stringent requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support instruments, tubing, piping, wiring, and conduits to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a force.

D. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

E. Firestop penetrations made in fire-rated assemblies and seal penetrations made in acoustically rated assemblies.

F. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

G. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

H. Corrosive Environments:

1. Use products that are suitable for environment to which they will be subjected.
2. If possible, avoid or limit use of materials in corrosive environments, including. but not limited to, the following:

    a. Laboratory exhaust airstreams.
    b. Process exhaust airstreams.

3. Use Type 316 stainless-steel tubing and fittings when in contact with a corrosive environment.
4. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
5. Where control devices are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.3 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.4 CONTROL VALVES

A. Install pipe reducers for valves smaller than line size. Position reducers as close to valve as possible but at distance to avoid interference and impact to performance. Install with manufacturer-recommended clearance.

B. Install flanges or unions to allow drop-in and -out valve installation.

C. Where indicated, install control valve with three-valve bypass manifold to allow for control valve isolation and removal without interrupting system flow by providing manual throttling valve in bypass pipe.

D. Install drain valves in piping upstream and downstream of each control valve installed in a three-valve manifold and for each control valve larger than NPS 2 (DN 50) or NPS 4 (DN 100) as directed.

E. Install pressure temperature taps in piping upstream and downstream of each control valve larger than NPS 1 (DN 25) or NPS 2 (DN 50) as directed.

F. Valve Orientation:

1. Where possible, install globe and ball valves installed in horizontal piping with stems upright and not more than 15 degrees off of vertical, not inverted.
2. Install valves in a position to allow full stem movement.
3. Where possible, install butterfly valves that are installed in horizontal piping with stems in horizontal position and with low point of disc opening with direction of flow.

G. Clearance:

1. Locate valves for easy access and provide separate support of valves that cannot be handled by service personnel without hoisting mechanism.
2. Install valves with at least 12 inches (300 mm) of clear space around valve and between valves and adjacent surfaces.

H. Threaded Valves:

1. Note internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.
2. Align threads at point of assembly.
3. Apply thread compound to external pipe threads, except where dry seal threading is specified.
4. Assemble joint, wrench tight. Apply wrench on valve end as pipe is being threaded.

I. Flanged Valves:

1. Align flange surfaces parallel.
2. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly with a torque wrench.

J. Connect electrical devices and components to electrical grounding system. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

K. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

L. Install engraved phenolic nameplate with valve identification on valve and on face of ceiling directly below valves concealed above ceilings.

3.5 CHECKOUT PROCEDURES

A. Control Valve Checkout:

1. Check installed products before continuity tests, leak tests, and calibration.
2. Check valves for proper location and accessibility.
3. Check valves for proper installation for direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
4. For pneumatic products, verify air supply for each product is properly installed.
5. For pneumatic valves, verify that pressure gauges are provided in each airline to valve actuator and positioner.
6. Verify that control valves are installed correctly for flow direction.
7. Verify that valve body attachment is properly secured and sealed.
8. Verify that valve actuator and linkage attachment are secure.
9. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
10. Verify that valve ball, disc, and plug travel are unobstructed.
11. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.

3.6 ADJUSTMENT, CALIBRATION, AND TESTING

A. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.

B. Stroke control valves with pilot positioners. Adjust valve and positioner following manufacturer's recommended procedure, so valve is 100 percent closed, 50 percent closed, and 100 percent open at proper air pressures.

C. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.

D. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

END OF SECTION 230923.11

SECTION 230923.12 - CONTROL DAMPERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes control dampers and actuators for DDC systems.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.12.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Include diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal:

1. Schedule and design calculations for control dampers and actuators, including the following.

a. Flow at project design and minimum flow conditions.
b. Face velocity at project design and minimum airflow conditions.
c. Pressure drop across damper at project design and minimum airflow conditions.
d. AMCA 500D damper installation arrangement used to calculate and schedule pressure drop, as applicable to installation.
e. Maximum close-off pressure.
f. Leakage airflow at maximum system pressure differential (fan close-off pressure).
g. Torque required at worst case condition for sizing actuator.
h. Actuator selection indicating torque provided.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.

C. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to size products where indicated as delegated design.

D. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.

E. Selection Criteria:

1. Control dampers shall be suitable for operation at following conditions:

    a. Supply Air: As directed.
    b. Return Air: As directed.
    c. Outdoor Air: As directed.
    d. Mixed Air: As directed.
    e. Exhaust Air: As directed.

2. Fail positions unless otherwise indicated:

    a. Supply Air: As directed.
    b. Return Air: As directed.
    c. Outdoor Air: As directed.
    d. Mixed Air: As directed.
    e. Exhaust Air: As directed.

3. Select modulating dampers for a pressure drop of 2 or 5 percent as directed of fan total static pressure unless otherwise indicated.

2.2 RECTANGULAR CONTROL DAMPERS

A. General Requirements:

1. Unless otherwise indicated, use parallel blade configuration for two-position control, equipment isolation service, and when mixing two airstreams. For other applications, use opposed blade configuration.
2. Factory assemble multiple damper sections to provide a single damper assembly of size required by the application.

B. Rectangular Dampers with Aluminum Airfoil Blades:

1. Performance:

a. Leakage: AMCA 511, Class 1A. Leakage shall not exceed 3 cfm/sq. ft. (15.2 L/s per sq. m) against 1-in. wg (250-Pa) differential static pressure.
b. Pressure Drop: 0.05-in. wg (12.5 Pa) at 1500 fpm (7.6 m/s) across a 24-by-24-inch (600-by-600-mm) damper when tested according to AMCA 500-D, figure 5.3.
c. Velocity: Up to 6000 fpm (30 m/s).
d. Temperature: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
f. Damper shall have AMCA seal for both air leakage and air performance.

2. Construction:

a. Frame:

1) Material: ASTM B211, Alloy 6063 T5 extruded-aluminum profiles, 0.07 inch (1.8 mm) thick.
2) Hat-shaped channel with integral flange(s). Mating face shall be a minimum of 1 inch (25 mm).
3) Width not less than 5 inches (125 mm).

b. Blades:

1) Hollow, airfoil, extruded aluminum.
2) Parallel or opposed blade configuration as required by application.
3) Material: ASTM B211, Alloy 6063 T5 aluminum, 0.07 inch (1.8 mm) thick.
4) Width not to exceed 6 inches (150 mm).
5) Length as required by close-off pressure, not to exceed 48 inches (1200 mm).

c. Seals:

1) Blades: Replaceable, mechanically attached extruded silicone, vinyl, or plastic composite.
2) Jambs: Stainless steel, compression type.

d. Axles: 0.5-inch- (13-mm-) diameter plated or stainless steel, mechanically attached to blades.
e. Bearings:

1) Molded synthetic or stainless-steel sleeve mounted in frame.
2) Where blade axles are installed in vertical position, provide thrust bearings.

f. Linkage:

1) Concealed in frame.
2) Constructed of aluminum and plated or stainless steel.
3) Hardware: Stainless steel.

g. Transition:

1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connection.
2) Factory mount damper in a sleeve with a close transition to mate to field connection.
3) Damper size and sleeve shall be connection size plus 2 inches (50 mm).
4) Sleeve length shall be not less than 12 inches (300 mm) for dampers without jackshafts and shall be not less than 16 inches (450 mm) for dampers with jackshafts.
5) Sleeve material shall match adjacent duct.

h. Additional Corrosion Protection for Corrosive Environments:

1) Provide anodized finish for aluminum surfaces in contact with airstream. Anodized finish shall be a minimum of 0.0007 inch (0.018 mm) thick.
2) Axles, damper linkage, and hardware shall be constructed of Type 316L stainless steel.

3. Airflow Measurement:
   a. Where indicated, provide damper assembly with integral airflow monitoring.
   b. Zero- to 10-V dc or 4- to 20-mA scaled output signal for remote monitoring of actual airflow.
   c. Accuracy shall be within 5 percent of the actual flow rate between the range of minimum and design airflow. For applications with a large variation in range between the minimum and design airflow, configure the damper sections and flow measurement assembly as required to comply with the stated accuracy over the entire modulating range.
   d. Provide a straightening device as part of the flow measurement assembly to achieve the specified accuracy with configuration indicated.
   e. Suitable for operation in untreated and unfiltered air.
   f. Provide temperature and altitude compensation and correction to maintain accuracy over temperature range encountered at site altitude.
   g. Provide automatic zeroing feature.

4. Airflow Control:
   a. Where indicated, provide damper assembly with integral airflow measurement and control.
   b. A factory-furnished and -calibrated controller shall be programmed, in nonvolatile EPROM, with application-specific airflow set point and range.
   c. The controller and actuator shall communicate to control the desired airflow.
   d. The controller shall receive a zero- to 10-V dc input signal and report a zero- to 20-mA output signal that is proportional to the airflow.
   e. Airflow measurement and control range shall be suitable for operation between 150 to 2000 fpm (0.8 to 10 m/s).
   f. Ambient Operating Temperature Range: Minus 40 to plus 140 deg F (Minus 40 to plus 60 deg C).
   g. Ambient Operating Humidity Range: 5 to 95 percent relative humidity, non-condensing.
   h. Provide unit with control transformer rated for not less than 85 VA. Provide transformer with primary and secondary protection and primary disconnecting means. Coordinate requirements with field power connection.

i. Provide screw terminals for interface to field wiring.
j. Factory mount electronics within a NEMA 250, Type 1 painted steel enclosure.

C. Rectangular Dampers with Steel Airfoil Blades:
1. Performance:

a. Leakage: AMCA 511, Class 1A. Leakage shall not exceed 3 cfm/sq. ft. (15.2 L/s per sq. m) against 1-in. wg (250-Pa) differential static pressure.
b. Pressure Drop: 0.06-in. wg (15 Pa) at 1500 fpm (7.6 m/s) across a 24-by-24-inch (600-by-600-mm) damper when tested according to AMCA 500-D, figure 5.3.
c. Velocity: Up to 6000 fpm (30 m/s).
d. Temperature: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
f. Damper shall have AMCA seal for both air leakage and air performance.

2. Construction:

a. Frame:

1) Material: ASTM A653/A653M galvanized-steel profiles, 0.06 inch (1.6 mm) thick.
2) Hat-shaped channel with integral flanges. Mating face shall be a minimum of 1 inch (25 mm).
3) Width not less than 5 inches (125 mm).

b. Blades:

1) Hollow, airfoil, galvanized steel.
2) Parallel or opposed blade configuration as required by application.
3) Material: ASTM A653/A653M galvanized steel, 0.05 inch (1.3 mm) thick.
4) Width not to exceed 6 inches (150 mm).
5) Length as required by close-off pressure, not to exceed 48 inches (1200 mm).

c. Seals:

1) Blades: Replaceable, mechanically attached extruded silicone, vinyl, or plastic composite.
2) Jambs: Stainless steel, compression type.

d. Axles: 0.5-inch- (13-mm-) diameter plated or stainless steel, mechanically attached to blades.
e. Bearings:

1) Stainless steel mounted in frame.
2) Where blade axles are installed in vertical position, provide thrust bearings.

f. Linkage:

1) Concealed in frame.
2) Constructed of aluminum and plated or stainless steel.
3) Hardware: Stainless steel.

g. Transition:

1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connection.
2) Factory mount damper in a sleeve with a close transition to mate to field connection.
3) Damper size and sleeve shall be connection size plus 2 inches (50 mm).
4) Sleeve length shall be not less than 12 inches (300 mm) for dampers without jackshafts and shall be not less than 16 inches (450 mm) for dampers with jackshafts.
5) Sleeve material shall match adjacent duct.

h. Additional Corrosion Protection for Corrosive Environments:

1) Provide epoxy finish for surfaces in contact with airstream.
2) Axles, damper linkage, and hardware shall be constructed of Type 316L stainless steel.

D. Rectangular Dampers with Aluminum Flat Blades:

1. Performance:

a. Leakage: Leakage shall not exceed 3.2 cfm/sq. ft. (16.2 L/s per sq. m) against 1-in. wg (250-Pa) differential static pressure.
b. Pressure Drop: 0.07-in. wg (17.5 Pa) at 1500 fpm (7.6 m/s) across a 24-by-24-inch (600-by-600-mm) damper when tested according to AMCA 500-D, figure 5.3.
c. Velocity: Up to 2000 fpm (10 m/s).
d. Temperature: Minus 50 to plus 250 deg F (Minus 46 to plus 121 deg C).
e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length, not to exceed 3-in. wg (750 Pa).
f. Damper shall have AMCA seal for both air leakage and air performance.

2. Construction:

a. Frame:

1) Material: ASTM B211, Alloy 6063 T5 extruded-aluminum profiles, 0.12 inch (3.2 mm) thick.
2) Hat-shaped channel with integral flanges.
3) Width not less than 5 inches (125 mm).

b. Blades:

1) Flat blades of extruded aluminum.
2) Parallel or opposed blade configuration as required by application.
3) Material: ASTM B211, Alloy 6063 T5 extruded-aluminum profiles, 0.12 inch (3.2 mm) thick.

4) Width not to exceed 6 inches (150 mm).
5) Length as required by close-off pressure, not to exceed 48 inches (1200 mm).

c. Seals:

1) Blades: Replaceable, mechanically attached extruded silicone, vinyl or plastic composite.
2) Jambs: Stainless steel, compression type.

d. Axles: 0.5-inch- (13-mm-) diameter plated or stainless steel, mechanically attached to blades.

e. Bearings:

1) Molded-synthetic sleeve, mounted in frame.
2) Where blade axles are installed in vertical position, provide thrust bearings.

f. Linkage:

1) Concealed in frame.
2) Constructed of plated or stainless steel.
3) Hardware: Stainless steel.

g. Transition:

1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connection.
2) Factory mount damper in a sleeve with a close transition to mate to field connection.
3) Damper size and sleeve shall be connection size plus 2 inches (50 mm).
4) Sleeve length shall be not less than 12 inches (300 mm) for dampers without jackshafts and shall be not less than 16 inches (450 mm) for dampers with jackshafts.
5) Sleeve material shall match adjacent duct.

h. Additional Corrosion Protection for Corrosive Environments:

1) Provide anodized finish for aluminum surfaces in contact with airstream. Anodized finish shall be a minimum of 0.0007 inch (0.018 mm) thick.
2) Axles, damper linkage, and hardware shall be constructed of Type 316L stainless steel.

E. Rectangular Dampers with Steel Flat Blades:

1. Performance:

a. Leakage: Leakage shall not exceed 4.8 cfm/sq. ft. (24.3 L/s per sq. m) against 1-in. wg (250-Pa) differential static pressure.
b. Pressure Drop: 0.1-in. wg (25 Pa) at 1500 fpm (7.6 m/s) across a 24-by-24-inch (600-by-600-mm) damper when tested according to AMCA 500-D, figure 5.3.
c. Velocity: Up to 1500 fpm (7.6 m/s).
d. Temperature: Minus 25 to plus 180 deg F (Minus 32 to plus 82 deg C).

e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length, not to exceed 4-in. wg (1000 Pa).
f. Damper shall have AMCA seal for both air leakage and air performance.

2. Construction:

a. Frame:

1) Material: Galvanized or stainless steel, 0.06 inch (1.6 mm) thick.
2) Hat-shaped channel with integral flanges.
3) Width not less than 5 inches (125 mm).

b. Blades:

1) Flat blades with multiple grooves positioned axially for reinforcement.
2) Parallel or opposed blade configuration as required by application.
3) Material: Galvanized or stainless steel, 0.06 inch (1.6 mm) thick.
4) Width not to exceed 6 inches (150 mm).
5) Length as required by close-off pressure, not to exceed 48 inches (1200 mm).

c. Seals:

1) Blades: Replaceable, mechanically attached, PVC-coated polyester.
2) Jambs: Stainless steel, compression type.

d. Axles: 0.5-inch- (13-mm-) diameter plated or stainless steel, mechanically attached to blades.
e. Bearings:

1) Molded-synthetic sleeve, mounted in frame.
2) Where blade axles are installed in vertical position, provide thrust bearings.

f. Linkage:

1) Concealed in frame.
2) Constructed of plated or stainless steel.
3) Hardware: Stainless steel.

2.3 GENERAL CONTROL-DAMPER ACTUATORS REQUIREMENTS

A. Actuators shall operate related damper(s) with sufficient reserve power to provide smooth modulating action or two-position action and proper speed of response at velocity and pressure conditions to which the damper is subjected.

B. Actuators shall produce sufficient power and torque to close off against the maximum system pressures encountered. Actuators shall be sized to close off against the fan shutoff pressure as a minimum requirement.

C. The total damper area operated by an actuator shall not exceed 80 percent of manufacturer's maximum area rating.

D. Provide one actuator for each damper assembly where possible. Multiple actuators required to drive a single damper assembly shall operate in unison.

E. Avoid the use of excessively oversized actuators which could overdrive and cause linkage failure when the damper blade has reached either its full open or closed position.

F. Use jackshafts and shaft couplings in lieu of blade-to-blade linkages when driving axially aligned damper sections.

G. Provide mounting hardware and linkages for connecting actuator to damper.

H. Select actuators to fail in desired position in the event of a power failure.

I. Actuator Fail Positions as directed:

1. Exhaust Air: As directed.
2. Outdoor Air: As directed.
3. Supply Air: As directed.
4. Return Air: As directed.

2.4 ELECTRIC AND ELECTRONIC ACTUATORS

A. Type: Motor operated, with or without gears, electric and electronic.

B. Voltage:
1. Actuator shall deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
2. Actuator shall function properly within a range of 85 to 120 percent of nameplate voltage.

C. Construction:

1. Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
2. 100 up to 400 W: Gears ground steel, oil immersed, shaft-hardened steel running in bronze, copper alloy, or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel, or cast-aluminum housing.
3. Greater Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.

D. Field Adjustment:

1. Spring return actuators shall be easily switchable from fail open to fail closed in the field without replacement.
2. Provide gear-type actuators with an external manual adjustment mechanism to allow manual positioning of the damper when the actuator is not powered.

E. Two-Position Actuators: Single direction, spring return or reversing type.

F. Modulating Actuators:

1. Capable of stopping at all points across full range and starting in either direction from any point in range.
2. Control Input Signal:

    a. Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position, and other input drives actuator to close position. No signal of either input remains in last position.
    b. Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for zero- to 10- or 2- to 10-V dc and 4- to 20-mA signals.
    c. Pulse Width Modulation (PWM): Actuator drives to a specified position according to a pulse duration (length) of signal from a dry-contact closure, triac sink or source controller.
    d. Programmable Multi-Function:

        1) Control input, position feedback, and running time shall be factory or field programmable.
        2) Diagnostic feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.
        3) Service data, including at a minimum, number of hours powered and number of hours in motion.

G. Position Feedback:

1. Equip or Where indicated, equip two-position actuators with limits switches or other positive means of a position indication signal for remote monitoring as directed.
2. Equip or Where indicated, equip modulating actuators with a position feedback through current or voltage signal for remote monitoring as directed.
3. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.

H. Fail-Safe:

1. Where indicated, provide actuator to fail to an end position.
2. Internal spring return mechanism to drive controlled device to an end position (open or close) on loss of power.
3. Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.

I. Integral Overload Protection:

1. Provide against overload throughout the entire operating range in both directions.
2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

J. Damper Attachment:

1. Unless otherwise required for damper interface, provide actuator designed to be directly coupled to damper shaft without need for connecting linkages.

2. Attach actuator to damper drive shaft in a way that ensures maximum transfer of power and torque without slippage.
3. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.

K. Temperature and Humidity:

1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F (minus 29 to plus 49 deg C).
2. Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from 5 to 95 percent relative humidity, non-condensing.

L. Enclosure:

1. Suitable for ambient conditions encountered by application.
2. NEMA 250, Type 2 for indoor and protected applications.
3. NEMA 250, Type 4 or Type 4X for outdoor and unprotected applications.
4. Provide actuator enclosure with a heater and controller where required by application.

M. Stroke Time:

1. Operate damper from fully closed to fully open within as directed number of seconds.
2. Operate damper from fully open to fully closed within as directed number of seconds.
3. Move damper to failed position within as directed number of seconds.
4. Select operating speed to be compatible with equipment and system operation.
5. Actuators operating in smoke control systems comply with governing code and NFPA requirements.

N. Sound:

1. Spring Return: 62 dBA.
2. Non-Spring Return: 45 dBA.

PART 3 - EXECUTION

3.1 CONTROL-DAMPER APPLICATIONS

A. Control Dampers:

B. Select from damper types indicated in "Control Dampers" Article to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.

1. Rectangular Exhaust Air Duct Applications with SMACNA Construction Class and Velocities as directed: As directed.
2. Round Exhaust Air Duct Applications with SMACNA Construction Class and Velocities as directed: As directed.

3. Rectangular Outdoor Air Duct Applications with SMACNA Construction Class and Velocities as directed: As directed.
4. Round Outdoor Air Duct Applications with SMACNA Construction Class and Velocities as directed: As directed.
5. Rectangular Return Air Duct Applications with SMACNA Construction Class and Velocities as directed: As directed.
6. Round Return Air Duct Applications with SMACNA Construction Class and Velocities as directed: Rectangular dampers with aluminum airfoil blades or Rectangular dampers with aluminum flat blades as directed.
7. Rectangular Supply Air Duct Applications with SMACNA Construction Class and Velocities as directed: As directed.
8. Round Supply Air Duct Applications with SMACNA Construction Class and Velocities as directed: Rectangular dampers with aluminum airfoil blades or Rectangular dampers with aluminum flat blades as directed.

3.2 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy most stringent requirements indicated.

B. Properly support dampers and actuators, tubing, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a force.

C. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

D. Seal penetrations made in fire-rated and acoustically rated assemblies.

E. Fastening Hardware:

1. Stillson wrenches, pliers, or other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

F. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

G. Corrosive Environments:

1. Use products that are suitable for environment to which they will be subjected.
2. If possible, avoid or limit use of materials in corrosive environments, including, but not limited to, the following:

    a. Laboratory exhaust airstreams.
    b. Process exhaust airstreams.

3. Use Type 316 stainless-steel tubing and fittings when in contact with a corrosive environment.
4. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
5. Where actuators are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.3 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.4 CONTROL DAMPERS

A. Install smooth transitions, not exceeding 15 or 30 degrees as directed, to dampers smaller than adjacent duct. Install transitions as close to damper as possible but at distance to avoid interference and impact to performance. Consult manufacturer for recommended clearance.

B. Clearance:

1. Locate dampers for easy access and provide separate support of dampers that cannot be handled by service personnel without hoisting mechanism.
2. Install dampers with at least 24 inches (600 mm) of clear space on sides of dampers requiring service access.

C. Service Access:

1. Dampers and actuators shall be accessible for visual inspection and service.
2. Install access door(s) in duct or equipment located upstream of damper to allow service personnel to hand clean any portion of damper, linkage, and actuator. Comply with requirements in Section 233300 "Air Duct Accessories."

D. Install dampers straight and true, level in all planes, and square in all dimensions. Install supplementary structural steel reinforcement for large multiple-section dampers if factory support alone cannot handle loading.

E. Attach actuator(s) to damper drive shaft.

F. For duct-mounted and equipment-mounted dampers installed outside of equipment, install a visible and accessible indication of damper position from outside.

G. Connect electrical devices and components to electrical grounding system. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

H. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

I. Install engraved phenolic nameplate with damper identification on damper and on face of ceiling where damper is concealed above ceiling.

3.5 CHECKOUT PROCEDURES

A. Control-Damper Checkout:

1. Check installed products before continuity tests, leak tests, and calibration.
2. Check dampers for proper location and accessibility.
3. Verify that control dampers are installed correctly for flow direction.
4. Verify that proper blade alignment, either parallel or opposed, has been provided.
5. Verify that damper frame attachment is properly secured and sealed.
6. Verify that damper actuator and linkage attachment are secure.
7. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
8. Verify that damper blade travel is unobstructed.

3.6 ADJUSTMENT, CALIBRATION, AND TESTING:

A. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.

B. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.

C. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

END OF SECTION 230923.12

SECTION 230923.13 - ENERGY METERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes thermal and electric power energy meters that connect to DDC systems.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.13.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each product requiring a certificate.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 THERMAL ENERGY METERS

A. Performance Requirements: Manufacturer shall certify that each energy meter indicated complies with specified performance requirements and characteristics.

1. Product certificates are required.

B. Insertion-Type Thermal Energy Meters:

1. Description:

   a. Factory-packaged meter consisting of supply and return temperature sensors, flow sensor, digital display, keypad user interface, installation hardware, color-coded interconnecting cabling, and installation instructions.
   b. Each thermal energy meter shall be individually calibrated and provided with calibration certification traceable to NIST.

2. Alphanumeric display of the following on face of enclosure:

   a. Total energy consumption.
   b. Energy rate.
   c. Flow rate.
   d. Supply temperature.
   e. Return temperature.
   f. Visual indication of power status (on/off) on face of enclosure.

3. Electronics Enclosure:

   a. Remote from temperature and flow sensors.
   b. NEMA 250, Type 12 or Type 13 for indoor applications and NEMA 250, Type 4 or Type 4X for outdoor applications.
   c. Labeled terminal strip for field wiring connections.

4. Programming:

   a. Factory programmed for specific application and field programmable through keypad on face of enclosure.
   b. Programmed parameters and total energy consumption shall be stored in non-volatile EEPROM memory.

5. Output Signals:

   a. Total Energy Consumption: Isolated solid-state dry contact with 100 mA, 50-V rating and contact duration of 0.5, 1, 2, or 6 seconds.
   b. Energy Rate, Flow Rate, Supply Temperature, Return Temperature: 4 to 20 mA or zero- to 10-V dc for each.
   c. In lieu of hardwired analog signals, a serial communication interface may be used.

6. Serial Communication Interface: Compatible with host to share total energy consumption, energy rate, flow rate, and supply and return temperature data.
7. Temperature Sensors:

   a. Temperature range matched to application.
   b. Differential temperature accuracy within 0.15 deg F (0.08 deg C) over the calibrated range.
   c. NEMA 250, Type 4 junction box with thermal isolation.
   d. Stainless-steel thermowell with NPS 1/2 (DN 15) NPT connection for each sensor.

8. Flow Sensor:

a. Suitable for an operating pressure of at least 200 psig (1378 kPa).
b. Meters in hot-water systems shall be suitable for maximum system temperatures encountered, but not less than 250 deg F (121 deg C).
c. Pressure drop not to exceed 1 psig (6.89 kPa) at 20-fps (6.1-m/s) flow velocity in NPS 2 (DN 50) pipe and decreasing in large pipe with lower velocity.
d. Sensor Accuracy:

1) Within 1 percent of actual flow between the flow velocity range of 3 to 30 fps (0.9 to 9 m/s).
2) Within 2 percent of actual flow between the flow velocity range of 0.4 to 20 fps (0.1 to 6.1 m/s).
3) Within 0.5 percent of actual reading at the calibrated velocity.

e. Wet calibrate and tag each sensor to standards traceable to NIST and provide each sensor with a certificate of calibration.
f. Provide single turbine sensors for pipe size NPS 2 (DN 50) and smaller. Provide dual turbine sensors for pipe size NPS 2-1/2 (DN 65) and larger. Provide bidirectional dual turbine sensors where installed in bypass piping.
g. For sensors with dual contra-rotating turbine elements, provide each turbine element with its own rotational sensing system and an averaging circuit to reduce measurement errors due to a poor flow profile.
h. Rotational sensing of each turbine shall be accomplished electronically by sensing impedance change. The sensor shall have an integral frequency output linear with flow rate and individual top and bottom turbine outputs for diagnostic purposes.
i. Provide the flow sensor complete with installation hardware necessary to enable insertion and removal from the pipe without system shutdown.
j. Construct turbine elements of polypropylene with sapphire jewel bearings and tungsten carbide shafts. Construct wetted metal components of Type 316 stainless steel, including the installation hardware.
k. House the sensor electronics in a NEMA 250, Type 4 weathertight aluminum enclosure with a gasketed cover. Housing shall include connection for field-installed conduit.
l. Sensor cable length shall be sufficient to connect to display module.
m. Sensor housing shall have full-port Type 316 stainless-steel ball valve for system isolation.

9. Power Supply:

a. Field Power: 120-V ac, 60 Hz unless otherwise required by the application.
b. Internal Power: As required by flow meter.

C. In-Line, Compact-Type Thermal Energy Meters:
1. Description:

a. Factory-packaged meter consisting of supply and return temperature sensors, flow sensor, digital display, operator interface, installation hardware, interconnecting cabling, and installation instructions.
b. Each thermal energy meter shall be individually calibrated and provided with calibration certifications traceable to NIST.
c. Meter limited to flow rates between 0.8 and 38 gpm (0.05 to 2.4 L/s).

d. Meter mode of operation shall be field configurable to accommodate two pipe systems that change from between heating and cooling.

2. Alphanumeric display of the following on face of enclosure:

a. Total energy consumption.
b. Energy rate.
c. Flow rate.
d. Supply temperature.
e. Return temperature.

3. Diagnostic Lights:

a. Meter equipped with diagnostic indicator lights that confirm the operation of the microprocessor and its input circuitry.
b. Red LED labeled "BTU" shall flash as energy is transferred.
c. Red LED labeled "FLOW" shall flash at a rate that is proportional to the liquid flow rate. An unlit LED indicates no flow signal.

4. Programming:

a. Meter shall be factory programmed for specific application.
b. Programmed parameters and total energy consumption shall be stored in non-volatile memory.

5. Output Signals:

a. Mode 1 and Mode 2 Total Energy Consumption: Isolated solid-state dry contact with 100 mA, 50-V rating and contact duration of 0.5, 1, 2, or 6 seconds.
b. Factory-set isolated analog output for energy rate, flow rate, or temperature difference: 4 to 20 mA, zero to 5 or 10 V.
c. In lieu of hardwired output signals, a serial communication interface may be used.

6. Serial Communication Interface: Compatible with host to share total energy consumption, energy rate, flow rate, and supply and return temperature data.
7. Temperature Sensors:

a. Temperature range matched to application.
b. Differential temperature accuracy within 0.15 deg F (0.08 deg C) over the calibrated range.
c. One temperature sensor shall be built into the body of the flow sensor.
d. Second sensor shall be provided with brass thermowell with NPS 1/2 (DN 15) sweat fitting or NPS 1/4 (DN 6) NPT connection.

8. Flow Sensor:

a. Ambient Temperature: 40 to 120 deg F (4 to 49 deg C).
b. Process Temperature: 32 to 200 deg F (0 to 93 deg C).
c. Maximum Process Pressure: 400 psig (2758 kPa).
d. Pressure Drop: 3 psig (20 kPa) at 38 gpm (2.4 L/s).

e. Accuracy:

1) Within 1 percent of actual flow over flow rate range of 5.7 to 38 gpm (0.4 to 2.4 L/s).
2) Within 2 percent of actual flow over flow rate range of 0.8 to 38 gpm (0.05 to 2.4 L/s).
3) Within 0.5 percent of actual reading at the calibrated velocity.

f. Construct flow sensor body of brass.
g. Furnish with two tail pieces to facilitate connection to the piping system. One end of each tail piece shall be a compression fitting with retaining nut, and the other end shall either be a sweat fitting for copper or a threaded nipple with NPT threads.
h. Process Connections: NPS 3/4 or NPS 1 (DN 20 or DN 25).
i. House electronics in a NEMA 250, Type 4 weathertight aluminum enclosure with a gasketed cover. Housing shall include connection for field-installed conduit.
j. Sensor cable length shall be sufficient to connect to display module.

9. Power Supply:

a. Field Power: 24-V ac, 50 or 60 Hz unless otherwise required by the application.

2.2 ELECTRIC POWER METERS

A. Performance Requirements: Manufacturer shall certify that each energy meter indicated complies with specified performance requirements and characteristics.

1. Product certificates are required.

B. Multifunction Electric Power Meter:
1. Hardware:

a. Voltage Inputs: Three voltage inputs capable of measuring from zero- to 400-V rms (line to neutral) or from zero- to 690-V rms (line to line). The instrument shall have provisions for direct connection for wye (Star) systems up to 347/600-V ac. For higher-voltage systems, PTs with 120-, 277-, or 347-V ac secondaries shall be supported. Voltage inputs shall provide the following:

1) 1500-V ac continuous surge protection.
2) 25 percent of full-scale voltage over range capability.

b. Current Inputs: Three 5-A nominal (6-A full-scale) current inputs. Current inputs shall be transformer coupled and accept CTs with 5-A nominal (6-A full-scale) outputs. Current inputs shall provide the following:

1) 120-A surge protection for one second.
2) 20 percent of nominal current continuous over range capability.

c. Power Supply: 100- to 240-V ac (within 10 percent) at 50 to 60 Hz, 110- to 300-V dc, or 20- to 60-V dc power source. Load shall not exceed 15 W.
d. Onboard I/O:

1) Two Form A solid-state digital (status) outputs with the following features:

a) The ability to be used to provide pulse outputs according to any energy consumption levels.
b) Rated 200-V ac/dc with a maximum current of 100 mA.

e. Communications:

1) Provide the following built-in communication ports of standard technology, as defined by the IEEE:

a) One optically isolated RS-485 communication port, supporting data rates from 1200 to 19200 bits per second.

2) Communication ports shall support the following communication capabilities, independently configurable:

a) PML protocol.
b) Modbus RTU protocol.
c) Shall provide simultaneous access through all communication ports to any measured or derived parameter.
d) Protocols shall be field configurable from the front display, or via communication ports, and be capable of being accomplished without resetting the meter or interrupting its operation in any way.
e) Support time synchronization broadcast messages from a host computer system.

f. Mounting and Display:

1) The instrument shall support the following mounting options:

a) 3.6-by-3.6-inch (92-by-92-mm) panel cutout, using sliding clamps tightened by thumbscrews.
b) ANSI 4-inch (100-mm) round cut-out.
c) Transducer-type base unit with a remote LED display with cable for remote display applications.
d) Transducer-type base unit only with no display locally mounted.
e) Allow the operator to remove and replace the display panel without removing the instrument from the equipment in which it is mounted.

g. Enclosure: If installation requires meter to be installed in a dedicated enclosure, install meter in an NRTL-listed enclosure suitable for operating environment at meter location.

1) Indoors: NEMA 250, Type 1 or Type 12.
2) Outdoors: NEMA 250, Type 4 or Type 4X.

h. Memory: Sufficient non-volatile (RAM) to store setup data and accumulated energy values.

2. The instrument shall measure and calculate the following information:

    a. Voltage line-to-neutral and line-to-line for each phase and average of three phases.
    b. Current for each phase and average of three phases.
    c. Peak current demand.
    d. Neutral current.
    e. Power (kW).
    f. Peak power demand (kW).
    g. Energy (kWh) import/export.
    h. Power factor total.
    i. Frequency.

3. Operator interface features are as follows:

    a. Capable of calculating the following information for any reading at one-second intervals:

        1) Sliding window demands for any parameter with operator-programmable length of demand period and number of subperiods to match local utility billing method.

    b. Support direct display of all parameters on the front panel or remote display in user-programmable groups, using plain language labels. Simultaneous access to all parameters shall be available through any communication port.
    c. Field programmable as follows:

        1) Basic Parameters: Voltage input scale, voltage mode (wye, delta, single phase), current input scale, auxiliary input and output scales, and communication setup parameters are programmable from the front panel.
        2) Using ION modules, support customized configurations of all operating parameters.
        3) Provisions to ensure that programming through a computer can be secured by user ID and password.
        4) Provisions to ensure that programming through the front panel is secured by password.
        5) Digital outputs shall support pulse output relay operation for kWh total, kWh imported, kWh exported, kVARh total, kVARh imported, kVARh exported, and kVAh values.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a force as directed.

C. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

3.2 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.3 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

B. Coordinate video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

C. Record videos on DVD disks.

D. Owner shall have right to make additional copies of video for internal use without paying royalties.

END OF SECTION 230923.13

SECTION 230923.14 - FLOW INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Airflow measurement stations and sensors.
2. Airflow switches.
3. Airflow transmitters.
4. Liquid flow meters.
5. Liquid flow sensors.
6. Liquid flow switches.
7. Liquid flow transmitters.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.14.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include diagrams for power, signal, and control wiring.
3. Include diagrams for air and process signal tubing.
4. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

D. Delegated-Design Submittal:

1. Schedule and design calculations for flow instruments, including the following.

a. Flow at Project design and minimum flow conditions.
b. Pressure drop at Project design and minimum flow conditions.

1.3 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each product requiring a certificate.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Select and size products to achieve specified performance requirements.

B. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 GENERAL REQUIREMENTS FOR FLOW INSTRUMENTS

A. Air sensors and transmitters shall have an extended range of 10 or 20 percent above Project design flow as directed and 10 or 20 percent below minimum Project flow as directed to signal abnormal flow conditions and to provide flexibility for changes in operation.

B. Liquid and steam sensors, meters, and transmitters shall have an extended range of 10 or 20 percent above Project design flow as directed and 10 or 20 percent below Project minimum flow as directed to signal abnormal flow conditions and to provide flexibility for changes in operation.

C. Source Limitations: For flow instruments, obtain products from single source from single manufacturer.

2.3 AIRFLOW MEASUREMENT STATIONS AND SENSORS

A. Performance Requirements:

1. Adjustable for changes in system operational parameters.
2. Airflow Sensor and Transmitter Range: Extended range of 10 or 20 percent above Project design flow as directed and 10 or 20 percent below minimum Project flow as directed to signal abnormal flow conditions.
3. Manufacturer shall certify that each flow instrument indicated complies with specified performance requirements and characteristics.

    a. Product certificates are required.

B. Thermal Airflow Measurement Stations:

1. Common Performance Requirements:

a. Provide stations that are adjustable for changes in system operational parameters.
b. Manufacturer shall certify that each flow instrument indicated complies with specified performance requirements and characteristics.
c. Thermal airflow stations with one or more sensor nodes mounted in a probe, and a remotely mounted microprocessor-based transmitter at each measurement location.
d. Sensor Nodes: One self-heated and one zero-power bead-in-glass thermistor, using the principle of thermal dispersion.
e. Airflow Rate and Temperature of Each Sensor: Equally weighted and averaged by the transmitter prior to output.
f. Sensor-Node and Probe Assemblies:

    1) Sensor-Node Construction: Two bead-in-glass, hermetically sealed thermistors potted in a marine-grade waterproof epoxy with sensor housings constructed of glass-filled polypropylene. Construct with only the thermistor located within the sensing node and all other electronic components outside the airstream. Epoxy- or glass-encapsulated chip thermistors or devices with exposed leads are not allowed. Devices that use epoxy- or glass-encapsulated chip thermistors, or electronics in the airstream, are unacceptable. Devices with exposed leads are unacceptable.
    2) Store sensor-node airflow and temperature calibration data in a serial memory chip, in the cable connecting plug. Stored data does not require matching or adjustments to the transmitter in the field.
    3) Sensing-Node Temperature Accuracy: Within 0.15 deg F (0.08 deg C) over an operating range of minus 20 to plus 160 deg F (minus 28.9 to plus 71.1 deg C) and humidity range of 0 to 100 percent RH.
    4) Sensor-Probe Mounting Bracket Construction: Type 304 stainless steel.
    5) Internal Probe Wiring: Kynar-coated copper between the connecting cable and sensor nodes. PVC-jacketed wiring is unacceptable.
    6) Internal Probe Wiring Connections: Solder joints and spot welds, sealed and protected from the elements, so that direct exposure to water will not affect instrument operation. Connectors within the probe, of any type, are unacceptable. Printed circuit boards within the probe are unacceptable.
    7) Sensor-Probe Jacket: Integral, FEP jacket, plenum-rated CMP/CL2P, UL/cUL-listed cable, rated for exposures from minus 67 to plus 392 deg F (minus 55 to plus 200 deg C), and for continuous and direct UV exposure. Plenum-rated PVC jacket cables are unacceptable.
    8) Sensor-Probe Cable Connector Plug: Gold-plated pins for connection to the transmitter.

g. Transmitter Features and Functions:

    1) High and/or low airflow alarm with user-defined set point and percent of set-point tolerance.
    2) Manual or automatic alarm reset, and low-limit cutoff value may be selected to disable the alarm.
    3) Alarm delay function, field defined.
    4) Sensor-node malfunction via the system status alarm and ignore the sensor node that is in a fault condition.

5) Field configuration, diagnostics, and field output adjustment wizard that allow for a one- or two-point field adjustment to factory calibration for installations that require adjustment.
6) Automatic reset after power disruption, transients, and brown-outs through a watchdog timer circuit.
7) Operating temperature range of minus 20 to plus 120 deg F (minus 28.9 to plus 48.9 deg C) and humidity range of 5 to 95 percent RH.
8) Electrical Power Requirement: 24 V ac (between 22.8 and 26.4 V ac under load) at 20 VA maximum, using a switching power supply that is overcurrent and overvoltage protected.
9) Printed Circuit Board Interconnects: Gold-plated edge fingers, receptacle plug pins, and printed circuit board test points.
10) Printed Circuit Boards: Electroless nickel immersion gold (ENIG) plated.
11) Integrated Circuitry: Temperature-rated, industrial-grade. Commercial-grade integrated circuitry is not acceptable.
12) Integration Buffers: Separate integration buffers for display of airflow output, airflow signal output (analog and network), and individual sensor output (IR-interface).

2. For Air-Ducted/Plenum:
   a. Airflow Station Performance:

      1) Independent processing of up to 16 separately wired sensor-node assemblies.
      2) Accuracy: Within 3 percent of reading for ducted applications, and within 5 percent of reading for non-ducted applications, when installed in accordance with manufacturer's recommended placement guidelines. Include the combined uncertainty of the sensor nodes and transmitter. For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with the accuracy requirement over the entire operating range.

   b. Sensor-Node and Probe Assemblies:

      1) Performance rated and tested with a 100 percent survival rate in a 30-day saltwater and acid vapor test with written independent laboratory results.
      2) Sensor-Node Calibration: Individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard.

         a) Accuracy: Within 2 percent of reading over the entire calibrated airflow range of 0 to 5000 fpm (0 to 25.4 m/s).
         b) Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.

      3) Provide the number of independent sensor nodes as follows:

         a) For Duct/Plenum Area up to 0.5 sq. ft. (0.046 sq. m): One.
         b) For Duct/Plenum Area Greater Than 0.5 through 1.0 sq. ft. (0.046 through 0.092 sq. m): Two.

c) For Duct/Plenum Area Greater Than 2.0 through 4.0 sq. ft. (0.186 through 0.372 sq. m): Six.
d) For Duct/Plenum Area Greater Than 4.0 through 8.0 sq. ft. (0.372 through 0.743 sq. m): Eight.
e) For Duct/Plenum Area Greater Than 8.0 through 12.0 sq. ft. (0.743 through 1.11 sq. m): 12.
f) For Duct/Plenum Area Greater Than 12.0 through 14.0 sq. ft. (1.11 through 1.30 sq. m): 14.
g) For Duct/Plenum Area Greater Than 14.0 sq. ft. (1.30 sq. m): 16.

4) For an aspect ratio of 1.5 or less, and an area of 25 sq. ft. (2.32 sq. m) or greater, four probes are required.
5) Sensor-Probe Construction: Gold-anodized, 6063 aluminum alloy tube or Type 316 stainless steel tube as directed, with each sensor probe containing one or more independently wired sensing nodes.

c. Transmitter:

1) Transmitter determines the average airflow rate and temperature of connected sensor nodes in an array for a single location.
2) User Interface: 16-character, alpha-numeric, LCD display, with two field-selectable analog output signals and network output capability. Provide one of the following transmitter configurations:

a) Model GTC116 Transmitter: Two field-selectable 0- to 5-V dc, 0- to 10-V dc, or 4- to 20-mA, scalable, isolated, overcurrent protected analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The RS-485 (BACnet MS/TP, or Modbus RTU) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter shall be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software shall allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.
b) Model GTM116 Transmitter: Two field-selectable 0- to 5-V dc, 0- to 10-V dc, or 4- to 20-mA, scalable, isolated, and overcurrent protected analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The Ethernet (BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter shall be

provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software shall allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.

c) Model GTL116 Transmitter with LonWorks Free Topology Network Interface: Connection capable of providing average airflow and temperature rates across the network.

d) Model GTD116 Transmitter with Data-Logger Interface: Capable of logging airflow and temperature rates over specified time intervals.

3. For Air-Ducted/Plenum - Duct Size 2 sq. ft. (0.18 sq. m)or Less:

a. Airflow Station Performance:

1) Independent processing of up to four separately wired sensor-node assemblies.

2) Accuracy: Within 3 percent of reading for ducted applications, and within 5 percent of reading for non-ducted applications, when installed in accordance with manufacturer's recommended placement guidelines. Include the combined uncertainty of the sensor nodes and transmitter. For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with the accuracy requirement over the entire operating range.

b. Sensor-Node and Probe Assemblies:

1) Performance rated and tested with a 100 percent survival rate in a 30-day saltwater and acid vapor test with written independent laboratory test results.

2) Sensor-Node Calibration: Individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard.

a) Accuracy: Within 2 percent of reading over the entire calibrated airflow range of 0 to 5000 fpm (0 to 25.4 m/s).

b) Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.

3) Provide the number of independent sensor nodes as follows:

a) For Duct/Plenum Area up to 0.5 sq. ft. (0.046 sq. m): One.

b) For Duct/Plenum Area Greater Than 0.5 through 1.0 sq. ft. (0.046 through 0.092 sq. m): Two.

c) For Duct/Plenum Area Greater Than 1.0 sq. ft. (0.092 sq. m): Four.

4) For probes less than 8 inches (203 mm), one sensor node/probe is required.)

5) Sensor-Probe Construction: Gold-anodized, 6063 aluminum alloy tube or Type 316 stainless steel tube, with each sensor probe containing one or more independently wired sensing nodes.

c. Transmitter:

1) Transmitter determines the average airflow rate and temperature of connected sensor nodes in an array for a single location.
2) User Interface: 16-character, alpha-numeric, LCD display, with two field-selectable analog output signals or one isolated RS-485 (BACnet MS/TP, or Modbus RTU) field-selectable network connection.
3) Model HTA104 Transmitter, Analog Capability: Two field-selectable 0- to 5-V dc, 0- to 10-V dc, or 4- to 20-mA, scalable, isolated, and overcurrent protected analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm.
4) Model HTAN104 Transmitter, Network Communications: The RS-485 (BACnet MS/TP or Modbus RTU) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures.

4. For Supply or Return Fan Array:
a. Airflow Station Performance:

1) Independent processing of up to eight separately wired sensor-node assemblies.
2) Accuracy: Within 10 percent of reading under operating conditions, when installed in accordance with manufacturer's sensor density and placement guidelines, with no effect on fan performance. Include the combined uncertainty of the sensor nodes and transmitter. For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with the accuracy requirement over the entire operating range.

b. Sensor-Node and Probe Assemblies:

1) Performance rated and tested with a 100 percent survival rate in a 30-day saltwater and acid vapor test with written independent laboratory test results.
2) Sensor-Node Calibration: Individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard.

a) Accuracy: Within 2 percent of reading over the entire calibrated airflow range of 0 to 10,000 fpm (0 to 50.8 m/s).
b) Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.

3) Sensor-Probe Construction: One sensor node mounted on a Type 304 stainless steel block with two adjustable zinc-plated steel rods connected to Type 304 stainless steel pivoting mounting feet.

4) Number of Independent Sensor Nodes, Fan Arrays (One to Eight Fans): One probe with one sensor node per probe in each fan inlet.

c. Transmitter:

1) Transmitter determines the average airflow rate and temperature of each fan. Startup firmware facilitates the setup of multiple fans and fan areas.
2) User Interface: 16-character, alpha-numeric, LCD display, with two field-selectable analog output signals and network output capability. Provide one of the following transmitter configurations:

a) Model GTC108 Transmitter: Two field-selectable 0- to 5-V dc, 0- to 10-V dc, or 4- to 20-mA, scalable, isolated, overcurrent protected analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The RS-485 (BACnet MS/TP, or Modbus RTU) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter shall be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software shall allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.
b) Model GTM108 Transmitter: Two field-selectable 0- to 5-V dc, 0- to 10-V dc, or 4- to 20-mA, scalable, isolated, and overcurrent protected analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The Ethernet (BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter shall be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software shall allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.
c) Model GTL108 Transmitter with LonWorks Free Topology Network Interface: Connection capable of providing average airflow and temperature rates across the network.

d) Model GTD108 Transmitter with Data-Logger Interface: Capable of logging airflow and temperature rates over specified time intervals.

5. For Supply or Return Fan, Single-Width Single-Inlet (SWSI) or Double-Width Double-Inlet (DWDI) Fans - Both Analog and Network Outputs:
   a. Airflow Station Performance:
      1) Independent processing of up to eight separately wired sensor-node assemblies.
      2) Accuracy: Within 10 percent of reading under operating conditions, when installed in accordance with manufacturer's sensor density and placement guidelines, with no effect on fan performance. Include the combined uncertainty of the sensor nodes and transmitter. For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with the accuracy requirement over the entire operating range.

   b. Sensor-Node and Probe Assemblies:
      1) Performance rated and tested with a 100 percent survival rate in a 30-day saltwater and acid vapor test with written independent laboratory test results.
      2) Sensor-Node Calibration: Individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard.
         a) Accuracy: Within 2 percent of reading over the entire calibrated airflow range of 0 to 10,000 fpm (0 to 50.8 m/s).
         b) Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.
      3) Sensor-Probe Construction: One sensor node mounted on a Type 304 stainless steel block with two adjustable zinc-plated steel rods connected to Type 304 stainless steel pivoting mounting feet.
      4) Number of Independent Sensor Nodes, SWSI Fans, and DWDI Fans: Two probes with one sensor node per probe in each fan inlet.

   c. Transmitter:
      1) Transmitter determines the average airflow rate and temperature of each fan. Startup firmware facilitates the setup of multiple fans and fan areas.
      2) User Interface: 16-character, alpha-numeric, LCD display, with two field-selectable analog output signals and network output capability. Provide one of the following transmitter configurations:
         a) Model GTC108 Transmitter: Two field-selectable 0- to 5-V dc, 0- to 10-V dc, or 4- to 20-mA, scalable, isolated, overcurrent protected analog output signals and network output capability. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The RS-485 (BACnet MS/TP,

or Modbus RTU) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter shall be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software shall allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.

b) Model GTM108 Transmitter: Two field-selectable 0- to 5-V dc, 0- to 10-V dc, or 4- to 20-mA, scalable, isolated, and overcurrent protected analog output signals and network output capability. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The Ethernet (BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter shall be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software shall allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.

c) Model GTL108 Transmitter Network Interface: Connection capable of providing average airflow and temperature rates across the network.

d) Model GTD108 Transmitter with Data-Logger Interface: Capable of logging airflow and temperature rates over specified time intervals.

6. For Supply or Return Fan, Single-Width Single-Inlet (SWSI) or Double-Width Double-Inlet (DWDI) Fans - Either Analog or Network Outputs:

a. Airflow Station Performance:

1) Independent processing of up to four separately wired sensor-node assemblies.

2) Accuracy: Within 10 percent of reading under operating conditions, when installed in accordance with manufacturer's sensor density and placement guidelines, with no effect on fan performance. Include the combined uncertainty of the sensor nodes and transmitter. For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with the accuracy requirement over the entire operating range.

b. Sensor-Node and Probe Assemblies:

1) Performance rated and tested with a 100 percent survival rate in a 30-day saltwater and acid vapor test with written independent laboratory test results.
2) Sensor-Node Calibration: Individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard.

    a) Accuracy: Within 2 percent of reading over the entire calibrated airflow range of 0 to 10,000 fpm(0 to 50.8 m/s).
    b) Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.

c. Sensor-Probe Construction: One sensor node mounted on a Type 304 stainless steel block with two adjustable zinc-plated steel rods connected to Type 304 stainless steel pivoting mounting feet.
d. Number of Independent Sensor Nodes, SWSI Fans, and DWDI Fans: Two probes with one sensor node per probe in each fan inlet.
e. Transmitter:

    1) Transmitter determines the average airflow rate and temperature of connected sensor nodes in an array for a single location.
    2) User Interface: 16-character, alpha-numeric, LCD display, with two field-selectable analog output signals or one isolated RS-485 (BACnet MS/TP or Modbus RTU) field-selectable network connection.
    3) Model HTA104 Transmitter, Analog Capability: Two field-selectable 0- to 5-V dc, 0- to 10-V dc, or 4- to 20-mA, scalable, isolated, and overcurrent protected analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm.
    4) Model HTN104 Transmitter, Network Communications: The RS-485 (BACnet MS/TP or Modbus RTU) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures.

7. For Air Terminal Units:

8. Airflow Station Performance:

    a. Independent processing of up to two separately wired sensor-node assemblies.
    b. Accuracy: Within 3 percent of reading when installed in accordance with manufacturer's recommended placement guidelines. Include the combined uncertainty of the sensor nodes and transmitter. For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with the accuracy requirement over the entire operating range.

9. Sensor-Node and Probe Assemblies:

    a. Sensor-Node Calibration:

1) Individually calibrated at a minimum of seven calibration points to NIST-traceable volumetric standards from 0 to 3000 fpm(0 to 15.2 m/s).
2) Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.

b. Provide the number of independent sensor nodes as follows:

1) For a Duct Diameter of 4 Inches (102 mm): One.
2) For Duct Diameters 5 through 16 Inches (127 through 406 mm): Two.

c. Sensor-Probe Construction: Mill-finish, 6063 aluminum alloy tube or Type 316 stainless steel tube, with each sensor probe containing one or more independently wired sensing nodes.

10. Transmitter:

a. Transmitter determines the average airflow rate and temperature of all connected sensor nodes in an array for a single location.
b. User Interface: An alpha-numeric, LCD display, with two field-selectable analog output signals or one isolated RS-485 (BACnet MS/TP or Modbus RTU) field-selectable network connection.
c. Model EF-A Transmitter, Analog Capability: Two field-selectable 0- to 5-V dc, 1- to 5-V dc, 0- to 10-V dc, or 2- to 10-V dc, scalable analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm.
d. Model EF-N Transmitter, Network Communications: The RS-485 (BACnet MS/TP or Modbus RTU) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures.
e. Contact Closure Relay: One dry contact relay with onboard jumper to drive a remote LED, rated for no less than 30 V dc or 24 V ac at 3 A maximum. User configurable as normally open or normally closed during set up.

11. For Packaged HVAC Units, 12.5 Tons (44.0 kW) or Smaller:
a. Airflow Station Performance:

1) Independent processing of up to two separately wired sensor-node assemblies.
2) Accuracy: Within 10 percent of reading when installed in accordance with manufacturer's recommended placement guidelines. Include the combined uncertainty of the sensor nodes and transmitter. For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with the accuracy requirement over the entire operating range.

b. Sensor-Node and Probe Assemblies:

1) Sensor-Node Internal Wiring Connections: Sealed and protected from the elements and suitable for direct exposure to water. Devices with exposed leads are unacceptable.
2) Sensor-Node Calibration:

a) Individually calibrated at a minimum of seven calibration points to NIST-traceable airflow standards from 0 to 3000 fpm(0 to 15.2 m/s).
b) Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.

3) Provide the number of independent sensor nodes as follows:

a) For a Duct Diameter of 4Inches (102 mm): One.
b) For Duct Diameters 5 through 16 Inches (127 through 406 mm): Two.

4) Sensor-Probe Construction: Mill-finish, 6063 aluminum alloy tube, with each sensor probe containing one or more independently wired sensing nodes.

c. Transmitter:

1) Transmitter determines the average airflow rate and temperature of all connected sensor nodes in an array for a single location.
2) User Interface: An alpha-numeric, LCD display, with two field-selectable analog output signals or one isolated RS-485 (BACnet MS/TP or Modbus RTU) field-selectable network connection.
3) Model EF-A Transmitter, Analog Capability: Two field-selectable 0- to 5-V dc, 1- to 5-V dc, 0- to 10-V dc, or 2- to 10-V dc, scalable analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm.
4) Model EF-N Transmitter, Network Communications: RS-485 (BACnet MS/TP or Modbus RTU) network connection to provide average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures.
5) Contact Closure Relay: One dry contact relay with onboard jumper to drive a remote LED, rated for no less than 30 V dc or 24 V ac at 3 A maximum. User configurable as normally open or normally closed during set up.

12. For Directional Airflow:
a. Bi-directional airflow measurement station with temperature output and integral airflow alarming to determine the exfiltration or infiltration airflow rate, and its direction and temperature at each measurement location.
b. Bi-directional airflow, or equivalent differential pressure date, is provided to the BAS, with system status indication, configurable airflow alarm, and internal diagnostics routine.
c. Sensor-Node Calibration:

1) Individually calibrated at a minimum of nine calibration points to NIST-traceable volumetric standards from minus 3000 to plus 3000 fpm(minus 15.2 to plus 15.2 m/s).
2) Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.
3) Probe to Transmitter Cables: Integral, FEP jacket, plenum-rated CMP/CL2P, UL/cUL-listed cable, rated for exposures from minus 67 to plus 392 deg F(minus 55 to plus 200 deg C), and UV tolerant, with terminal plug for connection to the remotely mounted transmitter.

d. Transmitter:

1) Transmitter determines the average airflow rate and temperature of all connected sensor nodes in an array for a single location.
2) User Interface: An alpha-numeric, LCD display, with two field-selectable analog output signals or one isolated RS-485 (BACnet MS/TP or Modbus RTU) field-selectable network connection.
3) Model EF-A Transmitter, Analog Capability: Two field-selectable 0- to 5-V dc, 1- to 5-V dc, 0- to 10-V dc, or 2- to 10-V dc, scalable and protected analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature low and/or high airflow set-point (user-defined) or system status alarm.
4) Model EF-N Transmitter, Network Communications: The RS-485 (BACnet MS/TP or Modbus RTU) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures.
5) Contact Closure Relay: One dry contact relay with onboard jumper to drive a remote LED, rated for no less than 30 V dc or 24 V ac at 3 A maximum. User configurable as normally open or normally closed during set up.

13. For Data Center Server Rack Airflow/Pressure and Temperature Monitor:
a. Bi-directional airflow measurement station with temperature output and integral airflow alarming to determine the exfiltration or infiltration airflow rate, and its direction and temperature at each measurement location.
b. Bi-directional airflow, or equivalent differential pressure data, is provided to the BAS, with system status indication, configurable airflow alarm, and internal diagnostics routines.
c. Sensor-Node and Probe Assemblies:

1) Sensor-Node Internal Wiring Connections: Sealed and protected from the elements and suitable for direct exposure to water. Devices with exposed leads are unacceptable.
2) Sensor-Node Calibration:

a) Individually calibrated at a minimum of nine calibration points to NIST-traceable volumetric standards from minus 2000 to plus 2000 fpm(minus 10.2 to plus 10.2 m/s).
b) Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.

d. Probe to Transmitter Cables: Integral, FEP jacket, plenum-rated CMP/CL2P, UL/cUL-listed cable, rated for exposures from minus 67 to plus 392 deg F (minus 55 to plus 200 deg C), and UV tolerant, with terminal plug for connection to the remotely mounted transmitter. Plenum-rated PVC jacket cables are unacceptable.

e. Transmitter:

1) Integral Transmitter with Display: Mounted internally to the rack enclosure an integral, minimum 16-character LCD display capable of simultaneously displaying airflow and temperature, and capable of displaying individual airflow and temperature readings.
2) Transmitter Interface: Four-button interface for field configuration and diagnostics.
3) Power Supply: On-off power switch, 110 V ac at 8 VA, fused and protected from overvoltage, overcurrent, and power surges. Provide dual independent and redundant power supplies.
4) Network Interface: One isolated Ethernet network connection (simultaneously supporting field-selectable BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP protocols).

14. For Combination Control Damper and Airflow Station - Equal Area Method Distribution Pattern:

a. Thermal airflow station and integral damper with two or more sensor nodes mounted in a probe, and a remotely mounted microprocessor-based transmitter at each measurement location. Sensor-node distribution pattern to be based on equal area method.

b. Airflow Station Performance:

1) Independent processing of up to 16 separately wired sensor-node assemblies.
2) Accuracy: Within 3 percent of reading for ducted applications, and within 5 percent of reading for non-ducted applications, when installed in accordance with manufacturer's recommended placement guidelines. Include the combined uncertainty of the sensor nodes and transmitter. For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with the accuracy requirement over the entire operating range.

c. Sensor-Node and Probe Assemblies:

1) Performance rated and tested with a 100 percent survival rate in a 30-day saltwater and acid vapor test with written independent laboratory test results.
2) Sensor-Node Calibration: Individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard.

a) Accuracy: Within 2 percent of reading over the entire calibrated airflow range of 0 to 5000 fpm (0 to 25.4 m/s).
b) Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.

3) Provide the number of independent sensor nodes as follows:

a) For Damper Area up to 1.0 sq. ft. (0.092 sq. m): Two.
b) For Duct/Plenum Area Greater Than 1.0 through 4.0 sq. ft. (0.092 through 0.372 sq. m): Four.
c) For Duct/Plenum Area Greater Than 4.0 through 8.0 sq. ft. (0.372 through 0.743 sq. m): Six.
d) For Duct/Plenum Area Greater Than 8.0 through 12.0 sq. ft. (0.743 through 1.11 sq. m): Eight.
e) For Duct/Plenum Area Greater Than 12.0 through 16.0 sq. ft. (1.11 through 1.49 sq. m): 12.
f) For Duct/Plenum Area Greater Than 16.0 sq. ft. (1.49 sq. m): 16.

4) Sensor-Probe Construction: Gold-anodized, 6063 aluminum alloy tube with each sensor probe containing one or more independently wired sensing nodes.

d. Transmitter:

1) Transmitter determines the average airflow rate and temperature of connected sensor nodes in an array for a single location.
2) User Interface: 16-character, alpha-numeric, LCD display, with two field selectable analog output signals and network output capability. Provide one of the following transmitter configurations:

a) Model GTC116 Transmitter: Two field-selectable 0- to 5-V dc, 0- to 10-V dc, or 4- to 20-mA, scalable, isolated, overcurrent protected analog output signals and network output capability. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The RS-485 (BACnet MS/TP, or Modbus RTU) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter shall be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software shall allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.
b) Model GTM116 Transmitter: Two field-selectable 0- to 5-V dc, 0- to 10-V dc, or 4- to 20-mA, scalable, isolated, and overcurrent protected analog output signals and network output capability. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The Ethernet (BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection provides the average airflow rate, temperature, high and/or low

airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter shall be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software shall allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.

c) Model GTL116 Transmitter with LonWorks Free Topology Network Interface: Connection capable of providing average airflow and temperature rates across the network.

d) Model GTD116 Transmitter with Data-Logger Interface: Capable of logging airflow and temperature rates over specified time intervals.

e. Integral Control Damper and Sleeve:

1) Frame and Sleeve: Extruded 6063T5 aluminum with an integral damper frame.

a) Thickness: Not less than 0.080-inch(2.0-mm) thickness for each damper section.

b) Sleeve Depth: 15 inches (381 mm) for ducted applications and 18-inches(457 mm) for non-ducted applications including damper frame. Non-ducted applications include a 3-inch-(7.6-mm-) radius, aluminum entry flair.

c) Installation: Provide an additional 7 inches (178 mm) for non-ducted, 10 inches(254 mm) for ducted, applications between the downstream edge of an intake louver and the leading edge of the entry flair for outside air intake applications that are close coupled to intake louvers.

d) Leakage: The damper leakage shall not exceed 3 cfm/sq. ft. (15.2 L/s per sq. m) of face area against 1-inch wg(248.8-Pa) differential static pressure.

2) Blades: Extruded 6063T5 aluminum airfoil blades not less than 0.060-inch (1.52-mm) thickness.

a) Blade Seals: Extruded EPDM.

b) Frame Seals: Extruded silicone secured in an integral slot within the aluminum extrusions.

c) Orientation: Parallel or opposed blade configuration as required by application.

3) Bearings: Celcon inner bearing fixed to a 7/16-inch (11.1-mm) aluminum hexagon blade pin, rotating within a polycarbonate outer bearing inserted in the frame, resulting in no metal-to-metal or metal-to-plastic contact.

4) Linkage: Aluminum- and corrosion-resistant zinc-plated steel, complete with cup-point trunnion screws for a slip-proof grip, installed inside the frame.

5) Control-Damper Actuator: Modulating, electronic, damper actuator of sufficient number and adequate size, factory mounted and tested. Control-damper actuators are specified in Section 230923.12 "Control Dampers."

15. For Combination Control Damper and Airflow Station - Modified Log Distribution Pattern:
    a. Thermal airflow station and integral damper with one or more sensor nodes mounted in a probe, and a remotely mounted microprocessor-based transmitter at each measurement location. Sensor node distribution pattern to be based on modified log Tchebycheff method.
    b. Airflow Station Performance:

        1) Independent processing of up to 16 separately wired sensor-node assemblies.
        2) Accuracy: Within 3 percent of reading for ducted applications, and within 5 percent of reading for non-ducted applications, when installed in accordance with manufacturer's recommended placement guidelines. Include the combined uncertainty of the sensor nodes and transmitter. For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with the accuracy requirement over the entire operating range.

    c. Sensor-Node and Probe Assemblies:

        1) Performance rated and tested with a 100 percent survival rate in a 30-day saltwater and acid vapor test with written independent laboratory test results.
        2) Sensor-Node Calibration: Individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard.

            a) Accuracy: Within 2 percent of reading over the entire calibrated airflow range of 0 to 5000 fpm (0 to 25.4 m/s).
            b) Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.

        3) Provide the number of independent sensor nodes as follows:

            a) For Damper Area up to 1.0 sq. ft. (0.092 sq. m): Two.
            b) For Duct/Plenum Area Greater Than 1.0 through 2.0 sq. ft. (0.092 through 0.185 sq. m): Four.
            c) For Duct/Plenum Area Greater Than 2.0 through 4.0 sq. ft. (0.185 through 0.372 sq. m): Six.
            d) For Duct/Plenum Area Greater Than 4.0 through 8.0 sq. ft. (0.372 through 0.743 sq. m): Eight.
            e) For Duct/Plenum Area Greater Than 8.0 through 12.0 sq. ft. (0.743 through 1.11 sq. m): 12.
            f) For Duct/Plenum Area Greater Than 12.0 through 14.0 sq. ft. (1.11 through 1.30 sq. m): 14.
            g) For Duct/Plenum Area Greater Than 14.0 sq. ft. (1.49 sq. m): 16.

4) Sensor-Probe Construction: Gold-anodized, 6063 aluminum alloy tube with each sensor probe containing one or more independently wired sensing nodes.

d. Transmitter:

1) Transmitter determines the average airflow rate and temperature of connected sensor nodes in an array for a single location.
2) User Interface: 16-character, alpha-numeric, LCD display, with two field selectable analog output signals and network output capability. Provide one of the following transmitter configurations:

a) Model GTC116 Transmitter: Two field-selectable 0- to 5-V dc, 0- to 10-V dc, or 4- to 20-mA, scalable, isolated, overcurrent protected analog output signals and network output capability. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The RS-485 (BACnet MS/TP, or Modbus RTU) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter shall be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software shall allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.

b) Model GTM116 Transmitter: Two field-selectable 0- to 5-V dc, 0- to 10-V dc, or 4- to 20-mA, scalable, isolated, and overcurrent protected analog output signals and network output capability. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The Ethernet (BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter shall be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software shall allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.

c) Model GTL116 Transmitter with LonWorks Free Topology Network Interface: Connection capable of providing average airflow and temperature rates across the network.

d) Model GTD116 Transmitter with Data-Logger Interface: Capable of logging airflow and temperature rates over specified time intervals.

e. Integral Control Damper and Sleeve:

1) Frame and Sleeve: Extruded 6063T5 aluminum with an integral damper frame.

a) Thickness: Not less than 0.080-inch (2.0-mm) thickness for each damper section.
b) Sleeve Depth: 13 inches (330 mm) for all applications including damper frame. Sleeve includes a 1-inch-(2.56-mm-) radius, aluminum entry flair.
c) Installation: Provide an additional 7 inches (178 mm) between the downstream edge of an intake louver and the leading edge of the entry flair for outside air intake applications that are close coupled to intake louvers.
d) Leakage: The damper leakage shall not exceed 3 cfm/sq. ft. (15.2 L/s per sq. m) of face area against 1-inch wg (248.8-Pa) differential static pressure.

2) Blades: Extruded 6063T5 aluminum airfoil blades not less than 0.060-inch(1.52-mm) thickness.

a) Blade Seals: Extruded EPDM.
b) Frame Seals: Extruded silicone secured in an integral slot within the aluminum extrusions.
c) Orientation: Parallel or opposed blade configuration as required by application.

3) Bearings: Celcon inner bearing fixed to a 7/16-inch (11.1-mm) aluminum hexagon blade pin, rotating within a polycarbonate outer bearing inserted in the frame, resulting in no metal-to-metal or metal-to-plastic contact.
4) Linkage: Aluminum- and corrosion-resistant zinc-plated steel, complete with cup-point trunnion screws for a slip-proof grip, installed inside the frame.
5) Control-Damper Actuator: Modulating, electronic, damper actuator of sufficient number and adequate size, factory mounted and tested. Control-damper actuators are specified in Section 230923.12 "Control Dampers."

16. For Combination Backdraft Damper and Airflow Station:
a. Thermal airflow station with one or more sensor nodes mounted in a probe, and a remotely mounted microprocessor-based transmitter at each measurement location.
b. Airflow Station Performance:

1) Independent processing of up to eight separately wired sensor-node assemblies.
2) Accuracy: Within 10 percent of reading under operating conditions, when installed in accordance with manufacturer's sensor density and placement guidelines, with no effect on fan performance. Include the combined

uncertainty of the sensor nodes and transmitter. For devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter, demonstrate compliance with the accuracy requirement over the entire operating range.

c. Sensor-Node and Probe Assemblies:

1) Performance rated and tested with a 100 percent survival rate in a 30-day saltwater and acid vapor test with written independent laboratory test results.
2) Sensor-Node Calibration: Individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard.

a) Accuracy: Within 2 percent of reading over the entire calibrated airflow range of 0 to 10,000 fpm (0 to 50.8 m/s).
b) Individually calibrate thermistor at a minimum of three temperatures to NIST-traceable temperature standards.

3) Sensor-Probe Construction: One sensor node mounted on a Type 304 stainless steel block with two adjustable zinc-plated steel rods connected to Type 304 stainless steel pivoting mounting feet.
4) Number of Independent Sensor Nodes, Fan Arrays (One to Eight Fans): One probe with one sensor node per probe in each fan inlet.

d. Transmitter:

1) Transmitter determines the average airflow rate and temperature of each fan. Startup firmware facilitates the setup of multiple fans and fan areas.
2) User Interface: 16-character, alpha-numeric, LCD display, with two field-selectable analog output signals and network output capability. Provide one of the following transmitter configurations:

a) Model GTC108 Transmitter: Two field-selectable 0- to 5-V dc, 0- to 10-V dc, or 4- to 20-mA, scalable, isolated, overcurrent protected analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The RS-485 (BACnet MS/TP, or Modbus RTU) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter shall be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software shall allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.
b) Model GTM108 Transmitter: Two field-selectable 0- to 5-V dc, 0- to 10-V dc, or 4- to 20-mA, scalable, isolated, and overcurrent protected

analog output signals. The first output (AO1) provides the total airflow rate. The second output (AO2) is field configurable for temperature or low and/or high airflow set-point (user-defined) or system status alarm. The Ethernet (BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection provides the average airflow rate, temperature, high and/or low airflow set-point alarm, system status alarm, individual sensor-node airflow rates, and individual sensor-node temperatures. The transmitter shall be provided with a Bluetooth low-energy interface card capable of transmitting all transmitter setup parameters, diagnostics, average airflow, and temperature of the device and the airflow and temperature of each sensor node. Software capable of capturing and displaying this transmission will be available via download to Android or iOS phone or tablet. Software shall allow for setup parameters, airflow, temperature, and diagnostic data to be saved on the phone or be emailed.

c) Model GTL108 Transmitter with LonWorks Free Topology Network Interface: Connection capable of providing average airflow and temperature rates across the network.

d) Model GTD108 Transmitter with Data-Logger Interface: Capable of logging airflow and temperature rates over specified time intervals.

e. Integral Heavy-Duty Backdraft Damper:

1) Frame and Sleeve: Extruded 6063T5 aluminum with an integral damper frame.

a) Thickness and Depth: Not less than 0.080-inch (2.0-mm) thickness.

b) Sleeve Depth: 8 inches (457 mm), which act as an integrated sleeve. Optional 1-inch-(7.6-mm-) radius, aluminum entry flair.

c) Installation: Provide an additional 7 inches (178 mm) between the downstream edge of any components and leading edge of the damper frame or entry flare.

d) Leakage: The damper leakage shall not exceed 3 cfm/sq. ft. (15.2 L/s per sq. m) of face area against 1-inch wg(248.8-Pa) differential static pressure.

2) Blades: Extruded 6063T5 aluminum airfoil blades not less than 0.060-inch(1.52-mm) thickness.

a) Blade Seals: Extruded EPDM.

b) Frame Seals: Extruded silicone secured in an integral slot within the aluminum extrusions.

c) Orientation: Parallel configuration as required by application.

3) Bearings: Celcon inner bearing fixed to a 7/16-inch (11.1-mm) aluminum hexagon blade pin, rotating within a polycarbonate outer bearing inserted in the frame, resulting in no metal-to-metal or metal-to-plastic contact.

4) Linkage: Aluminum- and corrosion-resistant zinc-plated steel, complete with cup-point trunnion screws for a slip-proof grip, installed inside the frame.

C. Pitot-Tube Airflow Sensor Station:

1. Description: Multiple total- and static-pressure sensors positioned at the center of equal area of the station cross section and interconnected by respective averaging manifolds.

    a. Stations 4 sq. ft. (0.4 sq. m) and Smaller: One total-pressure sensor and one static-pressure sensor for every 16 sq. in. (103 sq. cm) of station area.
    b. Stations Larger than 4 sq. ft. (0.4 sq. m): One total-pressure sensor and one static-pressure sensor for every 36 sq. in. (232 sq. cm) of station area.

2. Casing: Galvanized sheet steel at least 0.079 inch (2.0 mm) thick with coating complying with ASTM A653/A653M, G90 (Z275). Casings shall be stainless steel, 0.0781 inch (2.0 mm) thick, when connected to stainless duct and aluminum, 0.063 inch (1.6 mm) thick, when connected to aluminum duct.

    a. Joints and Seams: Continuously weld. Clean galvanized areas damaged by welding and coat with aluminum paint.
    b. Casing Depth: At least 8 inches (200 mm).
    c. Casing Flanges: Outward flange, minimum flange face 1.5 inches (38 mm).
    d. Casing Configuration and Size: Match shape (rectangular, round, flat oval) and same size as adjacent duct unless otherwise indicated.

3. Include an open parallel cell air straightener or air equalizer honeycomb mechanically fastened to casing.

    a. Construct straightener or equalizer from Type 3003 aluminum or Type 316 stainless steel, depending on casing material. Use stainless steel for units with stainless steel casings.

4. Construct pressure sensor array from drawn copper or stainless steel tubing. Use stainless steel for units with stainless steel casings. Copper tubing shall comply with ASTM B75 and ASTM B280. Minimum tube wall thickness shall be 0.030 inch (0.8 mm). Include internal piping and external pressure transmitter ports.
5. Station Labeling: Identification label on each station casing indicating model number, size, area, and application-specific airflow range.
6. Performance:

    a. Pressure Loss: 0.015-inch wg (3.8 Pa) at 1000 fpm (5 m/s), or 0.085-inch wg (22.5 Pa) at 2000 fpm (10 m/s).
    b. Accuracy: Within 2 percent of actual airflow.
    c. Self-Generated Sound: NC 40 and sound level within the duct shall not be amplified.
    d. Performance rated and tested according to AMCA 610. Each station shall bear the AMCA seal.

D. Pitot-Tube Fan Inlet Airflow Traverse Sensor:

1. Traverse manifold designed for mounting in fan inlets.
2. Contain multiple total- and static-pressure sensors placed at concentric area centers along the exterior surface of cylindrical manifold and internally connected to their respective averaging manifolds. Sensors shall not protrude beyond the surface of the manifold nor be adversely affected by particle contamination present in airstream.

3. Manifold (two per inlet) shall have dual end support swivel brackets suitable for mounting in the fan inlet bell and symmetrical averaging signal takeoffs and fittings.
4. Sensors shall be capable of producing steady, non-pulsating signals of standard total- and static-pressure without need for flow corrections or factors, with an accuracy of 3 percent of actual flow over a turndown range of 6 to 1.
5. Manifold Materials: Copper or anodized aluminum or Type 316 stainless steel.
6. Unless otherwise required by application and without affecting the fan and sensor performance, nominal diameter copper and aluminum manifolds shall be the following:

    a. For Fan Inlets Smaller Than 20 Inches (500 mm): 0.375 inch (9 mm).
    b. For Fan Inlets 20 Inches (500 mm) and Larger: 0.75 inch (19 mm).

7. Unless otherwise required by application and without affecting the fan and sensor performance, nominal diameter stainless steel manifolds shall be the following:

    a. For Fan Inlets Smaller Than 20 Inches (500 mm): 0.375 inch (9 mm).
    b. For Fan Inlets 20 through 48 Inches (500 through 1200 mm): 0.75 inch (19 mm).
    c. For Fan Inlets Larger Than 48 Inches (1200 mm): 1.0 inch (25 mm).

E. Piezometer Ring Fan Inlet Airflow Sensor:
1. In lieu of externally mounted fan inlet airflow sensors, option to provide fans with airflow measurement integral to fan inlet cones for continuous measurement of air volume flow rate.
2. Multiple pressure sensor points strategically placed along the circumference of the inlet cone and internally connected to an averaging ring manifold located behind the inlet cone.
3. Sensor points shall not protrude beyond the surface of the inlet cone nor be adversely affected by particle contamination present in the airstream.
4. Sensor shall produce steady, non-pulsating signals to achieve accuracy within 5 percent of actual airflow.
5. Sensor shall be non-intrusive and not impact fan performance.
6. Product shall be a standard offering of the fan manufacturer and include published literature with supporting test data to validate sensor performance.

2.4 AIRFLOW SWITCHES

A. Polymer Film Sail Switch:
1. Performance:

    a. Suitable for applications operating at velocities up to 400 fpm (2.0 m/s).
    b. Suitable for mounting with air direction in horizontal, vertical up or down.
    c. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
    d. Voltage: 24-, 120-, 240-V ac.
    e. Normally Open Full Load Current: 2 A at 120-V ac.
    f. Normally Closed Full Load Current: 1 A at 120-V ac.
    g. Normally open switch actuates at 250 fpm (1.3 m/s) and opens at 75 fpm (0.4 m/s).
    h. Normally closed switch actuates at 75 fpm (0.4 m/s) and closes at 250 fpm (1.3 m/s).

i. Maximum Process Temperature: 170 deg F (77 deg C).
j. Maximum Ambient Temperature: 125 deg F (52 deg C).

2. Construction:

a. Polyester film sail encasing a wire frame.
b. Sail actuates a SPDT snap switch.
c. Enclosure Material: Zinc-plated steel.
d. Enclosure with removable cover.
e. NEMA 250, Type 1 enclosure.
f. Removable spring counterbalances sail to allow mounting in either vertical (up or down) or horizontal airflow.
g. Electrical Connections: Screw terminals.
h. Conduit Connections: 1/2-inch (16-mm) trade size conduit knock outs on top and bottom.

B. Stainless Steel Single Vane Switch:
1. Description:

a. Velocities up to 2000 fpm (10.2 m/s).
b. Suitable for mounting with air direction in horizontal.

2. Performance:

a. Voltage: 125-, 240-, and 480-V ac.
b. Full Load Current: 9.8 A at 125-V ac.
c. Field-Adjustable Velocity Set Point: 400 to 1600 fpm (2.0 to 8.2 m/s).
d. Maximum Process Temperature: 180 deg F (82 deg C).
e. Maximum Ambient Temperature: 125 deg F (52 deg C).

3. Construction:

a. Stainless steel vane.
b. Vane actuates a SPDT snap switch.
c. Enclosure Material: Die-cast metal.
d. Enclosure with removable cover.
e. NEMA 250, Type 1 enclosure.
f. Screw set-point adjustment.
g. Electrical Connections: Screw terminals.
h. Conduit Connections: 1-inch (27-mm) trade size conduit knock outs on top and bottom.

2.5 AIRFLOW TRANSMITTERS

A. Airflow Transmitters with 0.25 Percent Accuracy and Auto-Zero Feature:
1. Transmitter shall receive total- and static-pressure signals from a flow element, amplify signals, extract the square foot, and scale the signals to produce 4- to 20-mA dc output signals linear to airflow.
2. NEMA 250, Type 1 enclosure.

3. Construct assembly so shock, vibration, and pressures surges of up to 1 psig (6.9 kPa) will neither harm transmitter, nor affect its accuracy.
4. Transmitter with automatic zeroing circuit capable of automatically readjusting transmitter zero at predetermined time intervals. The automatic zeroing circuit shall re-zero the transmitter to within 0.1 percent of true zero.
5. Performance:

    a. Range: As required by application and at least 10 percent below minimum airflow and 10 percent greater than design airflow.
    b. Calibrated Span: Field adjustable, minus 40 percent of the range.
    c. Accuracy: Within 0.25 percent of natural span.
    d. Repeatability: Within 0.15 percent of calibrated span.
    e. Linearity: Within 0.2 percent of calibrated span.
    f. Hysteresis and Deadband (Combined): Less than 0.2 percent of calibrated span.

6. Integral digital display for continuous indication of airflow.

B. Pressure Differential Transmitters for Airflow Measurement:
1. Performance:

    a. Range: As required by application and at least 10 percent below minimum airflow and 10 percent greater than design airflow.
    b. Accuracy: As directed.
    c. Hysteresis: Within 0.10 percent of full scale.
    d. Repeatability: Within 0.05 percent of full scale.
    e. Stability: Within one percent of span per year.
    f. Overpressure: 10 psig (69 kPa).
    g. Temperature Limits: Zero to 150 deg F (Minus 18 to plus 66 deg C).
    h. Compensate Temperature Limits: 40 to 150 deg F (4 to 66 deg C).
    i. Thermal Effects: 0.033 percent of full scale per degree F.
    j. Shock and vibration shall not harm the transmitter.

2. Output Signals:

    a. Analog Current Signal:

        1) Two-wire, 4- to 20-mA dc current source.
        2) Signal capable of operating into 800-ohm load.

    b. Analog Voltage Signal:

        1) Three wire, zero to 5 or 10 V as directed.
        2) Minimum Load Resistance: 1000 ohms.

3. Display: Four-digit digital with minimum 0.4-inch- (10-mm-) high numeric characters.
4. Operator Interface:

    a. Zero and span adjustments located behind cover.

5. Construction:

a. Plastic casing with removable plastic cover.
b. Fittings: Swivel fittings for connection to copper tubing or barbed fittings for connection to polyethylene tubing. Fittings on bottom of instrument case.
c. Screw terminal block for wire connections.
d. Vertical plane mounting.
e. NEMA 250, Type 4.
f. Mounting Bracket: Appropriate for installation.

2.6 LIQUID FLOW METERS

A. General Requirements for Liquid Flow Meters:

1. Adjustable for changes in system operational parameters.
2. Liquid and Steam Sensors, Meters, and Transmitters: Extended range of 10 or 20 percent above Project design flow as directed and 10 or 20 percent below Project minimum flow as directed to signal abnormal flow conditions.
3. Manufacturer shall certify that each flow instrument indicated complies with specified performance requirements and characteristics.
4. Product certificates are required.

B. Insertion Paddle Wheel Flow Meter, NPS 1 (DN 25):

1. Description:

a. Insertion-type meter with a non-magnetic spinning paddle wheel.
b. Each meter shall be wet calibrated at factory to standards traceable to NIST and provided with a certificate of calibration.
c. Programming kit including cable connector and Microsoft-Windows-compatible software.
d. Where indicated, provide meter with bi-directional flow measurement.

2. Performance:

a. Range: 0.33 to 20 fps (0.1 to 6.1 m/s).
b. Accuracy: Within 0.5 or 1 percent of flow rate as directed.
c. Repeatability: Within 0.5 percent.
d. Ambient Temperature: 14 to 150 deg F (Minus 10 to plus 66 deg C).
e. Maximum Process Temperature: 300 deg F (149 deg C) with PEEK sensor tip.
f. Maximum Pressure: 350 psig at 300 deg F (2413 kPa at 149 deg C) with PEEK sensor tip.
g. Pressure Drop: Up to 0.5 psig at 10 fps (3.5 kPa at 3 m/s) for pipe sizes NPS 1-1/2 (DN 20) and larger.

3. Output Signal:

a. Unidirectional Flow Meter: Frequency pulse.
b. Unidirectional Flow Meter: Analog, two wire, loop-powered, 4- to 20-mA signal.
c. Unidirectional Flow Meter: Scaled pulse.
d. Bi-directional Flow Meter: Analog 4- to 20-mA signal plus direction.
e. Bi-directional Flow Meter: Scaled pulse.

4. Operator Interface:

    a. Programming: Instrument programming through computer and programming kit.
    b. Digital Display: Eight-character digital display of flow rate, flow totalization, input, output, and flow direction for bi-directional meters.

5. Construction:

    a. Wetted Metal Parts (Including Sensor Stem, Mounting Adapter, and Isolation Valve): Type 316 stainless steel.
    b. Sensor Tip: PPS or PEEK.
    c. Shaft: Tungsten carbide.
    d. Impeller: Stainless steel.
    e. Process Connection: NPS 1 (DN 25).
    f. Instrument Isolation Valve: Full port ball valve for system isolation.
    g. Insertion Depth: Threaded positioning nut for accurate sensor depth in the pipe.
    h. Electronics Enclosure:

        1) Polypropylene with Viton-sealed acrylic cover.
        2) Removable cover.
        3) NEMA 250, Type 4X.
        4) Electrical Connection: Screw terminals.
        5) Conduit Connection: 1/2-inch (16-mm) trade size.

C. Insertion Turbine Flow Meter:

1. Description:

    a. Operating pressure of 300 psig (2068 kPa) with a temperature of 200 deg F (93 deg C).
    b. Meters in hot water systems shall be suitable for maximum system temperatures encountered, but not less than 250 deg F (121 deg C).
    c. Pressure drop not to exceed 1 psig (6.9 kPa) at 20-fps (6.1-m/s) flow velocity in a NPS 2 (DN 50) pipe and decreasing in large pipe with lower velocity.
    d. Sensor Accuracy:

        1) Within 1 percent of actual flow between the flow velocity range of 3 to 30 fps (0.9 to 9.1 m/s).
        2) Within 2 percent of actual flow between the flow velocity range of 0.4 to 20 fps (0.1 to 6.1 m/s).
        3) Within 0.5 percent of actual reading at the calibrated velocity.

    e. Wet calibrate and tag sensors to standards traceable to NIST and provide each sensor with a certificate of calibration.

2. Sensor:

    a. For Pipe Sizes NPS 2 (DN 50) and Smaller: Single turbine sensors.
    b. For Pipe Sizes NPS 2-1/2 (DN 65) and Larger: Dual turbine sensors.
    c. Piping with Bi-directional Flow: Bi-directional dual turbine sensors.

d. Dual turbine sensors shall have dual, contra-rotating turbine elements, each turbine element with its own rotational sensing system, and an averaging circuit.
e. Rotational sensing of each turbine shall be accomplished electronically by sensing electronic impedance change (non-magnetic and non-photoelectric).
f. Sensor shall have an integral frequency output linear with flow rate. For dual turbine units, with individual top and bottom turbine outputs for diagnostic purposes.
g. Bi-directional sensors shall have isolated solid-state dry contacts with a contact rating of 100 mA at 50 V. The contacts shall close when the flow in direction of arrow is 0.18 fps (0.05 m/s) or more.
h. Flow sensor shall be complete with installation hardware necessary to enable insertion and removal from pipe without system shutdown.
i. Construct turbine elements of polypropylene with sapphire jewel bearings and tungsten carbide shafts. Construct wetted metal components of Type 316 stainless steel, including installation hardware.
j. House sensor electronics in a NEMA 250, Type 4 enclosure.
k. Enclosure shall include connection(s) for field-installed conduit.
l. Sensor shall have cable of length sufficient to connect to display module.
m. Sensor housing shall have full port Type 316 stainless steel ball valve for system isolation.

3. Display Module:

a. Remote from sensor.
b. House in a NEMA 250, Type 4X enclosure.
c. Label terminal strip for all wiring connections.
d. 120-V ac power supply with 24-V dc output to power the flow sensor.
e. Remote Interface:

1) Hardwired Analog Outputs for Flow Rate and Totalization: 4 to 20 mA and zero- to 10-V dc.
2) Serial Communication Interface: Compatible with host to share flow rate and totalized flow data.
3) Outputs linear to within 0.1 percent of calibrated span.

f. Digital display for flow rate and totalized flow.

1) At least eight display digits for totalization.
2) Bi-directional units with separate digital display for flow and totalization in each direction.

g. Local reset of flow totalization.
h. Program and data shall be stored in nonvolatile memory in event of power loss.
i. For bi-directional units, with display of flow direction (contacts open or closed).

D. Inline Turbine Flow Meter:
1. Description:

a. Available in NPS 3/4 and NPS 1 (DN 20 and DN 25).

b. Operating pressure of 300 psig (2068 kPa) with a temperature of 200 deg F (93 deg C).
c. Meters in hot water systems shall be suitable for maximum system temperatures encountered, but not less than 250 deg F (121 deg C).
d. Pressure drop not to exceed 3 psig at 38 gpm (21 kPa at 2.4 L/s).
e. Sensor Accuracy:

1) Within 2 percent of actual flow between the flow range of 0.8 to 38 gpm (0.05 to 2.4 L/s).
2) Within 0.5 percent of actual reading at the calibrated velocity.

f. Wet calibrate and tag sensors to standards traceable to NIST, and provide each sensor with a certificate of calibration.

2. Sensor:

a. Rotational sensing of turbine shall be accomplished electronically by sensing electronic impedance change (non-magnetic and non-photoelectric).
b. Sensor shall have an integral frequency output linear with flow rate.
c. Sensor shall have threaded union on each end.
d. Construct turbine elements of polypropylene with sapphire jewel bearings and tungsten carbide shafts.
e. Construct wetted metal components of brass or stainless steel.
f. House sensor electronics in a NEMA 250, Type 4 enclosure.
g. Enclosure shall include connection(s) for field-installed conduit.
h. Sensor shall have cable of length sufficient to connect to display module.

3. Display Module:

a. Remote from sensor.
b. Enclosure: NEMA 250, Type 4X.
c. Label terminal strip for all wiring connections.
d. 120-V ac power supply with 24-V dc output to power the flow sensor.
e. Remote Interface:

1) Hardwired Analog Outputs for Flow Rate and Totalization: 4 to 20 mA and zero- to 10-V dc.
2) Serial Communication Interface: Compatible with host to share flow rate and totalized flow data.
3) Outputs linear to within 0.1 percent of calibrated span.

f. Digital display of flow rate and totalized flow.
g. At least eight display digits for totalization.
h. Local reset of flow totalization.
i. Program and data shall be stored in nonvolatile memory in the event of power loss.

2.7 LIQUID FLOW SENSORS (PRIMARY ELEMENTS)

A. Venturis:

1. On request, submit independent testing documentation (product test reports), demonstrating compliance with specified performance.
2. Standard: ASME MFC-3M.
3. Performance:

    a. Accuracy within 0.5 percent of measured flow throughout flow range from design to 10 percent of design flow.
    b. Accuracy with five pipe diameters of straight pipe upstream and two pipe diameters downstream.
    c. Size and beta ratio shall be matched with transmitter to provide accuracy of entire assembly within 1 percent of design flow rate, when the flow rate is allowed to vary between 10 to 100 percent of the design.

4. Construction:

    a. One-piece bronze or brass construction with threaded connections for pipe sizes NPS 1/2 through NPS 2 (DN 15 to DN 50).
    b. One-piece plated cast steel with flanged connections for pipe sizes NPS 2-1/2 through NPS 8 (DN 65 to DN 200), and fabricated steel with flanged connections for larger sizes.
    c. Sensing Taps: Two, accurately located built-in sensing taps, nipples, shut-off valves, and quick connect coupling.
    d. Identification Tag: Attached to each venturi with a chain and label indicating pipe size, venturi series, station identification, and meter reading at flow rate and pressure differential.
    e. Use venturi with pressure differential transmitter.

B. Orifice Plates:
1. Standards: ASME MFC-3M or ASME MFC-14M.
2. Performance:

    a. Orifice plates shall be sharp, square-edged concentric type.
    b. Shop fabricate and calibrate orifice meter runs through NPS 2 (DN 50).
    c. Field fabricate orifice runs NPS 3 (DN 80) and larger.
    d. Meter run piping or tubing shall be uniform internal surface, which is free of internal grooves and striations, but is not polished. Out of roundness shall not exceed 0.5 percent. A reduction of the pipe diameter or distortion caused by welding is unacceptable.
    e. Size orifice plates for 100-inch wg (24.9-kPa) pressure differential, except that the absolute value of the meter range shall not exceed the absolute value of the flowing pressure.
    f. Ratio of orifice diameter to actual internal pipe diameter d/B (beta) shall be between 0.70 and 0.30.
    g. Locate orifice plates in horizontal or vertical lines in accordance with good metering practice.
    h. Minimum upstream and downstream straight pipe shall comply with ASME Fluid Meters Research Committee Reports.

3. Construction:

a. Fabricate the orifice plate and matching companion flanges of Type 316 stainless steel.
b. Transmitter connection shall be at least NPS 1/2 (DN 15).
c. Stamp the orifice plates with the number and the orifice bore on the handle of the plate.

4. Use orifice plate with pressure differential transmitter.
5. Calibration information and calculations shall comply with either of the referenced standards for each orifice plate.

C. Portable Meter Package for Liquid Flow Sensors:

1. Metal-reinforced-plastic carrying case.
2. Waterproof meter with nominal 6-inch (150-mm) round dial face.
3. Meter with dual rupture-proof liquid-filled bellows having integral temperature compensation.
4. Meter with external range and zero adjustment.
5. Multiple meters in package, if required to accommodate venturis with a wide range of pressure signals.
6. Two connecting hoses, 10-feet (3-m) long, with quick connect couplings compatible with venturi couplings.
7. Two brass blowdown valves with Buna-N seals and blowdown hoses.
8. Instruction book with flow versus differential curves.
9. Suitable for working pressure of 200 psig (1380 kPa) at 200 deg F (93.3 deg C).
10. Portable meter package to connect to flow sensor without disturbing connection to pressure differential transmitter. Provide isolation valves at connections.
11. Turn over to Owner at Project completion.

2.8 LIQUID FLOW SWITCHES

A. Liquid Flow Switch (Bellows Type):

1. Description:

a. Field-adjustable four-vane combinations.
b. Field-adjustable set-point adjustment screw.
c. Suitable for pipe sizes NPS 1 through NPS 8 DN 25 through DN 200.
d. Switch mounted vertically in horizontal pipe.

2. Performance:

a. Flow Rate Actuation and De-actuation: Varies with vane combination and set-point adjustment.
b. Pressure Limit: 145 psig (1000 kPa).
c. Temperature Limit: 230 deg F (110 deg C).
d. Electrical Rating: 10 A resistive, 3 A conductive at 250-V ac.
e. Switch Type: SPDT snap switch.

3. Wetted Parts Construction:

a. Bellows: Tin-bronze.

b. Vanes: Stainless steel.
c. Body: Forged brass.
d. Process Connection: NPS 1 (DN 25).

4. Enclosure:

a. Die-cast aluminum alloy.
b. NEMA 250, Type 4.
c. Electrical Connection: Cable gland with attached wire leads.

B. Liquid Flow Switch (Magnetic Type):
1. Description:

a. Field-adjustable five-vane combinations.
b. Suitable for pipe sizes NPS 1-1/2 through NPS 20 (DN 40 to DN 500).
c. Mounting Suitable for Application: Switch vertically mounted in horizontal pipe or switch horizontally mounted in vertical pipe with flow up.
d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for hazardous-environment Class I, Groups C and D; Class II, Groups E, F, and G.

2. Performance:

a. Flow Rate Actuation and De-actuation: Varies with vane combination.
b. Pressure Limit: 1000 psig (6895 kPa) for brass body, 2000 psig (13790 kPa) for Type 316 stainless steel body.
c. Temperature Range: Minus 4 to plus 275 deg F (Minus 20 to plus 135 deg C).
d. Electrical Rating: 10 A at 125/250-V ac.
e. Switch Type: SPDT or DPDT snap switch as directed.

3. Wetted Parts Construction:

a. Vanes: Type 316 stainless steel.
b. Body: Brass or Type 316 stainless steel as directed.
c. Magnetic Keeper: Type 430 stainless steel or Type 316 stainless steel as directed.
d. Process Connection: NPS 1-1/2 (DN 40).

4. Enclosure:

a. Die-cast aluminum alloy.
b. Threaded cover.
c. NEMA 250, Type 4.
d. Electrical Connection: Terminal block.
e. Conduit Connection: 3/4-inch (21-mm) trade size.

2.9 LIQUID FLOW TRANSMITTERS

A. Liquid Pressure Differential Transmitter for Flow Measurement:
1. Performance:

a. Range: Approximately 2 times the set point.
b. Span: Adjustable plus or minus 1 mA, non-interactive.
c. Accuracy: Within 0.25 percent of full scale.
d. Maximum Operating Pressure: 2.5 times range.
e. Temperature Limits: Zero to 175 deg F (Minus 18 to plus 79 deg C).
f. Compensate Temperature Limits: 30 to 150 deg F (Minus 1 to plus 66 deg C).
g. Thermal Effects: 0.02 percent of full scale per degree F.
h. Response Time: 30 to 50 ms.
i. Shock and vibration shall not harm the transmitter.

2. Analog Output Current Signal:

a. Two wire, 4- to 20-mA dc current source.
b. Signal capable of operating into 1000-ohm load.

3. Operator Interface:

a. Zero and span adjustments located behind cover.
b. Bleed screws on side of body, two screws on low-pressure side and one screw on high-pressure side, for air in line and pressure cavity.

4. Construction:

a. Aluminum and stainless steel enclosure with removable cover.
b. Wetted parts of transmitter constructed of 17-4 PH or 300 series stainless steel.
c. NPS 1/4 (DN 8) process connections on side of instrument enclosure.
d. Knock out for 1/2-inch (15-mm) trade size conduit connection on side of instrument enclosure.
e. Screw terminal block for wire connections.
f. NEMA 250, Type 4X.
g. Mounting bracket shall be suitable for installation.

5. Transmitter shall have three-valve manifold. Construct manifold of brass, bronze, or stainless steel. Manifold shall have NPS 1/4 (DN 8) process connections.

PART 3 - EXECUTION

3.1 INSTRUMENT APPLICATIONS

A. Select from instrument types to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.

B. Thermal Airflow Measurement Stations:

1. For Air-Ducted/Plenum:

a. Measured Velocities Greater Than 200 fpm (1.0 m/s): Thermal airflow measurement station.)

b. Provide a remotely mounted microprocessor-based transmitter at each measurement location.

2. For Air-Ducted/Plenum - Duct Size 2 sq. ft. (0.18 sq. m)or Less:

   a. Measured Velocities Less Than 200 fpm (1.0 m/s): Thermal airflow measurement station.)
   b. Provide a remotely mounted microprocessor-based transmitter at each measurement location.

3. For Supply or Return Fan Array:

   a. Measured Velocities Greater Than 200 fpm (1.0 m/s): Thermal airflow measurement station.)
   b. Provide a remotely mounted microprocessor-based transmitter at each measurement location.

4. For Supply or Return Fan, Single-Width Single-Inlet (SWSI) or Double-Width Double-Inlet (DWDI) Fans:

   a. Measured Velocities Greater Than 200 fpm (1.0 m/s): Thermal airflow measurement station.)
   b. Provide a remotely mounted microprocessor-based transmitter at each measurement location.

5. For Air Terminal Units:

   a. Measured Velocities Greater Than 200 fpm (1.0 m/s): Thermal airflow measurement station.)
   b. Provide a microprocessor-based transmitter at each measurement location.

6. For Packaged HVAC Units, 12.5 Tons (44.0 kW) or Smaller:

   a. Measured Velocities Greater Than 200 fpm (1.0 m/s): Thermal airflow measurement station.)
   b. Provide a remotely mounted microprocessor-based transmitter at each measurement location.

7. For Directional Airflow Sensors:

   a. Measured Velocities Greater Than 50 fpm (0.25 m/s): Thermal airflow measurement station.
   b. Provide a remotely mounted microprocessor-based transmitter at each measurement location.

8. For Data Center Server Rack Airflow/Pressure and Temperature Monitor:

   a. Measured Velocities Greater Than 200 fpm (1.0 m/s): Thermal airflow measurement station.)
   b. Provide a remotely mounted microprocessor-based transmitter at each measurement location.

9. For Damper-Mounted Airflow Stations:

    a. Measured Velocities Greater Than 200 fpm (1.0 m/s): Thermal airflow measurement station.)
    b. Provide a remotely mounted microprocessor-based transmitter at each measurement location.

C. Duct-Mounted Airflow Sensors:

1. Measured Velocities 500 fpm (2.5 m/s) and Less: Thermal airflow station.
2. Measured Velocities Greater than 500 fpm (2.5 m/s): Pitot-tube airflow sensor station or Thermal airflow station as directed.

D. Damper-Mounted Airflow Sensors:

1. Measured Velocities 400 fpm (2.0 m/s) and Less: Thermal airflow station.
2. Measured Velocities Greater than 500 fpm (2.5 m/s): Pitot-tube airflow sensor station or Thermal airflow station as directed.

E. Fan-Mounted Airflow Sensors:

1. Measured Velocities 500 fpm (2.5 m/s) and Less: Thermal airflow station.
2. Measured Velocities Greater than 500 fpm (2.5 m/s): Thermal airflow station.

F. Airflow Switches:

1. Measured Velocities 400 fpm (2.0 m/s) and Less: Polymer film sail switch.
2. Measured Velocities Greater than 400 fpm (2.0 m/s): Stainless steel single-vane switch.

G. Airflow Transmitters for Use with Pitot-Tube-Type Sensors:

1. Exhaust Air Airflow: Airflow transmitter with 0.25 percent accuracy and auto-zero feature or Pressure differential transmitter for airflow measurement as directed.
2. Outdoor Air Airflow: Airflow transmitter with 0.25 percent accuracy and auto-zero feature or Pressure differential transmitter for airflow measurement as directed.
3. Return Air Airflow: Airflow transmitter with 0.25 percent accuracy and auto-zero feature or Pressure differential transmitter for airflow measurement as directed.
4. Supply Air Airflow: Airflow transmitter with 0.25 percent accuracy and auto-zero feature or Pressure differential transmitter for airflow measurement as directed.

H. Liquid Flow Sensors (Primary Elements):

1. System: Venturis or Orifice plates as directed.

I. Liquid Flow Meters:

1. System: As directed.

J. Liquid Flow Switches:

1. System: Bellows type or Magnetic type as directed.

K. Liquid Flow Transmitters:

1. System: Liquid pressure differential transmitter.

3.2 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a force as directed.

D. Install ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

E. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

F. Corrosive Environments:

1. Use products that are suitable for environment to which they will be subjected.
2. If possible, avoid or limit use of materials in corrosive environments, including, but not limited to, the following:

    a. Laboratory exhaust airstreams.
    b. Process exhaust airstreams.

3. When conduit is in contact with a corrosive environment, use Type 316 stainless steel conduit and fittings or conduit and fittings with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from the manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.3 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.4 INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS

A. Mounting Location:

1. Rough-in: Outline instrument-mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.
2. Install switches and transmitters for air and liquid flow associated with individual air-handling units and connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
3. Install liquid and steam flow switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
4. Install airflow switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
5. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
6. Install instruments in steam, liquid, and liquid-sealed-piped services below their process connection point. Slope tubing down to instrument with a slope of 2 or 3 percent as directed.
7. Install instruments in dry gas and non-condensable-vapor piped services above their process connection point. Slope process connection lines up to instrument with a minimum slope of 2 or 3 percent as directed.

B. Mounting Height:

1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
2. Mount switches and transmitters, located in mechanical equipment rooms and other similar space not subject to code, state, and federal accessibility requirements, within a range of 42 to 72 inches (1050 to 1800 mm) above the adjacent floor, grade, or service catwalk or platform.

    a. Make every effort to mount at 60 inches (1500 mm).

C. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

3.5 FLOW INSTRUMENTS INSTALLATION

A. Airflow Sensors:

1. Install sensors in straight sections of duct with manufacturer-recommended straight duct upstream and downstream of sensor.
2. Installed sensors shall be accessible for visual inspection and service. Install access door(s) in duct or equipment located upstream of sensor, to allow service personnel to hand clean sensors.

B. Liquid and Steam Sensors:

1. Install sensors in straight sections of piping with manufacturer-recommended straight piping upstream and downstream of sensor.
2. Alert manufacturer where installation cannot accommodate recommended clearance, and solicit recommendations for field modifications to installation, such as flow straighteners, to improve condition.
3. Install pipe reducers for in-line sensors smaller than line size. Position reducers at distance from sensor to avoid interference and impact on accuracy.
4. Install in-line sensors with flanges or unions to provide drop-in and -out installation.

C. Liquid Flow Meters:

1. Install meters in straight sections of piping with manufacturer-recommended straight piping upstream and downstream of sensor.
2. Install pipe reducers for in-line meters smaller than line size. Install reducers at distance from meter to avoid interference and impact on accuracy.
3. Install in-line meters with flanges or unions to provide drop-in and -out installation.
4. Insertion Meters:

    a. Install system process connections full size of meter connection, but not less than as directed. Provide stainless steel bushing if required to mate to system connection.
    b. Install meter in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement.
    c. In applications where top-dead-center location is not possible due to field constraints, install meter at location along top half of pipe if acceptable by manufacturer for mounting orientation.

D. Liquid Switches:

1. Install system process connection full size of switch connection, but not less than as directed. Install stainless steel bushing if required to mate switch to system connection.
2. Install switch in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement.
3. In applications where top-dead-center location is not possible due to field constraints, install switch at location along top half of pipe if switch is acceptable by manufacturer for mounting orientation.

E. Transmitters:

1. Install airflow transmitters serving an air system in a single location adjacent to or within system control panel.
2. Install liquid flow transmitters, not integral to sensors, in vicinity of sensor. Where multiple flow transmitters serving same system are located in same room, co-locate

transmitters by system to provide service personnel a single and convenient location for inspection and service.

3.6 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification and on face of ceiling directly below instruments concealed above ceilings.

3.7 CHECKOUT PROCEDURES

A. Description:

1. Check out installed products before continuity tests, leak tests, and calibration.
2. Check instruments for proper location and accessibility.
3. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
4. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

B. Flow Instrument Checkout:

1. Verify that sensors are installed correctly with respect to flow direction.
2. Verify that sensor attachment is properly secured and sealed.
3. Verify that processing tubing attachment is secure and isolation valves have been provided.
4. Inspect instrument tag against approved submittal.
5. Verify that recommended upstream and downstream distances have been maintained.

3.8 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

B. Coordinate video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

C. Record videos on DVD disks.

D. Owner shall have right to make additional copies of video for internal use without paying royalties.

END OF SECTION 230923.14

SECTION 230923.16 - GAS INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes the Following Gas Instruments:

1. Carbon-dioxide sensors and transmitters.
2. VOC sensors and transmitters.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.16.

1.2 DEFINITIONS

A. NDIR: Nondispersive infrared.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include diagrams for power, signal, and control wiring.
3. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

PART 2 - PRODUCTS

2.1 CARBON-DIOXIDE SENSORS AND TRANSMITTERS

A. Description:

1. NDIR technology or equivalent technology providing long-term stability and reliability.
2. Two-wire, 4-20 mA output signal, linearized to carbon-dioxide concentration in ppm.

B. Construction:

1. House electronics in an ABS plastic enclosure. Provide equivalent of NEMA 250, Type 1 enclosure for wall-mounted space applications and NEMA 250, Type 4 for duct-mounted applications.
2. Equip with digital display for continuous indication of carbon-dioxide concentration.

C. Performance:

1. Measurement Range: Zero to 2000 ppm.
2. Accuracy: Within 2 percent of reading, plus or minus 30 ppm.
3. Repeatability: Within 1 percent of full scale.
4. Temperature Dependence: Within 0.05 percent of full scale over an operating range of 25 to 110 deg F (minus 4 to 43 deg C).
5. Long-Term Stability: Within 5 percent of full scale after more than five years.
6. Response Time: Within 60 seconds.
7. Warm-up Time: Within five minutes.

D. Provide calibration kit. Turn over to Owner at start of warranty period.

2.2 VOC SENSORS AND TRANSMITTERS

A. Description:

1. VOC sensor shall use an oxidizing element that varies resistance with contaminant gases.
2. Senses and responds to combined concentration of more than 30 contaminates commonly found in indoor environments.

B. Output Signal: Zero to 5 or 10-V dc with minimum load resistance of 4000 ohms.

C. Performance:

1. Measurement Range: Zero to 100 percent.
2. Ambient Temperature: 32 to 140 deg F (zero to 60 deg C).
3. Ambient Relative Humidity: 5 to 95 percent non-condensing.

D. Enclosure: Lexan.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support instruments, tubing, piping, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to seismic loads.

D. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by using excessive force or oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

E. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

F. Corrosive Environments:

1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments, including but not limited to, the following:

    a. Laboratory exhaust airstreams.
    b. Process exhaust airstreams.

3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.2 ELECTRICAL POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.3 INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS

A. Mounting Location:

1. Install transmitters for gas associated with individual air-handling units and associated connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.

2. Install gas switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
3. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
4. Install instruments in dry gas and non-condensable vapor piped services above their process connection point. Slope process connection lines up to instrument with a minimum slope of 2 or 3 percent as directed.

B. Mounting Height:

1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code, state, and federal accessibility requirements within a range of 42 to 72 inches (1.1 to 1.6 m) above the adjacent floor, grade, or service catwalk or platform.

    a. Make every effort to mount at 60 inches (1.5 m).

C. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated, using neoprene gaskets or grommets.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification on face.

3.5 CHECKOUT PROCEDURES

A. Check out installed products before continuity tests, leak tests, and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance.

D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

B. Coordinate gas instrument demonstration video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

C. Record videos on DVD disks.

D. Owner shall have right to make additional copies of video for internal use without paying royalties.

END OF SECTION 230923.16

SECTION 230923.17 - LEVEL INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes liquid-level switches, sensors, and transmitters.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.17.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.
3. Include number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 LEVEL SWITCHES

A. Liquid-Level Switch (Magnetic Type with Float):

1. Description:

a. Mounting Suitable for Application: Horizontal or vertical switch mounting.
b. Float arm with hinge design limits vertical movement to prevent sticking.
c. Replaceable float with threaded connection.

d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for hazardous environments (Class I, Groups C and D; Class II, Groups E, F, and G).

2. Performance:

a. Level Actuation and De-Actuation: 0.75-inch (20-mm) deadband.
b. Body Pressure Limit: 1000 psig (6895kPa) for brass body; 2000 psig (13790 kPa) for Type 316 stainless-steel body.
c. Float Pressure Limit: 150 psig (1034 kPa).
d. Temperature Range: Minus 4 to 275 deg F (Minus 20 to 135 deg C).
e. Electrical Rating: 10 A at 125/250-V ac.
f. Switch Type: SPDT or DPDT snap switch as directed.

3. Wetted Parts Construction:

a. Float and Rod: Type 316 stainless steel.
b. Body: Brass or Type 316 stainless steel as directed.
c. Magnetic Keeper: Type 430 stainless steel or Type 316 stainless steel as directed.
d. Process Connection: NPS 1-1/2 (DN 40) NPT.
e. Enclosure:

1) Die-cast aluminum alloy.
2) Threaded cover.
3) NEMA 250, Type 4.
4) Electrical Connection: Terminal block.
5) Conduit Connection: NPS 3/4 (NPS 20) NPT.

B. Electrode-Type Liquid-Level Switches:

1. Description:

a. Conductivity technology.
b. Dual point level settings.
c. No moving parts.
d. Adjustable sensitivity.

2. Performance:

a. Pressure Limit: 30 psig (207 kPa).
b. Temperature Limit: 212 deg F (100 deg C).
c. Power Supply: 120-V ac, 50 or 60 Hz.
d. Electrical Rating: 5 A at 240-V ac.
e. Switch Type: SPDT snap switch.

3. Probes:

a. Electrodes: 0.125-inch (6-mm) diameter.
b. Material: Type 316 stainless steel.
c. Length: To suit application up to 72 inches (1800 mm).
d. Process Connection: NPS 1 (DN 25) NPT.

e. Enclosure:

1) Polypropylene.
2) NEMA 250, Type 6.
3) Electrical Connection: Cable and standard octal socket.

2.2 LEVEL TRANSMITTERS

A. RF Admittance-Type Liquid-Level Sensor and Transmitter:

1. Description: Complete package with electronic unit, sensing element, connecting cable.

a. Continuous level transmitter shall produce an output signal that is proportional to level.
b. Measurement shall be free from effects of changes in temperature, density, or acoustic noise in vapor space above level.
c. Continuous measurement shall be independent of changes in material density and unaffected by presence of material clinging to sensing element.
d. No moving parts and no routine cleaning and recalibration necessary.
e. Electronic unit shall be integral to sensing element or mounted remotely up to 100 feet (30 m) away from sensor.
f. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for hazardous environments (Class I, Groups C and D; Class II, Groups E, F, and G).

2. Sensor:

a. Material: Teflon-coated Type 304 or Type 316 stainless steel as directed.
b. Length: To suit installation.
c. Connection: NPS 3/4 (NPS 20) NPT or flanged.

3. Electronic unit housed in NEMA 250, Type 4X enclosure.

a. Calibrated Range: Varies with application. At least 10 or 20 percent beyond high- and low-level set point as directed and alarm levels.
b. Accuracy: Within 1 percent of calibrated range.
c. Two wire, loop powered.
d. Supply Voltage: 11.5 to 50-V dc.
e. Maximum Load: 625 ohms at 24-V dc.
f. Output Signal: 4 to 20 mA dc.
g. Response Time: 0.5 to 30 seconds, adjustable.
h. Temperature Range: Minus 40 to 165 deg F (Minus 40 to 74 deg C).
i. Zero and Span Adjustments: Noninteracting.
j. Visual Indication: Continuous digital display of level.
k. Field-changeable failsafe condition and phasing in event measurement requires changes to optimize level reading.
l. Free from effects of radio frequency interference.
m. Free from harmful effects of static electricity on sensing element with discharges of up to 10 A without damage.
n. Adjustable time delay (signal dampening).

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement, sway, or a break in attachment when subjected to a force as directed.

C. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by using excessive force or oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

D. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

E. Mount switches and transmitters not subject to code, state, and federal accessibility requirements within a range of 42 to 72 inches (1.1 to 1.6 m) above the adjacent floor, grade or service catwalk, or platform.

1. Make every effort to mount at 60 inches (1.5 m).

F. Corrosive Environments:

1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments.
3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.2 ELECTRICAL POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.3 LEVEL INSTRUMENTS INSTALLATION

A. Mounting Location: Rough-in instrument-mounting locations before setting instruments and routing, cable, wiring, tubing, and conduit to final location.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification on face.

3.5 CHECKOUT PROCEDURES

A. Check out installed products before continuity tests, leak tests, and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation on direction of elevation, orientation, insertion depth, or other applicable considerations that impact performance.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

B. Coordinate level instrument demonstration video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

C. Record videos on DVD disks.

D. Owner shall have right to make additional copies of video for internal use without paying royalties.

END OF SECTION 230923.17

SECTION 230923.18 - LEAK DETECTION INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following types of leak-detection switches:

1. Point-type, leak-detection switches.
2. Cable-type, leak-detection switches.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.18.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.
3. Include number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 LEAK-DETECTION SWITCHES

A. Point-Type, Leak-Detection Switches:

1. Features: Audible and visual alarm with relay output for remote indication.
2. Alarm activated based on change in resistance.
3. Performance:

a. Service: Water.
b. Temperature Limits: 32 to 122 deg F (zero to 50 deg C).
c. Switch Type: SPDT relay.
d. Electric Connection: Cable attached.

4. Construction: Acrylic, ABS plastic.
5. Field Power: 24-V ac or dc.

B. Cable-Type, Leak-Detection Switches:

1. Control Module Features:

a. Power and alarm LEDs.
b. Alarm test switch.
c. Continuous tape integrity self check.

2. Performance:

a. Service: Water, or other conductive liquid.
b. Switch Type: DPDT.
c. Electric Connection: Screw terminals.
d. Conduit Connection: 0.5 inch (13 mm).

3. Construction:

a. Control Module Enclosure: Extruded aluminum.
b. Tape: Hydrophobic with connector on each end.
c. Tape Length: As directed. Field extendable.

4. Field Power: 24-V ac or 24- to 30-V dc.

PART 3 - EXECUTION

3.1 LEAK-DETECTION INSTRUMENT APPLICATION

A. As directed: Leak-detection switches (point type) or Leak-detection switches (cable type) as directed.

3.2 INSTALLATION, GENERAL

A. Properly support instruments, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a force as directed.

B. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.

2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force, or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

C. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

D. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power connections.

E. Mount switches not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification and on face of ceiling directly below instruments concealed above ceilings.

3.4 CHECKOUT PROCEDURES

A. Check installed products before continuity tests and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation for applicable considerations that impact performance.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

B. Coordinate video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

C. Record videos on DVD disks.

D. Owner shall have right to make additional copies of video for internal use without paying royalties.

END OF SECTION 230923.18

SECTION 230923.19 - MOISTURE INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes moisture switches, sensors, and transmitters.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.19.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.
3. Include number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 MOISTURE SWITCHES

A. Humidistat for Duct Applications:

1. Description:

a. Two-position control.

b. Field-adjustable set point.
c. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2. Performance:

a. Relative Humidity Range: 15 to 95 percent.
b. Relative Humidity Differential: 5 percent.
c. Ambient Temperature: 40 to 135 deg F (4 to 57 deg C).
d. Voltage: 120-V ac.
e. Current: 7.2 FLA.
f. Switch Type: SPDT snap switch.

3. Construction:

a. Enclosure: Metal, NEMA 250, Type 1.
b. Electrical Connections: Screw terminals.

B. Humidistat for Space Applications:

1. Description:

a. Two-position control.
b. Field-adjustable set point.
c. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2. Performance:

a. Relative Humidity Range: 10 to 90 percent.
b. Relative Humidity Differential: 5 percent.
c. Ambient Temperature: 40 to 135 deg F (4 to 57 deg C).
d. Voltage: 24-V ac.
e. Pilot Duty: 60 VA.
f. Switch Type: SPDT snap switch.

3. Construction:

a. Enclosure: Plastic, NEMA 250, Type 1.
b. Electrical Connections: Cable, 6 inches (150 mm) long.

2.2 MOISTURE SENSORS AND TRANSMITTERS

A. Sensors and Transmitters with Digital Display:

1. Performance:

a. Accuracy including non-linearity, hysteresis, and repeatability: Within 2 percent from zero to 90 percent relative humidity and within 2.5 percent from 90 to 100 percent relative humidity when operating between 60 to 77 deg F (16 to 25 deg C).
b. Relative Humidity Range: Zero to 100 percent.
c. Factory calibrated and NIST traceable with certificate included.

2. Construction:

a. Provide housing with integral sensor for room applications.
b. Provide housing with remote sensor probe for ducted applications.

1) Duct Sensor Body: 300 series stainless steel or chrome-plated aluminum, at least 2 inches (50 mm) long for duct-mounted applications.
2) Provide sensor with cable for field installation in conduit.
3) For duct-mounted applications, thread the sensor assembly for connection to a threaded mounting flange.

c. Provide general-purpose humidity sensor unless application requires special requirements. Provide sensor with sintered stainless-steel filter for duct applications.
d. Housing shall be ABS/PC plastic or powder-coated aluminum.
e. Housing Classification: NEMA 250, Type 4 or 4X.
f. Provide housing with wall-mounting plate.

3. Output Signal: 2-wire, 4- to 20-mA output signal with a drive capacity of at least 500 ohms at 24-V dc.
4. Provide unit with a digital display of relative humidity in percent.

B. Sensor and Transmitter without Display:

1. Performance:

a. Relative Humidity Range: Zero to 100 percent.
b. Accuracy: Within 2 or 3 percent.
c. Operating Temperatures: Minus 30 to 130 deg F (Minus 1 to 54 deg C).
d. Hysteresis: Within 1 percent.

2. Construction:

a. Duct-type sensor for duct-mounted applications. Integral-type sensor for room or space applications.
b. Sensor Body: 300 series stainless steel, 6 inches (150 mm) long for duct-mounted applications.
c. For outdoor and duct applications, install circuitry in a NEMA 250, Type 4 or 4X enclosure.

3. Output Signal:

    a. Two-wire, 4- to 20-mA output signal with a drive capacity of at least 600 ohms at 24-V dc.
    b. Non-interacting zero and span adjustments.

PART 3 - EXECUTION

3.1 MOISTURE INSTRUMENT APPLICATIONS

3.2 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support instruments, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a force as directed.

C. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

D. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

E. Corrosive Environments:

1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments.
3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.3 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.4 MOISTURE INSTRUMENTS INSTALLATION

A. Mounting Location: Rough-in instrument-mounting locations before setting instruments and routing, cable, wiring, tubing, and conduit to final location.

B. Mounting Height:

1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code, state, and Federal accessibility requirements within a range of 42 to 72 inches (1.1 to 1.6 m) above the adjacent floor, grade, or service catwalk or platform.

    a. Make every effort to mount at 60 inches (1.5 m).

3.5 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification on face of ceiling directly below instruments concealed above ceilings.

3.6 CHECKOUT PROCEDURES

A. Check installed products before continuity tests and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance.

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

B. Coordinate video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

C. Record videos on DVD disks.

D. Owner shall have right to make additional copies of video for internal use without paying royalties.

END OF SECTION 230923.19

SECTION 230923.21 - MOTION INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. PIR motion sensors.
2. Ultrasonic motion sensors.
3. Dual-technology motion sensors.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.21.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.
3. Include number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Product installation location shown in relationship to visual range and obstructions.
2. Wall- and ceiling-mounted instruments located in finished space showing relationship to other installed devices.

B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 INDOOR MOTION SENSORS

A. Description: Wall- or ceiling-mounted, solid-state units with a separate relay unit.

1. Operation: Unless otherwise indicated, turn on when covered area is occupied and off when unoccupied; with a time delay for turning off, adjustable over a minimum range of 1 to 15 minutes.
2. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
3. Relay Unit: Dry contacts rated for 20-A load at 120- and 277-V ac. Power supply to sensor shall be 24-V dc, 150 mA, Class 2 power source as defined by NFPA 70.
4. Mounting:

    a. Sensor: Suitable for mounting in any position on a standard outlet box.
    b. Relay: Externally mounted through a 1/2-inch (13-mm) knock out in a standard electrical enclosure.
    c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.

5. Indicator: Digital display, to show when motion is being detected during testing and normal operation of the sensor.
6. Bypass Switch: Override the on function in case of sensor failure.

B. PIR Type: Ceiling mounting; detect occupancy by sensing a combination of heat and movement in coverage area.

1. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm).
2. Detection Coverage (Room): Detect occupancy anywhere in a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
3. Detection Coverage (Corridor): Detect occupancy within 90 feet (27.4 m) when mounted on a 10-foot- (3-m-) high ceiling.

C. Ultrasonic Type: Ceiling mounting; detect occupancy by sensing a change in pattern of reflected ultrasonic energy in coverage area.

1. Detector Sensitivity: Detect a person of average size and weight moving not less than 12 inches (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inches/s (305 mm/s).
2. Detection Coverage (Small Room): Detect occupancy anywhere within a circular area of 600 sq. ft. (56 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
4. Detection Coverage (Large Room): Detect occupancy anywhere within a circular area of 2000 sq. ft. (186 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
5. Detection Coverage (Corridor): Detect occupancy anywhere within 90 feet (27.4 m) when mounted on a 10-foot- (3-m-) high ceiling in a corridor not wider than 14 feet (4.3 m).

D. Dual-Technology Type: Ceiling mounting; detect occupancy by using a combination of PIR and ultrasonic detection methods in coverage area. A particular technology or combination of technologies that controls on-off functions shall be field selectable by operating controls on unit.

1. Sensitivity Adjustment: Separate for each sensing technology.
2. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm), and detect a person of average size and weight moving not less than 12 inches (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inches/s (305 mm/s).
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling. Apply occupancy detectors where indicated.

PART 3 - EXECUTION

3.1 SENSOR INSTALLATION

A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.

B. Coordinate layout and installation of wall-mounted devices with other wall-mounted devices. Align centerline with adjacent devices. Align centerline with devices above.

C. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

3.2 ELECTRICAL POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage or Engage a qualified testing agency to evaluate lighting control devices and perform tests and inspections as directed.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Motion instruments will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

END OF SECTION 230923.21

SECTION 230923.22 - POSITION INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes position limit switches for use in direct-digital control systems for HVAC.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.22.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.
3. Include number-coded identification system for unique identification of wiring.

PART 2 - PRODUCTS

2.1 POSITION LIMIT SWITCHES

A. Description: Select type of actuating head (plunger, roller lever, or rod) to suit application.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Performance:

1. Life expectancy: Not less than 30 million mechanical operations and 750,000 electrical operations.

2. Operating Frequency: 300 mechanical operations per minute and 30 electrical operations per minute.
3. Voltage: 125-, 250-, 480-, and 600-V ac or 8-, 12-, 14-, 24-, 30-, 48-, 125-, and 250-V dc, as required by application.
4. Current Rating: As required by application.
5. Temperature Rise: 50 deg C.
6. Ambient Temperature: 14 to 175 deg F (Minus 10 to 79 deg C).
7. Ambient Relative Humidity: 35 to 95 percent.

C. Construction:

1. NEMA 250, Type 4X enclosure.
2. Switch Type: SPDT or DPDT, as required by application.
3. Status indicator integral to switch. Field switchable to light when contacts are actuated and operating, or contacts are free and not operating.
4. Electrical Connection: Screw or plug-in terminals.
5. Conduit Connection: NPS 1/2 (DN 50).

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support instruments, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement, sway, or a break in attachment when subjected to a force as directed.

C. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not to overstress threads by using excessive force or oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

D. Install products in locations that are accessible and that permit maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

E. Corrosive Environments:

1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments, including, but not limited to:

a. Laboratory exhaust airstreams.
b. Process exhaust airstreams.

3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from the manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.2 ELECTRICAL POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.3 POSITION INSTRUMENTS INSTALLATION

A. Mounting Location:

1. Rough-in instrument-mounting locations before setting instruments and routing, cable, wiring, and conduit to final location.
2. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

B. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated, using neoprene gaskets or grommets.

END OF SECTION 230923.22

SECTION 230923.23 - PRESSURE INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Air-pressure sensors.
2. Air-pressure switches.
3. Air-pressure transmitters.
4. Liquid-pressure switches.
5. Liquid-pressure transmitters.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.23.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 AIR-PRESSURE SENSORS

A. Duct Insertion Static Pressure Sensor:

1. Insertion length shall be as directed.
2. Sensor with four radial holes of 0.04-inch (1-mm) diameter.
3. Brass or stainless-steel construction.
4. Sensor with threaded end support, sealing washers and nuts.
5. Connection: NPS 1/4 (DN 6) compression fitting.
6. Suitable for flat oval, rectangular, and round duct configurations.

B. Outdoor Static Pressure Sensor:

1. Provides average outdoor pressure signal.
2. Sensor with no moving parts.
3. Kit includes sensor, vinyl tubing mounting hardware.

C. Space Static Pressure Sensor for Wall Mounting:

1. 100-micron filter mounted in stainless-steel wall plate senses static pressure.
2. Wall plate provided with gasket and screws and sized to fit standard single-gang electrical box.
3. Back of sensor plate fitted with brass barbed fitting for tubing connection.

D. Space Static Pressure Sensor for Recessed Ceiling Mounting:

1. Aluminum or Stainless-steel round plate as directed with perforated center arranged to sense space static pressure. Exposed surfaces provided with brush finish.
2. Sensor intended for flush mount on face of ceiling with pressure chamber recessed in ceiling plenum.
3. Back of sensor plate fitted with multiple sensing ports, pressure impulse suppression chamber, airflow shielding, and 0.125-inch (3-mm) fitting for concealed tubing connection.
4. Performance: Within 1 percent of actual room static pressure in vicinity of sensor while being subjected to an air velocity of 1000 fpm (5.1 m/s) from a 360 degree radial source.

2.2 AIR-PRESSURE SWITCHES

A. Air-Pressure Differential Switch:

1. Diaphragm operated to actuate an SPDT snap switch.

a. Fan safety shutdown applications: Switch with manual reset.

2. Electrical Connections: Three-screw configuration, including one screw for common operation and two screws for field-selectable normally open or closed operation.
3. Enclosure Conduit Connection: Knock out or threaded connection.
4. User Interface: Screw-type set-point adjustment located inside removable enclosure cover.
5. High and Low Process Connections: Threaded, NPS 1/8 (DN 6).
6. Enclosure:

   a. Dry Indoor Installations: NEMA 250, Type 1.
   b. Outdoor and Wet Indoor Installations: NEMA 250, Type 4.
   c. Hazardous Environments: Explosion proof.

7. Operating Data:

   a. Electrical Rating: 15 A at 120- to 480-V ac.
   b. Pressure Limits:

      1) Continuous: 45 inches wg (11.2 kPa).
      2) Surge: 10 psig (68.9 kPa).

   c. Temperature Limits: Minus 30 to 180 deg F (Minus 34 to 82 deg C).
   d. Operating Range: Approximately 2 times set point.
   e. Repeatability: Within 3 percent.
   f. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 AIR-PRESSURE TRANSMITTERS

A. Air-Pressure Differential Transmitter:

1. Performance:

   a. Range: Approximately 2 times set point.
   b. Accuracy: Within 0.25 or 0.5 percent of the span as directed at reference temperature of 70 deg F (21 deg C).
   c. Hysteresis: Within 0.02 percent of the span.
   d. Repeatability: Within 0.05 percent of the calibrated span.
   e. Stability: Within 0.25 percent of span per year.
   f. Overpressure: 15 psig (103 kPa).
   g. Temperature Limits: Minus 20 to 160 deg F (Minus 29 to 71 deg C).
   h. Compensate Temperature Limits: 35 to 135 deg F (2 to 57 deg C).
   i. Thermal Effects: 0.015 percent of full scale per degree F.
   j. Warm-up Time: Within 5 seconds.
   k. Response Time: As directed.

l. Shock and vibration shall not harm the transmitter.

2. Output Signals:

a. Analog Current Signal:

1) Two-wire, 4- to 20-mA dc current source.
2) Signal capable of operating into 1000-ohm load.

b. Analog Voltage Signal:

1) Three wire, zero to 5 or 6 V as directed.
2) Minimum Load Resistance: 1000 ohms.

3. Operator Interface:

a. Zero and span adjustments within 10 percent of full span.
b. Potentiometer adjustments located on face of transmitter.

4. Construction:

a. Type 300 stainless-steel enclosure.
b. Swivel fittings for connection to copper tubing or barbed fittings for connection to polyethylene tubing. Fittings on front of instrument enclosure.
c. Screw terminal block for wire connections.
d. Vertical plane mounting.
e. NEMA 250, Type 2.
f. Mounting Bracket: Appropriate for installation.
g. Reverse wiring protected.
h. Calibrate to NIST-traceable standards and provide each transmitter with a certificate of calibration.

B. Air-Pressure Differential Indicating Transmitter:

1. Performance:

a. Range: Approximately 2 times set point.
b. Accuracy Including Hysteresis and Repeatability: Within 1 percent of full scale at 77 deg F (25 deg C).
c. Stability: Within 1 percent of full scale per year.
d. Overpressure: 10 psig (69 kPa).
e. Temperature Limits: 20 to 120 deg F (Minus 7 to 49 deg C).
f. Thermal Effects: 0.055 percent of full scale per degree F.

2. Display: Four-digit digital display with minimum 0.4-inch- (10-mm-)high numeric characters.
3. Operator Interface:

a. Zero and span adjustments.
b. Selectable engineering units.

4. Analog Output Current Signal:

a. Two-wire, 4- to 20-mA dc current source.
b. Signal capable of operating into a 1200-ohm load.

5. Construction:

a. Plastic casing with clear plastic cover.
b. Integral fittings for plastic tubing connections on side of instrument case for high- and low-pressure connections.
c. Terminal block for wire connections.
d. Vertical plane mounting.
e. NEMA 250, Type 1.
f. Nominal 4-inch (100-mm) diameter face.
g. Mounting Bracket: Appropriate for installation.

2.4 LIQUID-PRESSURE SWITCHES

A. Liquid Gage Pressure Switch, Diaphragm Operated, Low Pressure:

1. Description:

a. Diaphragm operated to actuate an SPDT snap switch.
b. Electrical Connections: Screw terminal.
c. Enclosure Conduit Connection: Knock out or threaded connection.
d. User Interface: External screw with visual set-point adjustment.
e. Process Connection: Threaded, NPS 1/4 (DN 10).
f. Enclosure:

1) Dry Indoor Installations: NEMA 250, Type 1.
2) Outdoor and Wet Indoor Installations: NEMA 250, Type 4.
3) Hazardous Environments: Explosion proof.

2. Operating Data:

a. Electrical Rating: 15 A at 120-V ac.
b. Pressure Limits:

1) Range 1 to 30 psig (7 to 207 kPa): 60 psig (414 kPa).
2) Range 10 to 125 psig (69 to 862 kPa): 160 psig (1103 kPa).

c. Temperature Limits: Minus 30 to 150 deg F (Minus 35 to 66 deg C).
d. Operating Range: 1 to 30 psig (7 to 207 kPa) or 10 to 250 psig (69 to 862 kPa) as directed.

e. Deadband: Fixed.

3. Pressure Chamber Material: Steel or Stainless steel.
4. Diaphragm Material: Nylon or PTFE.

B. Liquid-Pressure Differential Switch with Set-Point Indicator:

1. Description:

a. Brass or Type 316 stainless steel double opposing bellows operate to actuate a SPDT snap switch as directed.
b. Electrical Connections: Screw terminal.
c. Enclosure Conduit Connection: Knock out or threaded connection.
d. User Interface: Thumbscrew set-point adjustment with enclosed set-point indicator and scale.
e. High and Low Process Connections: Threaded, NPS 1/8 (DN 3).
f. Enclosure:

1) Dry Indoor Installations: NEMA 250, Type 1.
2) Outdoor and Wet Indoor Installations: NEMA 250, Type 4.
3) Hazardous Environments: Explosion proof.

g. Operating Data:

1) Electrical Rating: 15 A at 120- to 240-V ac.
2) Pressure Limits: At least 5 times full-scale range, but not less than system design pressure rating.
3) Temperature Limits: Minus 10 to 180 deg F (Minus 23 to 82 deg C).
4) Operating Range: Approximately 2 times set point.
5) Deadband: As directed.

2.5 LIQUID-PRESSURE TRANSMITTERS

A. Liquid-Pressure Differential Transmitter:

1. Performance:

a. Range: Approximately 2 times set point.
b. Span: Adjustable plus or minus one milliamp, noninteractive.
c. Accuracy: Within 0.25 percent of full scale.
d. Pressure: Maximum operating pressure 2.5 times range.
e. Temperature Limits: Zero to 175 deg F (Minus 18 to 79 deg C).
f. Compensate Temperature Limits: 30 to 150 deg F (Minus 1 to 66 deg C).
g. Thermal Effects: 0.02 percent of full scale per degree F.
h. Response Time: 30 to 50 ms.
i. Shock and vibration shall not harm the transmitter.

2. Analog Output Current Signal:

   a. Two-wire, 4- to 20-mA dc current source.
   b. Signal capable of operating into 1000-ohm load.

3. Operator Interface:

   a. Zero and span adjustments located behind cover.
   b. Bleed screws on side of body, two screws on low-pressure side, and one screw on high-pressure side, for air in line and pressure cavity.

4. Construction:

   a. Aluminum and stainless-steel enclosure with removable cover.
   b. Wetted parts of transmitter constructed of 17-4 PH or 300 Series stainless steel.
   c. Threaded, NPS 1/4 (DN 10) process connections on side of instrument enclosure.
   d. Knock out for 1/2-inch (16-mm) nominal conduit connection on side of instrument enclosure.
   e. Screw terminal block for wire connections.
   f. NEMA 250, Type 4X.
   g. Mounting Bracket: Appropriate for installation.

5. Three-valve manifold. Construct manifold of brass, bronze, or stainless steel. Manifold shall have threaded, NPS 1/4 (DN 10) process connections.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement, sway, or a break in attachment when subjected to a force as directed.

C. Provide ceiling, floor, roof, wall openings, and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

D. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not to overstress threads by using excessive force or oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

E. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

F. Corrosive Environments:

1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments.
3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from the manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.2 ELECTRICAL POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.3 PRESSURE INSTRUMENT INSTALLATION

A. Mounting Location:

1. Rough-in: Outline instrument-mounting locations before setting instruments and routing, cable, wiring, tubing, and conduit to final location.
2. Install switches and transmitters for air and liquid pressure associated with individual air-handling units and associated connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.

3. Install liquid and steam pressure switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
4. Install air-pressure switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
5. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
6. Install instruments (except pressure gages) in steam, liquid, and liquid-sealed piped services below their process connection point. Slope tubing down to instrument with a slope of 2 or 3 percent as directed.
7. Install instruments in dry gas and noncondensable vapor piped services above their process connection point. Slope process connection lines up to instrument with a minimum slope of 2 or 3 percent as directed.

B. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

C. Duct Pressure Sensors:

1. Install sensors using manufacturer's recommended upstream and downstream distances.
2. Unless indicated on Drawings, locate sensors of longest hydraulic run. Location of sensors shall be submitted and approved before installation.
3. Install mounting hardware and gaskets to make sensor installation airtight.
4. Route tubing from the sensor to transmitter.
5. Use compression fittings at terminations.
6. Install sensor in accordance with manufacturer's instructions.
7. Support sensor to withstand maximum air velocity, turbulence, and vibration encountered to prevent instrument failure.

D. Outdoor Pressure Sensors:

1. Install roof-mounted sensor in least-noticeable location and as far away from exterior walls as possible.
2. Locate wall-mounted sensor in an inconspicuous location.
3. Submit sensor location for approval before installation.
4. Verify signal from sensor is stable and consistent to all connected transmitters. Modify installation to achieve proper signal.
5. Route outdoor signal pipe full size of sensor connection to transmitters. Install branch connection of size required to match to transmitter.
6. Install sensor signal pipe with dirt leg and drain valve below roof penetration.

7. Insulate signal pipe with flexible elastomeric insulation as required to prevent condensation.
8. Connect roof-mounted signal pipe exposed to outdoors to building grounding system.

E. Air-Pressure Differential Switches:

1. Install air-pressure sensor in system for each switch connection. Install sensor in an accessible location for inspection and replacement.
2. A single sensor may be used to share a common signal to multiple pressure instruments.
3. Install access door in duct and equipment to access sensors that cannot be inspected and replaced from outside.
4. Route NPS 3/8 (DN 12) tubing from sensor to switch connection.
5. Do not mount switches on rotating equipment.
6. Install switches in a location free from vibration, heat, moisture, or adverse effects, which could damage the switch and hinder accurate operation.
7. Install switches in an easily accessible location serviceable from floor.
8. Install switches adjacent to system control panel if within 50 feet (15 m); otherwise, locate switch in vicinity of system connection.

F. Liquid-Pressure Differential Switches:

1. Where process connections are located in mechanical equipment room, install switch in convenient and accessible location near system control panel.
2. Where process connections are installed outside mechanical rooms, route processing tubing to mechanical room housing system control panel and locate switch near system control panel.
3. Where multiple switches serving same system are installed in same room, install switches by system to provide service personnel a single and convenient location for inspection and service.
4. System process tubing connection shall be full size of switch connection, but not less than as directed. Install stainless-steel bushing if required to mate switch to system connection.
5. Connect process tubing from point of system connection and extend to switch.
6. Install isolation valves in process tubing as close to system connection as practical.
7. Install dirt leg and drain valve at each switch connection.
8. Do not mount switches on rotating equipment.
9. Install switches in a location free from vibration, heat, moisture, or adverse effects, which could damage the switch and hinder accurate operation.
10. Install switches in an easily accessible location serviceable from floor.

G. Liquid-Pressure Transmitters:

1. Where process connections are installed in mechanical equipment room, install transmitter in convenient and accessible location near system control panel.

2. Where process connections are installed outside mechanical rooms, route processing tubing to mechanical room housing system control panel and locate transmitter near system control panel.
3. Where multiple transmitters serving same system are installed in same room, install transmitters by system to provide service personnel a single and convenient location for inspection and service.
4. System process tubing connection shall be full size of switch connection, but not less than as directed. Install stainless-steel bushing if required to mate switch to system connection.
5. Connect process tubing from point of system connection and extend to transmitter.
6. Install isolation valves in process tubing as close to system connection as practical.
7. Install dirt leg and drain valve at each transmitter connection.
8. Do not mount transmitters on equipment.
9. Install in a location free from vibration, heat, moisture, or adverse effects, which could damage and hinder accurate operation.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification and on face of ceiling directly below instruments concealed above ceilings.

3.5 CHECKOUT PROCEDURES

A. Check out installed products before continuity tests, leak tests, and calibration.

B. Check instruments for proper location and accessibility.

C. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

B. Coordinate pressure instrument demonstration video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

C. Record videos on DVD disks.

D. Owner shall have right to make additional copies of video for internal use without paying royalties.

END OF SECTION 230923.23

SECTION 230923.24 - SPEED INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes speed switches for direct-digital controls for HVAC.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.24.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include number-coded identification system for unique identification of wiring.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 ROTATIONAL SPEED SWITCHES

A. Rotational Speed Switch (Non-Contact Type):

1. Description:

a. Speed switch, sensor, and electronics housed in enclosure.

b. Shaft-end-mounted disc, or split collar wrap generates an alternating magnetic field sensed by the switch.
c. Dust, dirt, and grease proof.
d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for hazardous environments Class I, Group D; Class II, Groups E, F, and G; and Class III.

2. Performance:

a. Field-Adjustable Range: 10 to 100 100 to 5000 rpm as directed.
b. Temperature Limits: Minus 40 to 140 deg F (Minus 40 to 60 deg C).
c. Electrical Rating: 5 A at 115-V ac.
d. Switch Type: SPDT.
e. Gap Distance: Approximately 0.375 inch (9 mm).

3. Operator Interface: Potentiometer.
4. Enclosure Construction:

a. PVC or Cast aluminum as directed.
b. Removable cover.
c. NEMA 250, Type 4X.
d. Electrical Connection: Wiring, 12 inches (300 mm) long, furnished with switch.
e. Conduit Connection: 1-inch (27-mm) trade size.

5. Disc, Guard, and Mounting Bracket Construction:

a. Magnetic Disc: Nylon or PVC.
b. Disc Guard: Stainless steel.
c. Mounting Bracket: Aluminum with stainless-steel shaft.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support speed-switch wiring and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a force as directed.

C. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.

2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

D. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

E. Corrosive Environments:

1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments.
3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.2 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.3 SPEED-SWITCH INSTALLATIONS

A. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

B. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire shall have the same designation at each end for operators to determine continuity at points of

connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification and on face of ceiling directly below instruments concealed above ceilings.

END OF SECTION 230923.24

SECTION 230923.27 - TEMPERATURE INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Air temperature sensors.
2. Air temperature switches.
3. Air temperature RTD transmitters.
4. Liquid and steam temperature sensors.
5. High-end, commercial-grade, liquid and steam temperature sensors.
6. Liquid temperature switches.
7. High-end, commercial-grade, liquid and steam temperature transmitters.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.27.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Environmental Conditions:

1. Instruments shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.

    a. If instrument alone cannot meet requirement, install instrument in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated and cooled, filtered, and ventilated as required by instrument and application.

2. Instruments and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Instrument's installed location shall dictate following NEMA 250 enclosure requirements:

    a. Outdoors, Protected: As directed.
    b. Outdoors, Unprotected: Type 4 or Type 4X as directed.
    c. Indoors, Heated with Filtered Ventilation: Type 1 or Type 2 as directed.
    d. Indoors, Heated with Non-Filtered Ventilation: Type 2 or Type 12 as directed.
    e. Indoors, Heated and Air Conditioned: Type 1.
    f. Mechanical Equipment Rooms:

        1) Chiller and Boiler Rooms: As directed.
        2) Air-Moving Equipment Rooms: As directed.

    g. Localized Areas Exposed to Washdown: Type 4 or Type 4X as directed.
    h. Within Duct Systems and Air-Moving Equipment Not Exposed to Possible Condensation: As directed.
    i. Within Duct Systems and Air-Moving Equipment Exposed to Possible Condensation: Type 4 or Type 4X as directed.
    j. Hazardous Locations: Explosion-proof rating for condition.

2.2 AIR TEMPERATURE SENSORS

A. Platinum RTDs: Common Requirements:

1. 100 or 1000 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
2. Two-wire, PTFE-insulated, 22-gage stranded copper leads.
3. Performance Characteristics:

    a. Range: Minus 50 to 275 deg F (Minus 46 to 135 deg C).
    b. Interchangeable Accuracy: At 32 deg F (zero deg C) within 0.5 deg F (0.3 deg C).
    c. Repeatability: Within 0.5 deg F (0.3 deg C).
    d. Self-Heating: Negligible.

4. Transmitter Requirements:

    a. Transmitter required for each 100-ohm RTD.
    b. Transmitter optional for 1000-ohm RTD, contingent on compliance with end-to-end control accuracy.

B. Platinum RTD, Single-Point Air Temperature Duct Sensors:

1. 100 or 1000 ohms.
2. Temperature Range: Minus 50 to 275 deg F (Minus 45 to 135 deg C).
3. Probe: Single-point sensor with a stainless-steel sheath.
4. Length: As required by application to achieve tip at midpoint of air tunnel, up to 18 inches (450 mm) long).
5. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
6. Gasket for attachment to duct or equipment to seal penetration airtight.
7. Conduit Connection: 1/2-inch (16-mm) trade size.)

C. Platinum RTD, Air Temperature Averaging Sensors:

1. 100 or 1000 ohms as directed.
2. Temperature Range: Minus 50 to 275 deg F (Minus 45 to 135 deg C).
3. Multiple sensors to provide average temperature across entire length of sensor.
4. Rigid probe of aluminum, brass, copper, or stainless-steel sheath.
5. Flexible probe of aluminum, brass, copper, or stainless-steel sheath and formable to a 4-inch (100-mm) radius.
6. Length: As required by application to cover entire cross section of air tunnel.
7. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
8. Gasket for attachment to duct or equipment to seal penetration airtight.
9. Conduit Connection: 1/2-inch (16-mm) trade size.)

D. Platinum RTD Outdoor Air Temperature Sensors:

1. 100 or 1000 ohms as directed.
2. Temperature Range: Minus 50 to 275 deg F (Minus 45 to 135 deg C).
3. Probe: Single-point sensor with a stainless-steel sheath.

4. Solar Shield: Stainless steel.
5. Enclosure: NEMA 250, Type 4 or 4X junction box or combination conduit and outlet box with removable cover and gasket.
6. Conduit Connection: 1/2-inch (16-mm) trade size.

E. Platinum RTD Space Air Temperature Sensors:

1. 100 or 1000 ohms.
2. Temperature Range: Minus 50 to 212 deg F (Minus 45 to 100 deg C).
3. Sensor assembly shall include a temperature sensing element mounted under a bright white, non-yellowing, plastic or flush, brushed aluminum cover as directed.
4. Provide a mounting plate that is compatible with the surface shape that it is mounted to and electrical box used.
5. Concealed wiring connection.

F. Thermal Resistors (Thermistors): Common Requirements:

1. 10,000 ohms at 25 deg C and a temperature coefficient of 23.5 ohms/ohm/deg C.
2. Two-wire, PTFE-insulated, 22-gage stranded copper leads.
3. Performance Characteristics:

    a. Range: Minus 50 to 275 deg F (Minus 46 to 135 deg C).
    b. Interchangeable Accuracy: At 77 deg F (25 deg C) within 0.5 deg F (0.3 deg C).
    c. Repeatability: Within 0.5 deg F (0.3 deg C).
    d. Drift: Within 0.5 deg F (0.3 deg C) over 10 years.
    e. Self-Heating: Negligible.

4. Transmitter optional, contingent on compliance with end-to-end control accuracy.

G. Thermistor, Single-Point Duct Air Temperature Sensors:

1. Temperature Range: Minus 50 to 275 deg F (Minus 45 to 135 deg C).
2. Probe: Single-point sensor with a stainless-steel sheath.
3. Length: As required by application to achieve tip at midpoint of air tunnel, up to 18 inches (450 mm) long).
4. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
5. Gasket for attachment to duct or equipment to seal penetration airtight.
6. Conduit Connection: 1/2- inch (16-mm) trade size.

H. Thermistor Averaging Air Temperature Sensors:

1. Temperature Range: Minus 50 to 275 deg F (Minus 45 to 135 deg C).
2. Multiple sensors to provide average temperature across entire length of sensor.
3. Rigid probe of aluminum, brass, copper, or stainless-steel sheath.
4. Flexible probe of aluminum, brass, copper, or stainless-steel sheath and formable to a 4-inch (100-mm) radius.

5. Length: As required by application to cover entire cross section of air tunnel.
6. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
7. Gasket for attachment to duct or equipment to seal penetration airtight.
8. Conduit Connection: 1/2-inch (16-mm) trade size.

I. Thermistor Outdoor Air Temperature Sensors:

1. Temperature Range: Minus 50 to 275 deg F (Minus 45 to 135 deg C).
2. Probe: Single-point sensor with a stainless-steel sheath.
3. Solar Shield: Stainless steel.
4. Enclosure: NEMA 250, Type 4 or 4X junction box or combination conduit and outlet box with removable cover and gasket.
5. Conduit Connection: 1/2-inch (16-mm) trade size.

J. Thermistor Space Air Temperature Sensors:

1. Temperature Range: Minus 50 to 212 deg F (Minus 45 to 100 deg C).
2. Sensor assembly shall include a temperature sensing element mounted under a bright white, non-yellowing, plastic or flush, brushed aluminum cover as directed.
3. Provide a mounting plate that is compatible with the surface shape that it is mounted to and electrical box used.
4. Concealed wiring connection.

K. Space Air Temperature Sensors for Use with DDC Controllers Controlling Terminal Units:

1. 100-or 1000-ohm platinum RTD or thermistor.
2. Thermistor:

    a. Pre-aged, burned in, and coated with glass; inserted in a metal sleeve; and entire unit encased in epoxy.
    b. Thermistor drift shall be less than plus or minus 0.5 deg F (0.3 deg C) over 10 years.

3. Temperature Transmitter Requirements:

    a. Mating transmitter required with each 100-ohm RTD.
    b. Mating transmitters optional for 1000-ohm RTD and thermistor, contingent on compliance with end-to-end control accuracy.

4. Provide digital display of sensed temperature.
5. Provide sensor with local control.

    a. Local override to turn HVAC on.
    b. Local adjustment of temperature set point.

c. Both features shall be capable of manual override through control system operator.

2.3 AIR TEMPERATURE SWITCHES

A. Thermostat and Switch for Low Temperature Control in Duct Applications:

1. Description:

a. Two-position control.
b. Field-adjustable set point.
c. Manual reset.
d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2. Performance:

a. Operating Temperature Range: 15 to 55 deg F (Minus 9 to 13 deg C).
b. Temperature Differential: 5 deg F (2.8 deg C), non-adjustable and additive.
c. Enclosure Ambient Temperature: Minus 20 to 140 deg F (Minus 11 to 60 deg C).
d. Sensing Element Maximum Temperature: 250 deg F (121 deg C).
e. Voltage: 120-V ac.
f. Current: 16 FLA.
g. Switch Type: Two SPDT snap switches operate on coldest 12-inch (300-mm)section along element length.

3. Construction:

a. Vapor-Filled Sensing Element: Nominal 20 feet (6 m) long.
b. Dual Temperature Scale: Fahrenheit and Celsius visible on face.
c. Set-Point Adjustment: Screw.
d. Enclosure: Painted metal, NEMA 250, Type 1.
e. Electrical Connections: Screw terminals.
f. Conduit Connection: 1/2-inch (16-mm) trade size.

B. Thermostat and Switch for High Temperature Control in Duct Applications:
1. Source Limitations: Obtain temperature-measuring sensors and transmitters and airflow from single manufacturer.
2. Description:

a. Two-position control.
b. Field-adjustable set point.
c. Manual reset.
d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

3. Performance:

    a. Temperature Range: 100 to 160 deg F (38 to 71 deg C).
    b. Temperature Differential: 5 deg F (2.8 deg C).
    c. Ambient Temperature: Zero to 260 deg F (Minus 18 to 127 deg C).
    d. Voltage: 120-V ac.
    e. Current: 16 FLA.
    f. Switch Type: SPDT snap switch.

4. Construction:

    a. Sensing Element: Helical bimetal.
    b. Enclosure: Metal, NEMA 250, Type 1.
    c. Electrical Connections: Screw terminals.
    d. Conduit Connection: 1/2-inch (16-mm) trade size.

2.4 AIR TEMPERATURE RTD TRANSMITTERS

A. Source Limitations: Obtain temperature-measuring sensors and transmitters and airflow from single manufacturer.

B. House electronics in NEMA 250 enclosure.

1. Duct: As directed.
2. Outdoor: Type 4 or Type 4X.
3. Space: Type 1.

C. Conduit Connection: 1/2-inch (16-mm) trade size.)

D. Functional Characteristics:

1. Input:

    a. 100-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two-wire sensors.
    b. 1000-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two-wire sensors.

2. Span (Adjustable):

    a. Space: 40 to 90 deg F (4 to 32 deg C).
    b. Supply Air Cooling and Heating: 40 to 120 deg F (4 to 49 deg C).
    c. Supply Air Cooling Only: 40 to 90 deg F (4 to 32 deg C).
    d. Supply Air Heating Only: 40 to 120 deg F (4 to 49 deg C).
    e. Exhaust Air: 50 to 100 deg F (10 to 38 deg C).
    f. Return Air: 50 to 100 deg F (10 to 38 deg C).
    g. Mixed Air: Minus 40 to 140 deg F (Minus 40 to 60 deg C).

h. Outdoor: Minus 40 to 140 deg F (Minus 40 to 60 deg C).

3. Output: 4- to 20-mA dc, linear with temperature; RFI insensitive; minimum drive load of 600 ohms at 24-V dc.
4. Zero and span field adjustments, plus or minus 5 percent of span. Minimum span of 50 deg F (28 deg C).
5. Match sensor with temperature transmitter and factory calibrate together.

E. Performance Characteristics:

1. Calibration Accuracy: Within 0.1 percent of the span.
2. Stability: Within 0.2 percent of the span for at least 6 months.
3. Combined Accuracy: Within 0.5 percent.

2.5 LIQUID AND STEAM TEMPERATURE SENSORS, COMMERCIAL GRADE

A. RTD:

1. Description:

a. Platinum with a value of 100 or 1000 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
b. Encase RTD in a stainless-steel sheath with a 0.25-inch (6-mm) OD.
c. Sensor Length: 4, 6, or 8 inches (100, 150, or 200 mm) as required by application.
d. Process Connection: Threaded, NPS 1/2 (DN 15).
e. Two-stranded copper lead wires.
f. Powder-coated steel enclosure, NEMA 250, Type 4.
g. Conduit Connection: 1/2-inch (16-mm) trade size.)
h. Performance Characteristics:

1) Range: Minus 40 to 210 deg F (Minus 40 to 99 deg C).
2) Interchangeable Accuracy: Within 0.54 deg F (0.3 deg C) at 32 deg F (zero deg C).

B. Thermowells:

1. Stem: Straight or stepped shank formed from solid bar stock.
2. Material: Brass or stainless steel.
3. Process Connection: Threaded, NPS 3/4 (DN 20).
4. Sensor Connection: Threaded, NPS 1/2 (DN 15).
5. Bore: Sized to accommodate sensor with tight tolerance between sensor and well.
6. Furnish thermowells installed in insulated pipes and equipment with an extended neck.
7. Length: 4, 6, or 8 inches (100, 150, or 200 mm) as required by application.
8. Thermowells furnished with heat-transfer compound to eliminate air gap between wall of sensor and thermowell and to reduce time constant.

2.6 LIQUID AND STEAM TEMPERATURE SENSORS, HIGH-END COMMERCIAL GRADE

A. RTD:

1. Resistance temperature sensors shall comply with IEC 60751, Class B requirements.
2. Platinum with a value of 100 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
3. Encase RTD in a Type 316 stainless-steel sheath with a 0.25-inch (8-mm) OD.
4. Provide wire as directed, PTFE-insulated, nickel-coated, 22-gage, stranded copper leads.
5. Provide spring-loaded RTDs for thermowell installations.
6. Performance Characteristics:

    a. Range: Minus 328 to 932 deg F (Minus 200 to 500 deg C).
    b. Interchangeable Accuracy: Within 0.54 deg F (0.3 deg C) at 32 deg F (zero deg C).
    c. Stability: Within 0.05 percent maximum ice-point resistance shift after 1000 hours at 752 deg F (400 deg C).
    d. Hysteresis: Within 0.04 percent of range.
    e. Response Time: 62.8 percent of change in 4 seconds with water flowing across sensor at 3 fps (0.9 m/s).

B. Thermowells:

1. Stem: Straight or stepped or tapered shank formed from solid bar stock.
2. Material: Type 304 or Type 316 stainless steel.
3. Process Connection: Threaded, NPS 3/4 (DN 20).
4. Sensor Connection: Threaded, NPS 1/2 (DN 15).
5. Bore: Sized to accommodate sensor with tight tolerance between sensor and well.
6. Furnish thermowells installed in insulated pipes and equipment with an extended neck that extends beyond the face of the insulation covering.
7. Length: As required by application and pipe size.
8. Thermowells furnished with heat-transfer compound to eliminate air gap between wall of sensor and thermowell and to reduce time constant.

C. Connection Heads:

1. Housing: Low-copper cast-aluminum alloy, complying with NEMA 250, Type 4.
2. Terminals: Six or eight as required by sensor.
3. Conduit Connection: 1/2-inch (16-mm) trade size.
4. Sensor Connection: NPS 1/2 (DN 15).

D. Assembly: Sensor manufacturer shall furnish sensor, thermowell, and sensor connection head to provide a matched assembly.

2.7 LIQUID TEMPERATURE SWITCHES

A. Thermostat and Switch for Temperature Control in Pipe Applications:

1. Description:

a. Two-position control.
b. Field-adjustable set point.
c. Manual reset.
d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2. Performance:

a. Operating Temperature Range: 65 to 200 deg F (18 to 3 deg C).
b. Temperature Differential Deadband: 5 to 30 deg F (3 to 17 deg C), adjustable.
c. Enclosure Ambient Temperature: 150 deg F (66 deg C).
d. Sensing Element Pressure Rating: 200 psig (1379 kPa).
e. Voltage: 120-V ac.
f. Current: 8 FLA.
g. Switch Type: SPDT snap switch.

3. Construction:

a. Vapor-Filled Immersion Element: Copper, nominal 3 inches (75 mm) long.
b. Temperature Scale: Fahrenheit, visible on face.
c. Set-Point Adjustment: Screw.
d. Enclosure: Painted metal, NEMA 250, Type 1.
e. Electrical Connections: Screw terminals.
f. Conduit Connection: 3/4-inch (21-mm) trade size).

2.8 LIQUID AND STEAM TEMPERATURE TRANSMITTERS, COMMERCIAL GRADE

A. House electronics in NEMA 250, Type 4 or Type 4X enclosure.

B. Enclosure Connection: 1/2-inch (16-mm) trade size.

C. Functional Characteristics:

1. Input: 100-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two- or three-wire sensors.
2. Default Span (Adjustable):

a. Chilled Water: Zero to 100 deg F (Minus 18 to 38 deg C).
b. Condenser Water: Zero to 120 deg F (Minus 18 to 49 deg C).

c. Heating Hot Water: 32 to 212 deg F (Zero to 100 deg C).
d. Heat Recovery: Zero to 120 deg F (Minus 18 to 49 deg C).

3. Output: 4- to 20-mA dc, linear with temperature; RFI insensitive; minimum drive load of 600 ohms at 24-V dc.
4. Zero and span field adjustments, plus or minus 5 percent of span. Minimum span of 50 deg F (28 deg C).
5. Match sensor with temperature transmitter and factory calibrate together. Each matched sensor and transmitter set shall include factory calibration data traceable to NIST.

D. Performance Characteristics:

1. Calibration Accuracy: Within 0.1 percent of the span.
2. Stability: Within 0.2 percent of the span for at least 6 months.
3. Combined Accuracy: Within 0.5 percent.

PART 3 - EXECUTION

3.1 TEMPERATURE INSTRUMENT APPLICATIONS

A. Air Temperature Sensors:

1. Duct, as directed.
2. Outdoor, as directed.
3. Space, as directed.

B. Air Temperature Transmitters:

1. Duct: Not required or Air temperature RTD transmitter as directed.
2. Outdoor: Not required or Air temperature RTD transmitter as directed.
3. Space: Not required or Air temperature RTD transmitter as directed.

C. Liquid and Steam Temperature Sensors:

1. System: Liquid and steam temperature sensor, commercial grade or Liquid and steam temperature sensor, high-end commercial grade as directed.

D. Liquid and Temperature Transmitters:

1. System: Liquid and steam temperature transmitter, commercial grade.

3.2 INSTALLATION, GENERAL

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support instruments, tubing, piping, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a force as directed.

C. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

D. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

E. Corrosive Environments:

1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments.
3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.3 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.4 TEMPERATURE INSTRUMENT INSTALLATIONS

A. Mounting Location:

1. Roughing In:

    a. Outline instrument mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.
    b. Provide independent inspection to confirm that proposed mounting locations comply with requirements indicated and approved submittals.

        1) Indicate dimensioned locations with mounting height for all surface-mounted products on Shop Drawings.
        2) Do not begin installation without submittal approval of mounting location.

    c. Complete installation rough-in only after confirmation by independent inspection is complete and approval of location is documented for review by Owner and Architect on request.

2. Install switches and transmitters for air and liquid temperature associated with individual air-handling units and associated connected ductwork and piping near air-handling units co-located in air-handling unit system control panel to provide service personnel a single and convenient location for inspection and service.
3. Install liquid and steam temperature switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
4. Install air temperature switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
5. Mount switches and transmitters on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

B. Special Mounting Requirements:

1. Protect products installed outdoors from solar radiation, building and wind effect with stand-offs and shields constructed of Type 316 stainless.
2. Temperature instruments having performance impacted by temperature of mounting substrate shall be isolated with an insulating barrier located between instrument and substrate to eliminate effect. Where instruments requiring insulation are located in finished space, conceal insulating barrier in a cover matching the instrument cover.

C. Mounting Height:

1. Mount temperature instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code or state and Federal accessibility

requirements within a range of 42 to 72 inches (1.1 to 1.6 m) above the adjacent floor, grade, or service catwalk or platform.

a. Make every effort to mount at 60 inches (1500 mm).

D. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

E. Space Temperature Sensor Installation:

1. Conceal assembly in an electrical box of sufficient size to house sensor and transmitter, if provided.
2. Install electrical box with a faceplate to match sensor cover if sensor cover does not completely cover electrical box.
3. In finished areas, recess electrical box within wall.
4. In unfinished areas, electrical box may be surface mounted if electrical light switches are surface mounted. Use a cast-aluminum electric box for surface-mounted installations.
5. Align electrical box with other electrical devices such as visual alarms and light switches located in the vicinity to provide a neat and well-thought-out arrangement. Where possible, align in both horizontal and vertical axis.

F. Outdoor Air Temperature Sensor Installation:

1. Mount sensor in a discrete location facing north.
2. Protect installed sensor from solar radiation and other influences that could impact performance.
3. If required to have a transmitter, mount transmitter remote from sensor in an accessible and serviceable location indoors.

G. Single-Point Duct Temperature Sensor Installation:

1. Install single-point-type, duct-mounted, supply- and return-air temperature sensors. Install sensors in ducts with sensitive portion of the element installed in center of duct cross section and located to sense near average temperature. Do not exceed 24 inches (610 mm) in sensor length.
2. Install return-air sensor in location that senses return-air temperature without influence from outdoor or mixed air.
3. Rigidly support sensor to duct and seal penetration airtight.
4. If required to have transmitter, mount transmitter remote from sensor at accessible and serviceable location.

H. Averaging Duct Temperature Sensor Installation:

1. Install averaging-type air temperature sensor for temperature sensors located within air-handling units, similar equipment, and large ducts with air tunnel cross-sectional area of 20 sq. ft. (1.86 sq. m) and larger.

2. Install sensor length to maintain coverage over entire cross-sectional area. Install multiple sensors where required to maintain the minimum coverage.
3. Fasten and support sensor with manufacturer-furnished clips to keep sensor taut throughout entire length.
4. If required to have transmitter, mount transmitter in an accessible and serviceable location.

I. Low-Limit Air Temperature Switch Installation:

1. Install multiple low-limit switches to maintain coverage over entire cross-sectional area of air tunnel.
2. Fasten and support sensing element with manufacturer-furnished clips to keep element taut throughout entire length.
3. Mount switches outside of airstream at a location and mounting height to provide easy access for switch set-point adjustment and manual reset.
4. Install on entering side of cooling coil unless otherwise indicated on Drawings.

J. Liquid Temperature Sensor Installation:

1. Assembly shall include sensor, thermowell and connection head.
2. For pipe NPS 4 (DN 100) and larger, install sensor and thermowell length to extend into pipe between 50 to 75 percent of pipe cross section.
3. For pipe smaller than NPS 4 (DN 100):

    a. Install reducers to increase pipe size to NPS 4 (DN 100) at point of thermowell installation.
    b. For pipe sizes NPS 2-1/2 and NPS 3 (DN 65 and DN 80), thermowell and sensor may be installed at pipe elbow or tee to achieve manufacturer-recommended immersion depth in lieu of increasing pipe size.
    c. Minimum insertion depth shall be 2-1/2 inches (65 mm).

4. Install matching thermowell.
5. Fill thermowell with heat-transfer fluid before inserting sensor.
6. Tip of spring-loaded sensors shall contact inside of thermowell.
7. For insulated piping, install thermowells with extension neck to extend beyond face of insulation.
8. Install thermowell in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement. If top dead center location is not possible due to field constraints, install thermowell at location along top half of pipe.
9. For applications with transmitters, mount transmitter remote from sensor in an accessible and serviceable location from floor service platform or catwalk.

3.5 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine

continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification and on face of ceiling directly below instruments concealed above ceilings.

3.6 CLEANING

A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.

B. Wash and shine glazing.

C. Polish glossy surfaces to a clean shine.

3.7 CHECK-OUT PROCEDURES

A. Check installed products before continuity tests, leak tests, and calibration.

B. Check temperature instruments for proper location and accessibility.

C. Verify sensing element type and proper material.

D. Verify location and length.

E. Verify that wiring is correct and secure.

3.8 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform according to manufacturer's written instruction.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Prepare test and inspection reports.

3.9 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.10 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain temperature instruments.

END OF SECTION 230923.27

SECTION 230923.33 - VIBRATION INSTRUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes mechanical vibration switches connected to direct digital control systems for HVAC.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.33.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include number-coded identification system for unique identification of wiring and cable.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 MECHANICAL VIBRATION SWITCHES

A. Description: Inertia-sensitive armature mechanism trips on high vibration and operates snap action switch.

B. Performance:

1. Frequency Range: Zero to 3600 rpm.
2. Vibration Range: Zero to as directed.
3. Temperature Limits: Minus 40 to 158 deg F (Minus 40 to 70 deg C).
4. Electrical Rating: 15 A at 125- or 480-V ac.
5. Switch Type: SPDT or DPDT snap switch as directed.
6. Start Delay: 20 to 30 seconds, by applying reset voltage at start signal to prevent switch from tripping.

C. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for hazardous environments Class I, Groups B, C, and D; Class II, Groups E, F, and G.

D. Operator Interface:

1. Vibration Set-Point Adjustment: Zero to 100 percent of range.
2. Push-button reset on switch face and reset coil for remote reset.

E. Enclosure Construction:

1. Cast aluminum.
2. NEMA 250, Type 4 or Type 4X.
3. Electrical Connection: Screw terminals.
4. Conduit Connection: 3/4-inch (21-mm) trade size.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.

C. Properly support instrument wiring and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a force as directed.

D. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

E. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

F. Corrosive Environments:

1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments.
3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.2 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification.

END OF SECTION 230923.33

SECTION 230923.43 - WEATHER STATIONS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes weather stations connected to direct-digital controls for HVAC.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.43.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Include number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 WEATHER STATION

A. Description:

1. Weather station shall measure and record wind speed and direction, air temperature and relative humidity, barometric pressure, solar radiation, and rain.
2. Design weather station for applications with minimal visual impact, high reliability, and a long interval between routine servicing.
3. Weather station shall use solid-state sensors with no moving parts.
4. Weather station shall not be impaired by heavy snowfall or freezing conditions that produce rime ice. Provide a thermostatically controlled heater element in the sensor head that keeps the wind sensor elements and the precipitation sensor surface free of snow and ice to minus 62 deg F (minus 52 deg C).
5. Weather station shall directly connect to host device, or wirelessly connect to a host device through a fully integrated, industrial-grade, 916-MHz spread spectrum radio-frequency communications technology. Where required by application, replace 916-MHz radio-frequency components with 922-MHz and 2.4-GHz radio-frequency components to comply with local, regional, and national radio-frequency licensing requirements.
6. RS-232 serial data I/O shall be located on the bottom of the weather station and used as a second serial communications port, for programming and testing the system, or for direct data downloads using a personal computer or personal digital assistant.
7. Weather station shall be provided with a mounting system supplied by weather station manufacturer that is suitable for the installation.

B. Sensor Technology:

1. Wind speed and direction shall use acoustic techniques. Sensor shall consist of three equally spaced ultrasonic transducers in a horizontal plane. Values of any two array paths shall enable computation of both wind speed and direction, and a signal processing technique shall enable the measurement to be calculated using the two array paths of the best quality.
2. Rain shall be measured using a stainless-steel piezometric impact surface that counts the raindrops and measures their acoustic signature, integrating that information to provide a near-real-time value for rainfall amount and rate.
3. Barometric pressure, relative humidity, air temperature, and solar radiation measurements shall be made by scientific grade sensors.
4. Air-temperature and relative-humidity sensors shall be combined in an integrated, user-replaceable unit that requires no calibration.

    a. Relative humidity sensor shall be a thin-polymer, capacitive sensor.
    b. Air-temperature sensor shall be a capacitive ceramic sensor.

5. Barometric pressure shall be measured with a capacitive silicon, temperature-corrected, strain gage.
6. Solar radiation shall be measured by a silicon pyranometer with a cut filter limiting the spectral exposure to the 300- to 1100-nm wavelength.

C. Performance:

1. Air Temperature:

   a. Range: Minus 60 to 140 deg F (Minus 51 to 60 deg C).
   b. Accuracy: Within 0.9 deg F (0.5 deg C).
   c. Resolution: 0.1 deg F (0.06 deg C).

2. Relative Humidity:

   a. Range: Zero to 100 percent.
   b. Accuracy: Within 3 percent over the range of zero to 90 percent and within 5 percent between 90 to 100 percent.
   c. Resolution: 0.1 percent.

3. Barometric Pressure:

   a. Range: 17.72- to 32.48-in. Hg (450 to 825 mm).
   b. Accuracy: 0.015-in. Hg (0.38 mm) between 32 to 86 deg F (0 to 30 deg C).
   c. Resolution: 0.03-in. Hg (0.76 mm) between minus 60 to 140 deg F (minus 51 to 60 deg C).

4. Solar Radiation:

   a. Spectral Range: 300 to 1100 nm.
   b. Reproducibility: Within 2 percent.
   c. Output: 0.2 mV per watts per square meters.
   d. Range: Zero to 1000 W per square meters.
   e. Temperature Range: Minus 40 to 130 deg F (Minus 40 to 54 deg C).

5. Rain:

   a. Collecting Area: 9.3 sq. in. (6000 sq. mm).
   b. Range: Zero to 7.87 inches (Zero to 200 mm) per hour.
   c. Accuracy: Within 5 percent.
   d. Resolution: 0.001 inch (0.025 mm).

6. Wind Direction:

   a. Azimuth: Zero to 360 degrees.
   b. Response Time: 250 ms.
   c. Accuracy: Within 2 degrees.
   d. Resolution: 1 degree.

7. Wind Speed:

    a. Range: Zero to 134 mph (Zero to 216 km/h).
    b. Response Time: 0.25 second.
    c. Accuracy: Greater of 0.67 mph (1.1 km/h) or 2 percent.
    d. Resolution: 0.22 mph (0.35 km/h).

8. Data Storage: 60 days of hourly data.

D. Output Signals:

1. RS-232 or RS-485 serial interface directly from weather station to host.
2. In applications that cannot accept a serial signal, provide a serial-to-analog converter.
3. Serial-to-Analog Converter:

    a. Serial converter designed to add analog outputs for measuring instruments that have only serial output.
    b. Configure to give analog outputs from all measuring sensors and calculated parameters.
    c. Each converter shall have four analog outputs with a 4- to 20-mA signal.
    d. Provide multiple converters for applications requiring more points.
    e. Converter requires a 24-V dc power supply.

E. Communication Interface:

1. Weatherproof serial cables shall be used to connect the RS-232 I/O on the weather station. Cables shall use nickel-plated brass DB-9 connectors for corrosion resistance and include a Sanoprene jacket suitable for both high-ultraviolet and direct-burial environments.
2. An RF4xx spread spectrum radio-frequency transceiver shall be provided with every wireless weather station.

F. Unit shall be provided with a 120-V ac, 60-Hz power supply, a serial cable, and an antenna.

G. Software:

1. Data Transfer Protocols, Software, and Data Interface Hardware: Weather stations that communicate using a proprietary protocol shall be provided with a software development kit to enable a qualified software developer in development of software drivers for third-party devices or software.
2. Manufacturer shall submit description and pricing information of software application offerings for weather station management, data acquisition and logging, report generation, and data display for review and consideration.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install products level, plumb, parallel, and perpendicular with building construction.

B. Properly support weather station, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to forces that are consistent with building code structural design requirements.

C. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

D. Corrosive Environments:

1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments.
3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where components are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.2 ELECTRIC POWER

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Prepare test and inspection reports.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain weather stations.

END OF SECTION 230923.43

SECTION 230993.11 - SEQUENCE OF OPERATIONS FOR HVAC DDC

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes control sequences for DDC for HVAC systems, subsystems, and equipment.

B. Related Requirements:

1. Section 230923 "DDC Systems for HVAC" for control equipment.

1.2 HEATING CONTROL SEQUENCES

A. Control Circulating Pump(s):

1. Energize pump(s) at outdoor-air temperatures below 65 deg F (18 deg C).
2. Energize pump(s) at room temperatures below 72 deg F (22 deg C).

B. Additional Circulating Pump(s): Energize pump(s) and maintain operation when differential pressure drops below 30 percent of specified pump head.

C. Additional Circulating Pump(s): Energize pump(s) and maintain operation when differential pressure drops below specified pump head as directed.

D. Circulating Pump(s) Failure Alarm: Signal alarm condition, if there is no pressure differential between supply and return piping.

E. Alternate Pumps(s): Operate pump(s) on lead-lag, alternating each startup.

F. Alternate Pumps(s): Operate pump(s) on lead-lag, alternating on run hours as directed.

G. Control Circulating Pump(s) Speed: Control pump speed to maintain pressure differential as directed.

H. Heating-Water Supply Temperature Control:

1. Modulate control valve to maintain heating-water supply temperature.
2. Reset heating-water supply temperature in straight-line relationship with outdoor-air temperature for the following conditions:

a. 195 deg F (90 deg C) heating water when outdoor-air temperature is minus 30 deg F (minus 35 deg C).

b. 130 deg F (54 deg C) heating water when outdoor-air temperature is 75 deg F (24 deg C).

I. Heating-Water Supply Temperature Reset: Reset heating-water supply temperature in response to greatest heating demand to maintain at least one cooling control valve 90 percent open.

J. Heating-Water Supply Temperature Reset: Reset heating-water supply temperature in straight-line relationship with outdoor-air temperature for the following conditions:

1. 195 deg F (90 deg C) heating water when outdoor-air temperature is minus 30 deg F (minus 35 deg C).
2. 130 deg F (54 deg C) heating water when outdoor-air temperature is 75 deg F (24 deg C).
3. 150 deg F (65 deg C) minimum heating-water temperature.

K. Indicate the following on the operator's workstation display terminal:

1. DDC system graphic.
2. DDC system status, on-off.
3. Outdoor-air temperature.
4. Room temperature.
5. Circulating pump(s) on-off status (enabled or disabled).
6. Circulating pump(s) on-off indication (operating or not operating).
7. Additional circulating pump(s) pressure differential.
8. Additional circulating pump(s) pressure differential set point.
9. Additional circulating pump(s) on-off indication (operating or not operating).
10. Circulating pump(s) alarm pressure differential.
11. Circulating pump(s) alarm pressure differential set point.
12. Alarm (circulating pump(s) failure).
13. Circulating pump(s) speed pressure differential.
14. Circulating pump(s) speed pressure differential set point.
15. Circulating pump(s) speed.
16. Heating-water supply temperature.
17. Heating-water return temperature.
18. Heating-water control-valve position.
19. Heating-water supply temperature set point.
20. Heating-water control-point output valve.

1.3 CENTRAL CHILLED-WATER SYSTEM SEQUENCES

A. Central Chilled-Water System Occupied Time Schedule:

1. Enable startup, initiation, and control.
2. Energize condenser-water pumps on occupied/unoccupied cycle.
3. Energize condenser-water pumps on day/night cycle.

4. After chilled-water system shutdown, operate pump(s) for an additional 3 minutes.

B. Start and Stop Condenser-Water Pump(s): Confirm adequate water level in cooling-tower sump or at pump suction and energize pump(s) as directed.

C. Start and Stop Condenser-Water Pump(s): Confirm adequate water level in cooling-tower sump or at pump suction at pressures as directed and energize pump(s).

D. Start and Stop Condenser-Water Pump(s): Confirm outdoor-air temperature is above 50 deg F (10 deg C) and energize pump(s).

E. Start and Stop Condenser-Water Pump(s): Confirm cooling demand from ventilation system(s) and energize pump(s).

F. Start and Stop Chilled-Water Pump(s): Energize pump(s) when the condenser-water pump(s) and system start.

G. Start and Stop Cooling-Tower Fan(s): Energize fan(s) when the condenser-water pump(s) and system start.

H. Start and Stop Chillers: Energize chiller(s) when the condenser-water and chilled-water pump(s) and system start.

I. Start and Stop Chiller(s): Energize chiller internal control circuit when the condenser-water and chilled-water pump(s) and system start.

J. Alternate Chiller(s):

1. Operate chiller(s) on lead-lag, alternating each startup or based on adjustable runtime hour set point as directed.
2. Start additional chiller when load exceeds capacity of operating chillers as follows:

    a. When common chilled-water supply temperature exceeds set point for a 30-minute period.
    b. When chiller power draw has reached its operator adjustable high limit for a 30-minute period.
    c. When combination of outdoor temperature and time schedule ensure enough run-time before time schedule shutdown.

3. Stop chiller when load capacity of operating chillers drops to less than 11 percent of capacity of next chiller to be shut down for a 30-minute period.
4. Adding and dropping chiller(s) as follows: As directed.

K. Alarm Chiller(s) Start Failure: Signal alarm on signal from chiller control panel.

L. Start and Stop Chiller(s): Report chiller electronic control, operating, and alarm functions.

M. Chilled-Water Level: Signal alarm on expansion tank low level or low pressure as directed.

N. Chilled-Water Supply Temperature: Maintain chilled-water supply temperature.

1. Reset chilled-water supply temperature in response to greatest cooling demand to maintain at least one cooling control valve 90 percent open.
2. Reset chilled-water supply temperature in straight-line relationship with outdoor-air temperature for the following conditions:

    a. 44 deg F (7 deg C) chilled water when outdoor-air temperature is 80 deg F (26 deg C).
    b. 54 deg F (12 deg C) chilled water when outdoor-air temperature is 60 deg F (15 deg C).

3. Reset chilled-water supply temperature based on constant return chilled-water temperature of 54 deg F (12 deg C).

O. Condenser-Water Temperature:

1. Modulate control valve open to cooling tower and closed to bypass to maintain when condenser-water supply temperature is above 85 deg F (29 deg C) temperature set point. Modulate control valve closed to cooling tower and open to bypass when condenser-water supply temperature is below 55 deg F (13 deg C) temperature set point.
2. Cycle tower fan(s) on and off to maintain 55 deg F (13 deg C) temperature set point.
3. Cycle tower fan(s) on and off to maintain condenser-water supply temperature in straight-line relationship with outdoor-air temperature for the following conditions:

    a. 85 deg F (29 deg C) condenser water when outdoor-air temperature is 80 deg F (26 deg C).
    b. 55 deg F (13 deg C) condenser water when outdoor-air temperature is 55 deg F (13 deg C).

4. Cycle tower fan(s) on and modulate fan speed from minimum to maximum to maintain 55 deg F (13 deg C) temperature set point.
5. Cycle tower fan(s) on and off to maintain condenser-water supply temperature in straight-line relationship with outdoor-air temperature for the following conditions:

    a. 85 deg F (29 deg C) condenser water when outdoor-air temperature is 80 deg F (26 deg C).

b. 55 deg F (13 deg C) condenser water when outdoor-air temperature is 55 deg F (13 deg C).

P. Cooling-Tower Sump Heater:

1. Energize sump heater if sump temperature falls below 40 deg F (4.5 deg C) temperature set point.
2. Open control valve in sump heater drain piping if sump temperature falls below 35 deg F (1.5 deg C) temperature set point.

Q. Cooling-Tower Sump Heater:

1. Energize sump heater if sump temperature falls below as directed temperature set point.
2. Open control valve in sump heater drain piping if sump temperature falls below as directed temperature set point.

R. Control Circulating Pump(s) Speed:

1. Control pump speed to maintain flow through chiller.
2. Report pressure drop and flow.

S. Circulation through Chiller: Report pressure drop and flow through chiller.

T. Indicate the following on the operator's workstation display terminal:

1. DDC system graphic.
2. DDC system status, on-off.
3. Low-level cooling-tower sump alarm.
4. Outdoor temperature.
5. Cooling (software) demand indication.
6. Time and time schedule.
7. Condenser-water pump(s) on-off status (enabled or disabled).
8. Condenser-water pump(s) on-off indication (operating or not operating).
9. Condenser-water flow indication.
10. Chilled-water pump(s) on-off status (enabled or disabled).
11. Chilled-water pump(s) on-off indication (operating or not operating).
12. Cooling-tower fan(s) on-off indication (operating or not operating).
13. Chilled-water flow indication.
14. Refrigeration machine on-off indication (operating or not operating).
15. Chilled-water supply temperature.
16. Chilled-water return temperature.
17. Chilled-water temperature control-point adjustment.
18. Chiller(s) on-off status (enabled or disabled).
19. Chiller(s) on-off indication (operating or not operating).
20. Chiller "failure-to-start" indication.
21. Expansion tank low-level alarm.
22. Condenser-water sump (return) control-point temperature.

23. Condenser-water sump (return) temperature.
24. Condenser-water control-valve position.
25. Cooling-tower fan(s) on-off indication (operating or not operating).
26. Condenser-water supply temperature.
27. Cooling-tower sump temperature.
28. Cooling-tower sump heater on-off indication (operating or not operating).
29. Cooling-tower sump drain indication.
30. Chiller(s) power input (instantaneous).
31. Chilled-water pressure drop through chiller.
32. Chilled-water flow through chiller.
33. Condenser-water pressure drop through chiller.
34. Condenser-water flow through chiller.
35. Chiller condenser-water supply and return temperature.
36. Chiller chilled-water supply and return temperature.
37. System capacity in tons.

1.4 AIR-HANDLING-UNIT CONTROL SEQUENCES

A. Air-Handling Unit Occupied Time Schedule:

1. Enable startup, initiation, and control.
2. Energize unit on occupied/unoccupied cycle.
3. Energize unit on day/night cycle.
4. Energize unit on duty cycle.
5. Energize return-air fans 30 seconds after supply fans are energized.
6. Do not enable mixed-air control during morning warm-up period.

    a. Unoccupied: Position outdoor-air and relief-air dampers closed and return-air dampers open.

7. Do not enable humidifier control during morning warm-up period.
8. Enable control of heating coil(s) during morning warm-up period.
9. Energize coil circulating pump(s).
10. Return heating control valves to normal position when unit is cycled on.
11. Do not enable cooling-coil control during morning warm-up period.

B. Start and Stop Supply Fan(s):

1. Allow start if temperature is above 37 deg F (3 deg C).
2. Signal alarm if fan fails to start as commanded.

C. Start and Stop Supply Fan(s):

1. Allow start if temperature is below 120 deg F (49 deg C).
2. Signal alarm if fan fails to start as commanded.

D. Start and Stop Supply Fan(s):

1. Allow start if airstream is free of products of combustion.
2. Signal alarm if fan fails to start as commanded.

E. Supply Fan(s) Variable-Volume Control:

1. Fan Speed Control:

    a. Maintain constant supply-duct static-pressure set point as directed.
    b. Set-Point Reset (for Systems with DDC of Individual Zone Terminals): Reset static-pressure set point based on the zone requiring the most pressure; reset set point lower until one zone damper is nearly wide open.
    c. Set variable-frequency drive to minimum speed when fan is stopped.

2. Fan Airflow: Report supply-duct airflow.
3. High Pressure: When static pressure rises above excessive-static-pressure set point as directed:

    a. Stop fan.
    b. Signal alarm.

F. Return Fan(s) Variable-Volume Control:

1. Maintain constant airflow offset between supply- and return-air fans.
2. Set variable-frequency drive to minimum speed when fan is stopped.

G. Return Fan(s) Variable-Volume Control:

1. Maintain constant indoor static-pressure set point of 0.02-inch wg (5 Pa) positive for outdoors.
2. Set variable-frequency drive to minimum speed when fan is stopped.

H. Preheat Coil:

1. Freeze Protection: Allow air-handling unit start if duct temperature is above 33 deg F (1 deg C).
2. Low-Temperature Operation: Energize coil circulating pump(s) at outdoor-air temperatures below 35 deg F (2 deg C).
3. Supply or Discharge-Air Temperature as directed: Maintain air-temperature set point of 55 deg F (13 deg C).

I. Mixed-Air Control:

1. Minimum Position:

    a. Open minimum outdoor-air dampers or outdoor-air dampers to minimum position as directed.
    b. Modulate outdoor-air dampers to maintain minimum airflow at set point as directed.

2. Heating Reset: Close minimum outdoor-air dampers or Set outdoor-air dampers to minimum position as directed.
3. Carbon Dioxide Reset: Reset minimum outdoor-air damper position to maintain carbon dioxide set point as directed.
4. Supply or Mixed-Air Temperature as directed:

    a. Modulate outdoor-, return-, and relief-air dampers to maintain air-temperature set point of 55 deg F (13 deg C).
    b. Do not enable control during morning warm-up period.

5. Cooling Reset: Set outdoor-air dampers to minimum position when outdoor-air temperature exceeds return-air temperature or enthalpy exceeds return-air enthalpy as directed.

J. Humidifier:
1. Maintain humidity in straight-line relationship for the following conditions:

    a. 20 percent when outdoor-air temperature is minus 30 deg F (minus 35 deg C).
    b. 40 percent when outdoor-air temperature is 75 deg F (24 deg C).

K. Evaporative Cooler:

1. Temperature:

    a. Modulate evaporative cooler control valve and cycle evaporative cooler pump.
    b. Maintain air-temperature set point of 55 deg F (13 deg C).

2. Humidity Limit:

    a. Return to their normal position as directed.
    b. Signal high humidity alarm.

L. Filters: Signal alarm on low- and high-pressure differential conditions.

M. Hydronic Heating Coil:

1. Supply or Discharge-Air Temperature as directed:

    a. Maintain supply-air-temperature set point of 55 deg F (13 deg C) by modulating heating coil control valve.
    b. Maintain supply-air-temperature set point in straight-line relationship for the following conditions:

        1) 65 deg F (18 deg C) when return-air temperature is 70 deg F (21 deg C).

2) 55 deg F (13 deg C) when return-air temperature is 75 deg F (24 deg C).

c. Maintain supply-air-temperature set point within limits in response to space temperature reset:

1) Minimum 55 deg F (13 deg C).
2) Maximum 131 deg F (55 deg C).

d. During morning warm-up period, maintain supply-air-temperature set point of 80 deg F (27 deg C).

2. Low-Temperature Operation: Energize coil circulating pump(s) at outdoor-air temperatures below 35 deg F (2 deg C).

N. Hydronic Cooling Coil:

1. Supply or Discharge-Air Temperature as directed:

a. Maintain supply-air-temperature set point of 55 deg F (13 deg C) by modulating cooling-coil control valve.
b. Maintain supply-air-temperature set point within limits in response to space temperature reset:

1) Minimum 55 deg F (13 deg C).
2) Maximum 68 deg F (20 deg C).

c. Supply-Air-Temperature Reset: Reset the supply-air temperature to outdoor temperature at least 25 percent of the difference between the design supply-air temperature and the design room air temperature.

2. Temperature Reset: Reset supply-air temperature in straight-line relationship for the following conditions:

a. 65 deg F (18 deg C) when return-air temperature is 70 deg F (21 deg C).
b. 55 deg F (13 deg C) when return-air temperature is 75 deg F (24 deg C).

3. Temperature Reset:

a. Reset supply-air temperature in response to greatest cooling demand.
b. Supply-Air-Temperature Reset: Reset the supply-air temperature to outdoor temperature at least 25 percent of the difference between the design supply-air temperature and the design room air temperature.

4. Space Humidity Reset: Reset supply-air temperature to 55 deg F (13 deg C) to maintain space relative humidity of 45 percent.

O. Coordination of Air-Handling Unit Sequences: Ensure that preheat, mixed-air, heating-coil, and cooling-coil controls have common inputs and do not overlap in function.

P. Indicate the following on the operator's workstation display terminal:

1. DDC system graphic.
2. DDC system on-off indication (operating or not operating).
3. DDC system occupied/unoccupied mode.
4. Outdoor-air-temperature indication.
5. Supply-fan on-off indication (operating or not operating).
6. Supply duct static-pressure indication.
7. Supply duct static-pressure set point.
8. Supply-fan airflow rate.
9. Supply-fan speed.
10. Return-fan on-off indication (operating or not operating).
11. Space static-pressure indication.
12. Space static-pressure set point.
13. Return-fan airflow rate.
14. Return-fan speed.
15. Preheat-coil air-temperature indication.
16. Preheat-coil air-temperature set point.
17. Preheat-coil pump on-off indication (operating or not operating).
18. Preheat-coil control-valve position.
19. Mixed-air-temperature indication.
20. Mixed-air-temperature set point.
21. Mixed-air damper position.
22. Relative humidity indication.
23. Relative humidity set point.
24. Relative humidity control-valve position.
25. Filter air-pressure-drop indication.
26. Filter low-air-pressure drop set point.
27. Filter high-air-pressure drop set point.
28. Supply or Discharge-air-temperature indication as directed.
29. Supply or Discharge-air-temperature set point as directed.
30. Heating-coil leaving-air-temperature indication.
31. Heating-coil leaving-air-temperature set point.
32. Heating-coil pump on-off indication (operating or not operating).
33. Heating-coil control-valve position.
34. Cooling-coil leaving-air-temperature indication.
35. Cooling-coil leaving-air-temperature set point.
36. Cooling-coil control-valve position.
37. Space temperature indication.
38. Space temperature set point.

1.5 TERMINAL UNIT OPERATING SEQUENCE

A. Cabinet Unit Heater, Hydronic:

1. Space Temperature: Cycle fan to maintain 75 deg F (24 deg C) space temperature.
2. Space Temperature:

    a. Cycle fan to maintain 75 deg F (24 deg C) space temperature.
    b. Modulate valve to maintain 75 deg F (24 deg C) space temperature.

3. Low-Temperature Safety: Stop fan when return heating-water or condensate temperature falls below 35 deg F (2 deg C) as directed.

B. Cabinet Unit Heater, Electric: Cycle fan to maintain 75 deg F (24 deg C) space temperature.

C. Unit Heater, Hydronic:

1. Space Temperature:

    a. Cycle fan to maintain 75 deg F (24 deg C) space temperature.
    b. Modulate valve to maintain 75 deg F (24 deg C) space temperature.

2. Low-Temperature Safety: Stop fan when return heating-water or condensate temperature falls below 35 deg F (2 deg C).

D. Unit Heater, Electric: Space thermostat cycles fan and sequences stages of heating to maintain 75 deg F (24 deg C) space temperature.

E. Combustion-Air Unit Heaters: Modulate valve to maintain 75 deg F (24 deg C) space temperature.

F. Radiant Heating Cable, Electric: Cycle power to maintain 75 deg F (24 deg C) space temperature set point.

G. Radiant Heating Panel, Electric: Cycle power to maintain space temperature set points.

1. Occupied: 75 deg F (24 deg C).
2. Unoccupied: 65 deg F (18 deg C).

H. Radiant Heating Panel, Hydronic: Cycle valve open and closed to maintain temperature set point.

1. Occupied: 75 deg F (24 deg C).
2. Unoccupied: 65 deg F (18 deg C).

I. Two-Pipe, Single-Coil, Fan-Coil Unit:

1. Manual Start: Start and stop fan.

2. Space Temperature: Modulate valve to maintain space temperature set points.

    a. Occupied Cooling Temperature: 75 deg F (24 deg C).
    b. Occupied Heating Temperature: 70 deg F (24 deg C).
    c. Unoccupied Cooling Temperature: 85 deg F (24 deg C).
    d. Unoccupied Heating Temperature: 65 deg F (18 deg C).

3. Occupied Time Schedule: Start and stop fan.
4. Space Temperature: Modulate valve to maintain space temperature set points.

    a. Occupied: 75 deg F (24 deg C).
    b. Unoccupied: 65 deg F (18 deg C).
    c. System Changeover: Reverse control-valve action to switch from heating to cooling.

J. Four-Pipe, Hydronic Fan-Coil Unit:

1. Occupied Time Schedule: Start and stop fan and enable control.
2. Space Temperature: Modulate control valves to maintain space temperature set points.

    a. Occupied Cooling Temperature: 75 deg F (24 deg C).
    b. Occupied Heating Temperature: 70 deg F (24 deg C).
    c. Unoccupied Cooling Temperature: 85 deg F (24 deg C).
    d. Unoccupied Heating Temperature: 65 deg F (18 deg C).

K. Unit Ventilator:

1. Occupied Time Schedule: Start and stop fan, move outdoor- and return-air dampers to minimum or maximum outdoor-air position, and enable control as directed.
2. Space Temperature - Valves: Modulate heating-water control valve and chilled-water control valve in sequence to maintain space temperature set points.

    a. Occupied Cooling Temperature: 75 deg F (24 deg C).
    b. Occupied Heating Temperature: 70 deg F (24 deg C).
    c. Unoccupied Cooling Temperature: 85 deg F (24 deg C).
    d. Unoccupied Heating Temperature: 65 deg F (18 deg C).

3. Space Temperature - Dampers: Modulate outdoor- and return-air dampers to maintain space temperature set points.

    a. Occupied Cooling Temperature: 75 deg F (24 deg C).
    b. Occupied Heating Temperature: 70 deg F (24 deg C).
    c. Unoccupied Cooling Temperature: 85 deg F (24 deg C).
    d. Unoccupied Heating Temperature: 65 deg F (18 deg C).

4. Supply-Air-Temperature Limit: Override space temperature set point to control valves and dampers to prevent discharge air from dropping below a minimum set point as directed.
5. Warm-up Cycle: Open heating-water control valve, close outdoor-air damper, and open return-air damper.

L. Heating Coils, Hydronic: Modulate valve to maintain space temperature set points.

1. Space Temperature:

a. Occupied Cooling Temperature: 75 deg F (24 deg C).
b. Occupied Heating Temperature: 70 deg F (24 deg C).
c. Unoccupied Cooling Temperature: 85 deg F (24 deg C).
d. Unoccupied Heating Temperature: 65 deg F (18 deg C).

M. Heating Coils, Electric: Sequence stages of heating to maintain 75 deg F (24 deg C) space temperature.

N. Radiators and Convectors, Hydronic:

1. Occupancy: Report occupancy and enable occupied temperature set point.
2. Space Temperature: Modulate valve to maintain 75 deg F (24 deg C) space temperature set point.

a. Occupied Temperature: 75 deg F (24 deg C).
b. Unoccupied Temperature: 65 deg F (18 deg C).

O. Radiators and Convectors, Electric: Sequence stages of heating to maintain 75 deg F (24 deg C) space temperature set point.

P. Constant-Volume, Terminal Air Units, Hydronic:

1. Occupancy: Report occupancy and enable occupied temperature set point.
2. Space Temperature: Modulate valve to maintain space temperature set points.

a. Occupied Cooling Temperature: 75 deg F (24 deg C).
b. Occupied Heating Temperature: 70 deg F (24 deg C).
c. Unoccupied Cooling Temperature: 85 deg F (24 deg C).
d. Unoccupied Heating Temperature: 65 deg F (18 deg C).

Q. Variable-Air-Volume Terminal Air Units with Hydronic Coils:

1. Occupancy: Report occupancy and enable occupied temperature set point.

a. Occupied Cooling Temperature: 75 deg F (24 deg C).
b. Occupied Heating Temperature: 70 deg F (24 deg C).
c. Unoccupied Cooling Temperature: 85 deg F (24 deg C).
d. Unoccupied Heating Temperature: 65 deg F (18 deg C).

2. Space Temperature: Modulate damper and valve to maintain space temperature set points.

    a. Occupied Cooling Temperature: 75 deg F (24 deg C).
    b. Occupied Heating Temperature: 70 deg F (24 deg C).
    c. Unoccupied Cooling Temperature: 85 deg F (24 deg C).
    d. Unoccupied Heating Temperature: 65 deg F (18 deg C).
    e. Modulate damper actuator from full open to minimum position.
    f. When damper is at minimum position, modulate reheat coil valve from closed to open.
    g. If occupied space temperature is not maintained with valve open, modulate damper actuator from minimum position to 100 percent open.
    h. Reverse the sequence for full heating to full cooling.

R. Sequence Control:

1. Space Temperature: Modulate valves and dampers to maintain space temperature set points.

    a. Occupied Cooling Temperature: 75 deg F (24 deg C).
    b. Occupied Heating Temperature: 70 deg F (24 deg C).
    c. Unoccupied Cooling Temperature: 85 deg F (24 deg C).
    d. Unoccupied Heating Temperature: 65 deg F (18 deg C).
    e. Modulate damper actuator from open to minimum position.
    f. When damper is at minimum position, modulate finned-tube radiation valve from closed to fully open.
    g. When finned-tube radiation valve is fully open, modulate reheat coil valve from closed to fully open.
    h. If occupied space temperature is not maintained with both valves open, modulate damper actuator from minimum position to 100 percent open.
    i. Reverse the sequence for full heating to full cooling.

S. Indicate the following on the operator's workstation display terminal:

1. DDC system graphic.
2. DDC system on-off indication (operating or not operating).
3. DDC system occupied/unoccupied mode.
4. Outdoor-air-temperature indication.
5. Cabinet Unit Heater, Hydronic:

    a. Space temperature indication.
    b. Space temperature set point.
    c. Fan on.

6. Unit Heater, Hydronic:

    a. Space temperature indication.
    b. Space temperature set point.

c. Fan on.

7. Combustion-Air Unit Heaters:

   a. Space temperature indication.
   b. Space temperature set point.
   c. Control-valve position.

8. Radiant Heating Panel, Hydronic:

   a. Space temperature indication.
   b. Space temperature set point.
   c. Control-valve position.

9. Two-Pipe, Single-Coil, Fan-Coil Unit:

   a. Space temperature indication.
   b. Space temperature set point.
   c. Control-valve position.
   d. Supply-water temperature indication.

10. Four-Pipe, Hydronic Fan-Coil Unit:

    a. Space temperature indication.
    b. Space temperature set point.
    c. Control-valve position.

11. Unit Ventilator:

    a. DDC system on-off indication (operating or not operating).
    b. Space temperature indication.
    c. Space temperature set point.
    d. Control-valve position.
    e. Damper position.

12. Heating Coils, Hydronic:

    a. Space temperature indication.
    b. Space temperature set point.
    c. Control-valve position.

13. Radiators and Convectors, Hydronic:

    a. Space/area served.
    b. Space temperature indication.
    c. Space temperature set point.
    d. Space temperature set point, occupied.
    e. Space temperature set point, occupied standby.

f. Space temperature set point, unoccupied.
g. Control-valve position as percentage open.

14. Constant-Volume, Terminal Air Units, Hydronic:

a. Space/area served.
b. Space occupied/unoccupied.
c. Space temperature indication.
d. Space temperature set point, occupied.
e. Space temperature set point, unoccupied.
f. Control-valve position as percentage open.

15. Variable-Air-Volume Terminal Air Units with Hydronic Coils:

a. Space/area served.
b. Space occupied/unoccupied.
c. Space temperature indication.
d. Space temperature set point.
e. Space cooling and heating temperature set point, occupied.
f. Space cooling and heating temperature set point, unoccupied.
g. Air-damper position as percentage open.
h. Control-valve position as percentage open.

16. Sequence Control:

a. Space/area served.
b. Space occupied/unoccupied.
c. Space temperature indication.
d. Space temperature set point, occupied.
e. Space temperature set point, unoccupied.
f. Damper position as percentage open.
g. Control-valve positions as percentage open.

1.6 VENTILATION SEQUENCES

A. Combustion-Air, Makeup Unit Control, Electric:

1. Initiation: Start fan when appliance burner starts.
2. Space Temperature: Sequence electric coil stages to maintain 75 deg F (24 deg C) space temperature.

B. Combustion-Air, Makeup Unit Control, Hydronic:

1. Initiation: Start fan when appliance burner starts.
2. Space Temperature: Modulate control valve to maintain 75 deg F (24 deg C) space temperature set point.

C. Gravity Roof Ventilator: Open control damper when space is occupied or temperature rises above set point as directed.

D. Exhaust Fan as directed: Cycle fan on when.

E. Kitchen Exhaust Fan with Occupancy Sensor: Start fan and energize makeup air unit when space is occupied.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 230993.11

SECTION 231113 - FACILITY FUEL-OIL PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fuel-oil pipes, tubes, and fittings.
2. Piping specialties.
3. Joining materials.
4. Specialty valves.
5. Mechanical leak-detection valves.
6. Labels and identification.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Pipe Welding Qualifications: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Comply with ASME B31.9, "Building Services Piping," for fuel-oil piping materials, installation, testing, and inspecting.

B. Fuel-Oil Valves: Comply with UL 842 and have service mark initials "WOG" permanently marked on valve body.

C. Comply with requirements of the EPA and of state and local authorities having jurisdiction. Include recording of fuel-oil piping.

2.2 PERFORMANCE REQUIREMENTS

A. Maximum Operating-Pressure Ratings: 3-psig (21-kPa) fuel-oil supply pressure at oil-fired appliances.

2.3 FUEL-OIL PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A53/A53M, black steel, Schedule 40, Type E or S, Grade B.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
2. Wrought-Steel Welding Fittings: ASTM A234/A234M, for butt and socket welding.
3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

    a. Material Group: 1.1.
    b. End Connections: Threaded or butt welding to match pipe.
    c. Lapped Face: Not permitted underground.
    d. Gasket Materials: Asbestos free, ASME B16.20 metallic, or ASME B16.21 nonmetallic, gaskets compatible with fuel oil.
    e. Bolts and Nuts: ASME B18.2.1, cadmium-plated steel.

5. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.

    a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.

2.4 PIPING SPECIALTIES

A. Metallic Flexible Connectors:
1. Listed and labeled for aboveground and underground applications by an NRTL acceptable to authorities having jurisdiction.
2. Stainless-steel bellows with woven, flexible, bronze or stainless-steel, wire-reinforcing protective jacket.
3. Minimum Operating Pressure: 150 psig (1035 kPa).
4. End Connections: Socket, flanged, or threaded end to match connected piping.

5. Maximum Length: 30 inches (762 mm.)
6. Swivel end, 50-psig (345-kPa) maximum operating pressure.
7. Factory-furnished anode for connection to cathodic protection.

B. Nonmetallic Flexible Connectors:
1. Listed and labeled for underground applications by an NRTL acceptable to authorities having jurisdiction.
2. PFTE bellows with woven, flexible, bronze or stainless-steel, wire-reinforcing protective jacket.
3. Minimum Operating Pressure: 150 psig (1035 kPa).
4. End Connections: Socket, flanged, or threaded end to match connected piping.
5. Maximum Length: 30 inches (762 mm.)
6. Swivel end, 50-psig (345-kPa) maximum operating pressure.
7. Factory-furnished anode.

C. Y-Pattern Strainers:

1. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: 60 or 80-mesh startup strainer and perforated stainless-steel basket with 50 percent free area as directed.
4. CWP Rating: 125 psig (860 kPa).

D. Basket Strainers:

1. Body: ASTM A126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: 60 or 80-mesh startup strainer and perforated stainless-steel basket with 50 percent free area as directed.
4. CWP Rating: 125 psig (860 kPa).

E. T-Pattern Strainers:

1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
2. End Connections: Grooved ends.
3. Strainer Screen: 60 or 80-mesh startup strainer and perforated stainless-steel basket with 57 percent free area as directed.
4. CWP Rating: 750 psig (5170 kPa).

F. Manual Air Vents:

1. Body: Bronze.
2. Internal Parts: Nonferrous.

3. Operator: Screwdriver or thumbscrew.
4. Inlet Connection: NPS 1/2 (DN 15).
5. Discharge Connection: NPS 1/8 (DN 6).
6. CWP Rating: 150 psig (1035 kPa).
7. Maximum Operating Temperature: 225 deg F (107 deg C).

2.5 JOINING MATERIALS

A. Joint Compound and Tape for Threaded Joints: Suitable for fuel oil.

B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.6 SPECIALTY VALVES

A. Pressure Relief Valves:
1. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
2. Body: Brass, bronze, or cast steel.
3. Springs: Stainless steel, interchangeable.
4. Seat and Seal: Nitrile rubber.
5. Orifice: Stainless steel, interchangeable.
6. Factory-Applied Finish: Baked enamel.
7. Maximum Inlet Pressure: 150 psig (1035 kPa).
8. Relief Pressure Setting: 60 psig (414 kPa).

B. Oil Safety Valves:
1. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
2. Body: Brass, bronze, or cast steel.
3. Springs: Stainless steel.
4. Seat and Diaphragm: Nitrile rubber.
5. Orifice: Stainless steel, interchangeable.
6. Factory-Applied Finish: Baked enamel.
7. Manual override port.
8. Maximum Inlet Pressure: 60 psig (414 kPa).
9. Maximum Outlet Pressure: 3 psig (21 kPa).

C. Emergency Shutoff Valves:
1. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
2. Single or Double poppet valve as directed.
3. Body: ASTM A126, cast iron.
4. Disk: FPM.
5. Poppet Spring: Stainless steel.
6. Stem: Plated brass.

7. O-Ring: FPM.
8. Packing Nut: PTFE-coated brass.
9. Fusible link to close valve at 165 deg F (74 deg C).
10. Thermal relief to vent line pressure buildup due to fire.
11. Air test port.
12. Maximum Operating Pressure: 0.5 psig (3.45 kPa).

2.7 MECHANICAL LEAK-DETECTION VALVES

A. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.

B. Body: ASTM A126, cast iron.

C. O-Rings: Elastomeric compatible with fuel oil.

D. Piston and Stem Seals: PTFE.

E. Stem and Spring: Stainless steel.

F. Piston Cylinder: Burnished brass.

G. Indicated Leak Rate: Maximum 3 gph (3 mL/s) at 10 psig (69 kPa).

H. Leak Indication: Reduced flow.

2.8 LABELS AND IDENTIFICATION

A. Detectable Warning Tape: Acid- and alkali-resistant PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches (152 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches (762 mm) deep; colored yellow.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.2 PREPARATION

A. Close equipment shutoff valves before turning off fuel oil to premises or piping section.

B. Comply with NFPA 30 and NFPA 31 requirements for prevention of accidental ignition.

3.3 OUTDOOR PIPING INSTALLATION

A. Install Underground Fuel-Oil Piping Buried:

1. Under Compacted Backfill: 18 inches (457 mm) below finished grade.
2. Under Asphalt 2 Inches (51 mm) Thick: 8 inches (203 mm) below bottom of asphalt.
3. Under 4 Inches (102 mm) of Reinforced Concrete in Areas Subject to Vehicle Traffic: 4 inches (102 mm) below bottom of concrete.
4. If fuel-oil piping is installed with less than 12 inches (305 mm) of cover to finished grade, install in containment piping.
5. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

B. Steel Piping with Protective Coating:

1. Apply joint cover kits to pipe after joining, to cover, seal, and protect joints.
2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer. Review protective coating damage with Architect prior to repair.
3. Replace pipe having damaged PE coating with new pipe.

C. Install vent pipe at a minimum slope of 2 percent downward toward fuel-oil storage tank sump.

D. Assemble and install entry boots for pipe penetrations through sump sidewalls for liquid-tight joints.

E. Install metal pipes, fittings, valves, and flexible connectors at piping connections to AST and UST.

F. Install fittings for changes in direction in rigid pipe.

G. Install system components with pressure rating equal to or greater than system operating pressure.

3.4 INDOOR PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate

friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction to allow for mechanical installations.

C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings at a height that allows sufficient space for ceiling panel removal.

F. Install piping free of sags and bends.

G. Install fittings for changes in direction and branch connections.

H. Comply with requirements for equipment specifications for roughing-in requirements.

I. Conceal pipe installations in walls, pipe spaces, or utility spaces; above ceilings; below grade or floors; and in floor channels unless indicated to be exposed to view.

J. Prohibited Locations:

1. Do not install fuel-oil piping in or through HVAC ducts and plenums, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
2. Do not install fuel-oil piping in solid walls or partitions.

K. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

L. Connect branch piping from top or side of horizontal piping.

M. Install unions in pipes NPS 2 (DN 50) and smaller at final connection to each piece of equipment and elsewhere as indicated. Unions are not required on flanged devices.

N. Do not use fuel-oil piping as grounding electrode.

O. Install sleeves and sleeve seals for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

P. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.5 VALVE INSTALLATION

A. Install manual fuel-oil shutoff valves on branch connections to fuel-oil appliance.

B. Install valves in accessible locations.

C. Install oil safety valves at inlet of each oil-fired appliance.

D. Install pressure relief valves in distribution piping between the supply and return lines.

E. Install one-piece, bronze ball valve with hose end connection at low points in fuel-oil piping. Comply with requirements in Section 230523.12 "Ball Valves for HVAC Piping."

F. Install manual air vents at high points in fuel-oil piping.

G. Install emergency shutoff valves at dispensers.

3.6 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to "Quality Assurance" Article.

1. Bevel plain ends of steel pipe.
2. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

3.7 HANGER AND SUPPORT INSTALLATION

A. Pipe hanger and support and equipment support materials and installation requirements are specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 1-1/4 (DN 32) and Smaller: Maximum span, 84 inches (2130 mm); minimum rod size, 3/8 inch (10 mm).
2. NPS 1-1/2 (DN 40): Maximum span, 108 inches (2740 mm); minimum rod size, 3/8 inch (10 mm).
3. NPS 2 (DN 50): Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (10 mm).
4. NPS 2-1/2 (DN 65): Maximum span, 11 feet (3.4 m); minimum rod size, 1/2 inch (13 mm).
5. NPS 3 (DN 80): Maximum span, 12 feet (3.7 m); minimum rod size, 1/2 inch (13 mm).
6. NPS 4 (DN 100): Maximum span, 13 feet (4 m); minimum rod size, 5/8 inch (16 mm).

C. Support vertical steel pipe at each floor and at spacing not greater than 15 feet (4.5 m).

3.8 CONNECTIONS

A. Where installing piping adjacent to equipment, allow space for service and maintenance.

B. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment having threaded pipe connection.

C. Connect piping to equipment with shutoff valve and union. Install union between valve and equipment.

D. Install flexible piping connectors at final connection to burners or oil-fired appliances.

3.9 LABELING AND IDENTIFYING

A. Nameplates, pipe identification, valve tags, and signs are specified in Section 230553 "Identification for HVAC Piping and Equipment."

B. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplates and signs on or near each service regulator, service meter, and earthquake valve.

1. Text: In addition to identifying unit, distinguish between multiple units; inform operator of operational requirements; indicate safety and emergency precautions; and warn of hazards and improper operations.

C. Install detectable warning tape directly above fuel-oil piping, 12 inches (304 mm) below finished grade, except 6 inches (152 mm) below subgrade under pavements and

slabs. Terminate tracer wire in an accessible area and identify as "tracer wire" for future use with plastic-laminate sign.

1. Piping: Over underground fuel-oil distribution piping.

3.10 FIELD QUALITY CONTROL

A. Pressure Test Piping: Minimum hydrostatic or pneumatic test-pressures measured at highest point in system:

1. Fuel-Oil Distribution Piping: Minimum 5 psig (34.5 kPa) for minimum 30 minutes.
2. Suction Piping: Minimum 20-in. Hg (68 kPa) for minimum 30 minutes.
3. Isolate storage tanks if test pressure in piping will cause pressure in storage tanks to exceed 10 psig (69 kPa).

B. Inspect and test fuel-oil piping according to NFPA 31, "Tests of Piping" Paragraph; and according to requirements of authorities having jurisdiction.

C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Bleed air from fuel-oil piping using manual air vents.

E. Fuel-oil piping and equipment will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.11 OUTDOOR PIPING SCHEDULE

A. Underground Fuel-Oil-Tank Fill and Vent Piping: Steel pipe, steel or malleable-iron threaded fittings, and threaded joints. Coat pipe and fittings with protective coating for steel piping.

B. Aboveground Fuel-Oil Piping: Steel pipe, steel or malleable-iron threaded fittings, and threaded joints.

3.12 INDOOR PIPING SCHEDULE

A. Aboveground Fuel-Oil Piping: Steel pipe, steel or malleable-iron threaded fittings, and threaded joints

3.13 SHUTOFF VALVE SCHEDULE

A. Valves for Aboveground Distribution Piping:

1. One-piece, bronze ball valve with bronze trim.
2. Two-piece, full or regular-port, bronze ball valves with bronze trim as directed.

B. Valves in Branch Piping:

1. One-piece, bronze ball valve with bronze trim.
2. Two-piece, full or regular-port, bronze ball valves with bronze trim as directed.

END OF SECTION 231113

SECTION 231123 - FACILITY NATURAL-GAS PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipes, tubes, and fittings.
2. Piping specialties.
3. Piping and tubing joining materials.
4. Manual gas shutoff valves.
5. Motorized gas valves.
6. Earthquake valves.
7. Pressure regulators.
8. Dielectric unions.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: For facility natural-gas piping layout. Include plans, piping layout and elevations, sections, and details for fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

C. Delegated-Design Submittal: For natural-gas piping and equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of seismic restraints.
2. Design Calculations: Calculate requirements for selecting seismic restraints.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings:

1. Piping and Valves: 100 psig (690 kPa) minimum unless otherwise indicated.
2. Service Regulators: 65 psig (450 kPa) or 100 psig (690 kPa) minimum unless otherwise indicated.

B. Natural-Gas System Pressure within Buildings: 0.5 psig (3.45 kPa) or less or More than 0.5 psig (3.45 kPa) but not more than 2 psig (13.8 kPa).

C. Natural-Gas System Pressures within Buildings: Two pressure ranges. Primary pressure is more than 0.5 psig (3.45 kPa) but not more than 2 psig (13.8 kPa), and is reduced to secondary pressure of 0.5 psig (3.45 kPa) or less.

D. Delegated Design: Design restraints and anchors for natural-gas piping and equipment, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

2.2 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A53/A53M, black steel, Schedule 40, Type E or S, Grade B.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
2. Wrought-Steel Welding Fittings: ASTM A234/A234M for butt welding and socket welding.
3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
4. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.

    a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.

B. Corrugated, Stainless-Steel Tubing: Comply with ANSI/IAS LC 1.
   1. Tubing: ASTM A240/A240M, corrugated, Series 300 stainless steel.
   2. Coating: PE with flame retardant.

      a. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

         1) Flame-Spread Index: 25 or less.
         2) Smoke-Developed Index: 50 or 450 or less as directed.

   3. Fittings: Copper-alloy mechanical fittings with ends made to fit and listed for use with corrugated stainless-steel tubing and capable of metal-to-metal seal without gaskets. Include brazing socket or threaded ends complying with ASME B1.20.1.
   4. Striker Plates: Steel, designed to protect tubing from penetrations.
   5. Manifolds: Malleable iron or steel with factory-applied protective coating. Threaded connections shall comply with ASME B1.20.1 for pipe inlet and corrugated tubing outlets.
   6. Operating-Pressure Rating: 5 psig (34.5 kPa).

C. Annealed-Temper Copper Tube: Comply with as directed.

   1. Copper Fittings: ASME B16.22, wrought copper, and streamlined pattern.
   2. Flare Fittings: Comply with ASME B16.26 and SAE J513.

      a. Copper fittings with long nuts.
      b. Metal-to-metal compression seal without gasket.
      c. Dryseal threads complying with ASME B1.20.3.

   3. Protective Coating for Underground Tubing: Factory-applied, extruded PE a minimum of 0.022 inch (0.56 mm) thick.

D. PE Pipe: ASTM D2513, SDR 11.

   1. PE Fittings: ASTM D2683, socket-fusion type or ASTM D3261, butt-fusion type with dimensions matching PE pipe.
   2. PE Transition Fittings: Factory-fabricated fittings with PE pipe complying with ASTM D2513, SDR 11; and steel pipe complying with ASTM A53/A53M, black steel, Schedule 40, Type E or S, Grade B.
   3. Anodeless Service-Line Risers: Factory fabricated and leak tested.

      a. Underground Portion: PE pipe complying with ASTM D2513, SDR 11 inlet.
      b. Casing: Steel pipe complying with ASTM A53/A53M, Schedule 40, black steel, Type E or S, Grade B, with corrosion-protective coating covering. Vent casing aboveground.
      c. Aboveground Portion: PE transition fitting.
      d. Outlet shall be threaded or suitable for welded connection.

e. Tracer wire connection.
f. Ultraviolet shield.
g. Stake supports with factory finish to match steel pipe casing or carrier pipe.

4. Transition Service-Line Risers: Factory fabricated and leak tested.

a. Underground Portion: PE pipe complying with ASTM D2513, SDR 11 inlet connected to steel pipe complying with ASTM A53/A53M, Schedule 40, Type E or S, Grade B, with corrosion-protective coating for aboveground outlet.
b. Outlet shall be threaded or suitable for welded connection.
c. Bridging sleeve over mechanical coupling.
d. Factory-connected anode.
e. Tracer wire connection.
f. Ultraviolet shield.
g. Stake supports with factory finish to match steel pipe casing or carrier pipe.

2.3 PIPING SPECIALTIES

A. Appliance Flexible Connectors:

1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
2. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.
3. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
4. Corrugated stainless-steel tubing with polymer coating.
5. Operating-Pressure Rating: 0.5 psig (3.45 kPa).
6. End Fittings: Zinc-coated steel.
7. Threaded Ends: Comply with ASME B1.20.1.
8. Maximum Length: 72 inches (1830 mm.)

B. Quick-Disconnect Devices: Comply with ANSI Z21.41.

1. Copper-alloy convenience outlet and matching plug connector.
2. Nitrile seals.
3. Hand operated with automatic shutoff when disconnected.
4. For indoor or outdoor applications.
5. Adjustable, retractable restraining cable.

C. Y-Pattern Strainers:

1. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller.
3. Strainer Screen: 40 or 60-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area as directed.
4. CWP Rating: 125 psig (862 kPa).

D. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.4 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for natural gas.

B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

C. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F (540 deg C) complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

2.5 MANUAL GAS SHUTOFF VALVES

A. See "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles for where each valve type is applied in various services.

B. General Requirements for Metallic Valves, NPS 2 (DN 50) and Smaller: Comply with ASME B16.33.

1. CWP Rating: 125 psig (862 kPa).
2. Threaded Ends: Comply with ASME B1.20.1.
3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch (25 mm) and smaller.
6. Service Mark: Valves 1-1/4 inches (32 mm) to NPS 2 (DN 50) shall have initials "WOG" permanently marked on valve body.

C. One-Piece, Bronze Ball Valve with Bronze Trim: MSS SP-110.
1. Body: Bronze, complying with ASTM B584.
2. Ball: Chrome-plated brass.
3. Stem: Bronze; blowout proof.
4. Seats: Reinforced TFE; blowout proof.
5. Packing: Separate packnut with adjustable-stem packing threaded ends.
6. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
7. CWP Rating: 600 psig (4140 kPa).

8. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
9. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

D. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.
1. Body: Bronze, complying with ASTM B584.
2. Ball: Chrome-plated bronze.
3. Stem: Bronze; blowout proof.
4. Seats: Reinforced TFE; blowout proof.
5. Packing: Threaded-body packnut design with adjustable-stem packing.
6. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
7. CWP Rating: 600 psig (4140 kPa).
8. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
9. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

E. Two-Piece, Regular-Port Bronze Ball Valves with Bronze Trim: MSS SP-110.
1. Body: Bronze, complying with ASTM B584.
2. Ball: Chrome-plated bronze.
3. Stem: Bronze; blowout proof.
4. Seats: Reinforced TFE.
5. Packing: Threaded-body packnut design with adjustable-stem packing.
6. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
7. CWP Rating: 600 psig (4140 kPa).
8. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
9. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

F. Bronze Plug Valves: MSS SP-78.
1. Body: Bronze, complying with ASTM B584.
2. Plug: Bronze.
3. Ends: Threaded, socket, as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
4. Operator: Square head or lug type with tamperproof feature where indicated.
5. Pressure Class: 125 psig (862 kPa).
6. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
7. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

G. PE Ball Valves: Comply with ASME B16.40.
1. Body: PE.
2. Ball: PE.
3. Stem: Acetal.

4. Seats and Seals: Nitrile.
5. Ends: Plain or fusible to match piping.
6. CWP Rating: 80 psig (552 kPa).
7. Operating Temperature: Minus 20 to plus 140 deg F (Minus 29 to plus 60 deg C).
8. Operator: Nut or flat head for key operation.
9. Include plastic valve extension.
10. Include tamperproof locking feature for valves where indicated on Drawings.

H. Valve Boxes:

1. Cast-iron, two-section box.
2. Top section with cover with "GAS" lettering.
3. Bottom section with base to fit over valve and barrel a minimum of 5 inches (125 mm) in diameter.
4. Adjustable cast-iron extensions of length required for depth of bury.
5. Include tee-handle, steel operating wrench with socket end fitting valve nut or flat head, and with stem of length required to operate valve.

2.6 MOTORIZED GAS VALVES

A. Electrically Operated Valves: Comply with UL 429.
1. Pilot operated.
2. Body: Brass or aluminum.
3. Seats and Disc: Nitrile rubber.
4. Springs and Valve Trim: Stainless steel.
5. 120-V ac, 60 Hz, Class B, continuous-duty molded coil, and replaceable.
6. NEMA ICS 6, Type 4, coil enclosure.
7. Normally closed.
8. Visual position indicator.

2.7 EARTHQUAKE VALVES

A. Earthquake Valves, Maximum Operating Pressure of 5 psig (34.5 kPa): Comply with ASCE 25.
1. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction.
2. Maximum Operating Pressure: 5 psig (34.5 kPa).
3. Cast-aluminum body with nickel-plated chrome steel internal parts.
4. Nitrile-rubber valve washer.
5. Sight windows for visual indication of valve position.
6. Threaded end connections complying with ASME B1.20.1.
7. Wall mounting bracket with bubble level indicator.

B. Earthquake Valves, Maximum Operating Pressure of 60 psig (414 kPa): Comply with ASCE 25.

1. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction.
2. Maximum Operating Pressure: As directed.
3. Cast-aluminum body with stainless-steel internal parts.
4. Nitrile-rubber, reset-stem o-ring seal.
5. Valve position, open or closed, indicator.
6. Composition valve seat with clapper held by spring or magnet locking mechanism.
7. Level indicator.
8. End Connections: Threaded for valves NPS 2 (DN 50) and smaller.

2.8 PRESSURE REGULATORS

A. General Requirements:

1. Single stage and suitable for natural gas.
2. Steel jacket and corrosion-resistant components.
3. Elevation compensator.
4. End Connections: Threaded for regulators NPS 2 (DN 50) and smaller.

B. Line Pressure Regulators: Comply with ANSI Z21.80.
1. Body and Diaphragm Case: Cast iron or die-cast aluminum.
2. Springs: Zinc-plated steel; interchangeable.
3. Diaphragm Plate: Zinc-plated steel.
4. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
5. Orifice: Aluminum; interchangeable.
6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
7. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
8. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
9. Overpressure Protection Device: Factory mounted on pressure regulator.
10. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
11. Maximum Inlet Pressure: As directed.

C. Appliance Pressure Regulators: Comply with ANSI Z21.18.
1. Body and Diaphragm Case: Die-cast aluminum.
2. Springs: Zinc-plated steel; interchangeable.
3. Diaphragm Plate: Zinc-plated steel.
4. Seat Disc: Nitrile rubber.
5. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
6. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.

7. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
8. Maximum Inlet Pressure: As directed.

2.9 DIELECTRIC UNIONS

A. Dielectric Unions:
   1. Description:

      a. Standard: ASSE 1079.
      b. Pressure Rating: 125 psig (860 kPa) minimum at 180 deg F (82 deg C) or 150 psig (1035 kPa) or 250 psig (1725 kPa) as directed.
      c. End Connections: Solder-joint copper alloy and threaded ferrous.

2.10 LABELING AND IDENTIFYING

A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches (150 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches (750 mm) deep; colored yellow.

PART 3 - EXECUTION

3.1 OUTDOOR PIPING INSTALLATION

A. Comply with NFPA 54 or the International Fuel Gas Code for installation as directed and purging of natural-gas piping.

B. Install underground, natural-gas piping buried at least 36 inches (900 mm) below finished grade. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

   1. If natural-gas piping is installed less than 36 inches (900 mm) below finished grade, install it in containment conduit.

C. Install underground, PE, natural-gas piping according to ASTM D2774.

D. Steel Piping with Protective Coating:

   1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
   2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
   3. Replace pipe having damaged PE coating with new pipe.

E. Copper Tubing with Protective Coating:

1. Apply joint cover kits over tubing to cover, seal, and protect joints.
2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.

F. Install fittings for changes in direction and branch connections.

G. Install pressure gage downstream or upstream and downstream from each service regulator as directed. Pressure gages are specified in Section 230519 "Meters and Gages for HVAC Piping."

3.2 INDOOR PIPING INSTALLATION

A. Comply with NFPA 54 or the International Fuel Gas Code as directed for installation and purging of natural-gas piping.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.

D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

G. Locate valves for easy access.

H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.

I. Install piping free of sags and bends.

J. Install fittings for changes in direction and branch connections.

K. Verify final equipment locations for roughing-in.

L. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

M. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.

1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches (75 mm) long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.

N. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.

O. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.

P. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

Q. Connect branch piping from top or side of horizontal piping.

R. Install unions in pipes NPS 2 (DN 50) and smaller, adjacent to each valve, at final connection to each piece of equipment.

S. Do not use natural-gas piping as grounding electrode.

T. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

U. Install pressure gage downstream or upstream and downstream from each line regulator as directed. Pressure gages are specified in Section 230519 "Meters and Gages for HVAC Piping."

V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

W. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.3 VALVE INSTALLATION

A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing or copper connector.

B. Install underground valves with valve boxes.

C. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

D. Install earthquake valves aboveground outside buildings according to listing.

E. Install anode for metallic valves in underground PE piping.

3.4 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints:

1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
2. Cut threads full and clean using sharp dies.
3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints:

1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
2. Bevel plain ends of steel pipe.
3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.

F. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.

G. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D2657.

1. Plain-End Pipe and Fittings: Use butt fusion.
2. Plain-End Pipe and Socket Fittings: Use socket fusion.

3.5 HANGER AND SUPPORT INSTALLATION

A. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

C. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 1 (DN 25) and Smaller: Maximum span, 96 inches (2438 mm); minimum rod size, 3/8 inch (10 mm).
2. NPS 1-1/4 (DN 32): Maximum span, 108 inches (2743 mm); minimum rod size, 3/8 inch (10 mm).
3. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): Maximum span, 108 inches (2743 mm); minimum rod size, 3/8 inch (10 mm).

D. Install hangers for horizontal, corrugated stainless-steel tubing with the following maximum spacing and minimum rod sizes:

1. NPS 3/8 (DN 10): Maximum span, 48 inches (1220 mm); minimum rod size, 3/8 inch (10 mm).
2. NPS 1/2 (DN 15): Maximum span, 72 inches (1830 mm); minimum rod size, 3/8 inch (10 mm).
3. NPS 3/4 (DN 20) and Larger: Maximum span, 96 inches (2440 mm); minimum rod size, 3/8 inch (10 mm).

3.6 CONNECTIONS

A. Connect to utility's gas main according to utility's procedures and requirements.

B. Install natural-gas piping electrically continuous and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

C. Install piping adjacent to appliances to allow service and maintenance of appliances.

D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches (1800 mm) of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.

E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.7 LABELING AND IDENTIFYING

A. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for piping and valve identification.

B. Install detectable warning tape directly above gas piping, 12 inches (300 mm) below finished grade, except 6 inches (150 mm) below subgrade under pavements and slabs.

3.8 FIELD QUALITY CONTROL

A. Test, inspect, and purge natural gas according to NFPA 54 or the International Fuel Gas Code as directed and authorities having jurisdiction.

B. Natural-gas piping will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.9 OUTDOOR PIPING SCHEDULE

A. Underground natural-gas piping shall be one of the following:

1. PE pipe and fittings joined by heat fusion; service-line risers with tracer wire terminated in an accessible location.
2. Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.
3. Annealed-temper copper tube with wrought-copper fittings and brazed joints. Coat pipe and fittings with protective coating for copper tubing.

B. Aboveground natural-gas piping shall be one of the following:

1. Steel pipe with malleable-iron fittings and threaded joints.
2. Steel pipe with wrought-steel fittings and welded joints.
3. Annealed-temper copper tube with wrought-copper fittings and brazed joints.

C. Branch Piping in Cast-in-Place Concrete to Single Appliance: Annealed-temper copper tube with wrought-copper fittings and brazed or flared joints as directed. Install piping embedded in concrete with no joints in concrete.

D. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

3.10 INDOOR PIPING SCHEDULE

A. Aboveground, branch piping NPS 1 (DN 25) and smaller shall be one of the following:

1. Corrugated stainless-steel tubing with mechanical fittings having socket or threaded ends to match adjacent piping.
2. Annealed-temper copper tube with wrought-copper fittings and brazed or flared joints.
3. Steel pipe with malleable-iron fittings and threaded joints.

B. Aboveground, distribution piping shall be one of the following:

1. Steel pipe with malleable-iron fittings and threaded joints.
2. Steel pipe with wrought-steel fittings and welded joints.

C. Underground, below building, piping shall be one of the following:

1. Steel pipe with malleable-iron fittings and threaded joints.
2. Steel pipe with wrought-steel fittings and welded joints.

D. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

E. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.

3.11 UNDERGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Connections to Existing Gas Piping: Use valve and fitting assemblies made for tapping utility's gas mains and listed by an NRTL.

B. Underground: PE or Bronze plug valves as directed.

3.12 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Valves for pipe sizes NPS 2 (DN 50) and smaller at service meter shall be one of the following:

1. One-piece, bronze ball valve with bronze trim.
2. Two-piece, full or regular-port, bronze ball valves with bronze trim.
3. Bronze plug valve.

B. Distribution piping valves for pipe sizes NPS 2 (DN 50) and smaller shall be one of the following:

1. One-piece, bronze ball valve with bronze trim.
2. Two-piece, full or regular-port, bronze ball valves with bronze trim as directed.
3. Bronze plug valve.

C. Valves in branch piping for single appliance shall be one of the following:

1. One-piece, bronze ball valve with bronze trim.
2. Two-piece, full or regular-port, bronze ball valves with bronze trim as directed.
3. Bronze plug valve.

END OF SECTION 231123

SECTION 231126 - FACILITY LIQUEFIED-PETROLEUM GAS PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipes, tubes, and fittings.
2. Piping specialties.
3. Piping and tubing joining materials.
4. Valves.
5. Pressure regulators.
6. Storage containers.
7. Transport truck unloading facility specialties.
8. Pumps.
9. Vaporizers.

1.2 PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings:

1. For Piping Containing Only Vapor:

   a. Piping and Valves: 125 psig (862 kPa) unless otherwise indicated.

2. For Piping Containing Liquid:

   a. Piping between Shutoff Valves: 350 psig (2413 kPa) unless otherwise indicated.
   b. Piping Other Than Above: 250 psig (1723 kPa) unless otherwise indicated.
   c. Valves and Fittings: 250 psig (1723 kPa) unless otherwise indicated.

B. LPG System Pressure within Buildings: One pressure range. 0.5 psig (3.45 kPa) or less or More than 0.5 psig (3.45 kPa) but not more than 2 psig (13.8 kPa) as directed.

C. LPG System Pressures within Buildings: Two pressure ranges. Primary pressure is more than 0.5 psig (3.45 kPa) but not more than 2 psig (13.8 kPa) and is reduced to secondary pressure of 0.5 psig (3.45 kPa) or less.

D. Delegated Design: Design restraints and anchors for LPG piping and equipment, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

E. Seismic Performance: Vaporizers and storage container supports shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: For facility LPG piping layout. Include plans, piping layout and elevations, sections, and details for fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

C. Delegated-Design Submittal: For LPG piping and equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of seismic restraints.
2. Design Calculations: Calculate requirements for selecting seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Submit certification that vaporizer, storage container supports, accessories, and components will withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Welding certificates.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

A. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A53/A53M, black steel, Schedules 40 and 80, Type E or S, Grade B.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
2. Wrought-Steel Welding Fittings: ASTM A234/A234M for butt welding and socket welding.
3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
4. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.

    a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.

B. Corrugated, Stainless-Steel Tubing: Comply with ANSI/IAS LC 1.
1. Tubing: ASTM A240/A240M, corrugated, Series 300 stainless steel.
2. Coating: PE with flame retardant.

    a. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

        1) Flame-Spread Index: 25 or less.
        2) Smoke-Developed Index: 50 or 450 or less as directed.

3. Fittings: Copper-alloy mechanical fittings with ends made to fit and listed for use with corrugated stainless-steel tubing and capable of metal-to-metal seal without gaskets. Include brazing socket or threaded ends complying with ASME B1.20.1.
4. Striker Plates: Steel, designed to protect tubing from penetrations.
5. Manifolds: Malleable iron or steel with factory-applied protective coating. Threaded connections shall comply with ASME B1.20.1 for pipe inlet and corrugated tubing outlets.
6. Operating-Pressure Rating: 5 psig (34.5 kPa).

C. Annealed-Temper Copper Tube: Comply as directed.

1. Copper Fittings: ASME B16.22, wrought copper, and streamlined pattern.
2. Flare Fittings: Comply with ASME B16.26 and SAE J513.

    a. Copper fittings with long nuts.
    b. Metal-to-metal compression seal without gasket.
    c. Dryseal threads complying with ASME B1.20.3.

3. Protective Coating for Underground Tubing: Factory-applied, extruded PE a minimum of 0.022 inch (0.56 mm) thick.

D. PE Pipe: ASTM D2513, SDR 11.

1. PE Fittings: ASTM D2683, socket-fusion type or ASTM D3261, butt-fusion type with dimensions matching PE pipe.
2. PE Transition Fittings: Factory-fabricated fittings with PE pipe complying with ASTM D2513, SDR 11; and steel pipe complying with ASTM A53/A53M, black steel, Schedule 40, Type E or S, Grade B.
3. Anodeless Service-Line Risers: Factory fabricated and leak tested.

    a. Underground Portion: PE pipe complying with ASTM D2513, SDR 11 inlet.
    b. Casing: Steel pipe complying with ASTM A53/A53M, Schedule 40, black steel, Type E or S, Grade B with corrosion-protective coating covering. Vent casing aboveground.
    c. Aboveground Portion: PE transition fitting.
    d. Outlet shall be threaded suitable for welded connection.
    e. Tracer wire connection.
    f. Ultraviolet shield.
    g. Stake supports with factory finish to match steel pipe casing or carrier pipe.

4. Transition Service-Line Risers: Factory fabricated and leak tested.

    a. Underground Portion: PE pipe complying with ASTM D2513, SDR 11 inlet connected to steel pipe complying with ASTM A53/A53M, Schedule 40, Type E or S, Grade B, with corrosion-protective coating for aboveground outlet.
    b. Outlet shall be threaded suitable for welded connection.
    c. Bridging sleeve over mechanical coupling.
    d. Factory-connected anode.
    e. Tracer wire connection.
    f. Ultraviolet shield.
    g. Stake supports with factory finish to match steel pipe casing or carrier pipe.

2.2 PIPING SPECIALTIES

A. Flexible Piping Joints:

1. Approved for LPG service.
2. Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
3. Minimum working pressure of 250 psig (1723 kPa) and 250 deg F (121 deg C) operating temperature.
4. Threaded-end connections to match equipment connected and shall be capable of minimum 3/4-inch (20-mm) misalignment.
5. Maximum 36-inch (914-mm) length for liquid LPG lines.

B. Appliance Flexible Connectors:

1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
2. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.
3. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
4. Corrugated stainless-steel tubing with polymer coating.
5. Operating-Pressure Rating: 0.5 psig (3.45 kPa).
6. End Fittings: Zinc-coated steel.
7. Threaded Ends: Comply with ASME B1.20.1.

8. Maximum Length: 72 inches (1830 mm.)

C. Quick-Disconnect Devices: Comply with ANSI Z21.41.

1. Copper-alloy convenience outlet and matching plug connector.
2. Nitrile seals.
3. Hand operated with automatic shutoff when disconnected.
4. For indoor or outdoor applications.
5. Adjustable, retractable restraining cable.

D. Y-Pattern Strainers:

1. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller.
3. Strainer Screen: 40 or 60-mesh startup strainer as directed and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig (862 kPa).

E. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.3 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for LPG.

B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

C. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F (540 deg C) complying with AWS A5.8/A5.8M.

2.4 MANUAL GAS SHUTOFF VALVES

A. See "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles for where each valve type is applied in various services.

B. Metallic Valves, NPS 2 (DN 50) and Smaller for Liquid Service: Comply with ASME B16.33 and UL 842.

1. CWP Rating: 250 psig (1723 kPa).
2. Threaded Ends: Comply with ASME B1.20.1.
3. Socket ends for brazed joints.
4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
5. Listing by CSA or agency acceptable to authorities having jurisdiction for valves 1 inch (25 mm) and smaller.

6. Valves 1-1/4 inch (32 mm) and larger shall be suitable for LPG service, with "WOG" indicated on valve body.

C. General Requirements for Metallic Valves, NPS 2 (DN 50) and Smaller for Vapor Service: Comply with ASME B16.33.

1. CWP Rating: 125 psig (862 kPa).
2. Threaded Ends: Comply with ASME B1.20.1.
3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch (25 mm) and smaller.
6. Service Mark: Valves 1-1/4 inch (32 mm) to NPS 2 (DN 50) shall have initials "WOG" permanently marked on valve body.

D. One-Piece, Bronze Ball Valve with Bronze Trim: MSS SP-110.
1. Body: Bronze, complying with ASTM B584.
2. Ball: Chrome-plated brass.
3. Stem: Bronze; blowout proof.
4. Seats: Reinforced TFE; blowout proof.
5. Packing: Separate packnut with adjustable-stem packing threaded ends.
6. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
7. CWP Rating: 600 psig (4143 kPa).
8. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
9. Service: Suitable for LPG service with "WOG" indicated on valve body.

E. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.
1. Body: Bronze, complying with ASTM B584.
2. Ball: Chrome-plated bronze.
3. Stem: Bronze; blowout proof.
4. Seats: Reinforced TFE; blowout proof.
5. Packing: Threaded-body packnut design with adjustable-stem packing.
6. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
7. CWP Rating: 600 psig (4143 kPa).
8. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
9. Service: Suitable for LPG service with "WOG" indicated on valve body.

F. Two-Piece, Regular-Port Bronze Ball Valves with Bronze Trim: MSS SP-110.
1. Body: Bronze, complying with ASTM B584.
2. Ball: Chrome-plated bronze.
3. Stem: Bronze; blowout proof.
4. Seats: Reinforced TFE.
5. Packing: Threaded-body packnut design with adjustable-stem packing.
6. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.

7. CWP Rating: 600 psig (4140 kPa).
8. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
9. Service: Suitable for LPG service with "WOG" indicated on valve body.

G. Bronze Plug Valves: MSS SP-78.
1. Body: Bronze, complying with ASTM B584.
2. Plug: Bronze.
3. Ends: Threaded or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
4. Operator: Square head or lug type with tamperproof feature where indicated.
5. Pressure Class: 125 psig (862 kPa).
6. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
7. Service: Suitable for LPG service with "WOG" indicated on valve body.

H. PE Ball Valves: Comply with ASME B16.40.
1. Body: PE.
2. Ball: PE.
3. Stem: Acetal.
4. Seats and Seals: Nitrile.
5. Ends: Plain or fusible to match piping.
6. CWP Rating: 80 psig (552 kPa)
7. Operating Temperature: Minus 20 to plus 140 deg F (Minus 29 to plus 60 deg C).
8. Operator: Nut or flat head for key operation.
9. Include plastic valve extension.
10. Include tamperproof locking feature for valves where indicated on Drawings.

I. Valve Boxes:

1. Cast-iron, two-section box.
2. Top section with cover with "GAS" lettering.
3. Bottom section with base to fit over valve and barrel a minimum of 5 inches (125 mm) in diameter.
4. Adjustable cast-iron extensions of length required for depth of bury.
5. Include tee-handle, steel operating wrench with socket end fitting valve nut or flat head and with stem of length required to operate valve.

2.5 MOTORIZED GAS VALVES

A. Hydrostatic Relief Valves: Comply with NFPA 58.
1. Operating Pressure: 350 psig (2413 kPa).
2. Body: Brass.
3. Spring: Stainless steel.
4. Disc and Seat: Nitrile.
5. Brass body and stainless-steel, spring-operated valve with resilient rubber disc seat and protective cap.
6. Factory set and tested.
7. Listing: Valves listed and labeled by an NRTL acceptable to authorities having jurisdiction.

8. Valve shall reseat after relieving pressure.

B. Electrically Operated Valves: Comply with UL 429.
1. Pilot operated.
2. Body: Brass or aluminum.
3. Seats and Disc: Nitrile rubber.
4. Springs and Valve Trim: Stainless steel.
5. 120-V ac, 60 Hz, Class B, continuous-duty molded coil, replaceable.
6. NEMA ICS 6, Type 4, coil enclosure.
7. Normally closed.
8. Visual position indicator.

2.6 EARTHQUAKE VALVES

A. Earthquake Valves, Maximum Operating Pressure of 5 psig (34.5 kPA): Comply with ASCE 25.
1. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction.
2. Maximum Operating Pressure: 5 psig (34.5 kPa).
3. Cast-aluminum body with nickel-plated chrome steel internal parts.
4. Nitrile-rubber valve washer.
5. Sight windows for visual indication of valve position.
6. Threaded-end connections complying with ASME B1.20.1.

B. Earthquake Valves, Maximum Operating Pressure of 60 psig (414 kPa): Comply with ASCE 25.
1. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction.
2. Maximum Operating Pressure: As directed.
3. Cast-aluminum body with stainless-steel internal parts.
4. Nitrile-rubber, reset-stem o-ring seal.
5. Valve position, open or closed, indicator.
6. Composition valve seat with clapper held by spring or magnet locking mechanism.
7. Level indicator.
8. End Connections: Threaded for valves NPS 2 (DN 50) and smaller.

2.7 PRESSURE REGULATORS

A. General Requirements:

1. Single stage and suitable for LPG.
2. Steel jacket and corrosion-resistant components.
3. Elevation compensator.
4. End Connections: Threaded for regulators NPS 2 (DN 50) and smaller.

B. Line Pressure Regulators: Comply with ANSI Z21.80.
1. Body and Diaphragm Case: Cast iron or die-cast aluminum.
2. Springs: Zinc-plated steel; interchangeable.
3. Diaphragm Plate: Zinc-plated steel.
4. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.

5. Orifice: Aluminum; interchangeable.
6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
7. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet and no pressure sensing piping external to the regulator.
8. Pressure regulator shall maintain discharge pressure setting downstream and not exceed 150 percent of design discharge pressure at shutoff.
9. Overpressure Protection Device: Factory mounted on pressure regulator.
10. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
11. Maximum Inlet Pressure: As directed.

C. Appliance Pressure Regulators: Comply with ANSI Z21.18.
1. Body and Diaphragm Case: Die-cast aluminum.
2. Springs: Zinc-plated steel; interchangeable.
3. Diaphragm Plate: Zinc-plated steel.
4. Seat Disc: Nitrile rubber.
5. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
6. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
7. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
8. Maximum Inlet Pressure: As directed.

2.8 DIELECTRIC UNIONS

A. Dielectric Unions:
1. Standard: ASSE 1079.
2. Pressure Rating: As directed.
3. End Connections: Solder-joint copper alloy and threaded ferrous.

2.9 STORAGE CONTAINERS

A. Description: Factory fabricated, complying with requirements in NFPA 58 and ASME Boiler and Pressure Vessel Code and bearing the ASME label. Tanks shall be rated for 250-psig (1723-kPa) minimum working pressure.
1. Liquid outlet and vapor inlet and outlet connections shall have shutoff valves with excess-flow safety shutoff valves and bypass and back-pressure check valves with smaller than 0.039-inch (1-mm) drill-size hole to equalize pressure. Liquid-fill connection shall have backflow check valve.

a. Connections: Color-code and tag valves to indicate type.

1) Liquid fill and outlet, red.
2) Vapor inlet and outlet, yellow.

2. Level gage shall indicate current level of liquid in the container. Gages shall also indicate storage container contents; e.g., "Butane," "50-50 LPG Mix," or "Propane."
3. Pressure relief valves, type and number as required by NFPA 58, connected to vapor space and having discharge piping same size as relief-valve outlet and long enough to extend at least 84 inches (2130 mm) directly overhead. Identify relief valves as follows:

a. Discharge pressure in psig (kPa).
b. Rate of discharge for standard air in cfm (L/s).
c. Manufacturer's name.
d. Catalog or model number.

4. Container pressure gage.
5. For outdoor installation, exposed metal surfaces mechanically cleaned, primed, and painted for resistance to corrosion.
6. Ladders for access to valves more than 72 inches (1830 mm) aboveground.
7. Stainless-Steel Nameplate: Attach to aboveground storage container or to adjacent structure for underground storage container.

a. Name and address of supplier or trade name of container.
b. Water capacity in gallons and liters.
c. Design pressure in psig (kPa).
d. Statement, This container shall not contain a product having a vapor pressure in excess as directed.
e. Outside surface area in sq. ft. (sq. m).
f. Year of manufacture.
g. Shell thickness in inches (mm).
h. Overall length in feet (m).
i. OD in feet (m).
j. Manufacturer's serial number.
k. ASME Code label.

8. Felt support pads and two concrete or painted-steel saddles per storage container. Corrosion protection required at container-to-felt contact.
9. Tie straps for each saddle.
10. Straps and anchors for tie-down slab.
11. Asphalt-based coating for corrosion protection.
12. Container connections and valves protected in manway at top of storage container.
13. Manway equipped with ventilation louvers.

2.10 TRANSPORT TRUCK UNLOADING FACILITY

A. Description: Comply with requirements in NFPA 58.

1. Support structure consisting of a minimum 6-inch (150-mm) steel channel or 6-by-4-inch (150-by-100-mm) rectangular steel tubing, a minimum of 36 inches (914 mm) above and below grade.
2. Liquid-fill and vapor-return, quick-disconnect fittings.
3. Liquid and vapor shutoff valves with hydrostatic relief valves mounted between the quick-disconnect fittings and shutoff valves.
4. Excess-flow safety shutoff valve in vapor-return line.
5. Backflow check valve in liquid-fill line.
6. Remote emergency shutoff valve station with underground cable to the vapor emergency shutoff valve.

2.11 PUMPS

A. Description: Factory-assembled and -tested, duplex, positive-displacement, belt drive.

B. Pump Construction:

1. Casing: Ductile-iron casing with threaded gage tappings at inlet and outlet.
2. Internal Pressure Relief Valve: For pump protection in addition to the external pressure relief valves.
3. Impeller: Carbon or composite vane in cast-iron rotor.
4. Pump Shaft: Carbon steel.
5. Seal: Mechanical with Buna-N o-ring.
6. Pump Bearings: Ball bearings with grease fittings.
7. Baseplate: Bent carbon-steel channel or structural channel.

C. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Motor Speeds: Single.
3. Bearings: Permanently lubricated or Grease-lubricated ball bearings as directed.
4. Class I, Division 1, Group D requirements per NFPA 70.

D. Factory-Installed Piping and Specialties:

1. Pipe: ASTM A53/A53M, Type E or S, Grade B; Schedule 40 black steel with welded fittings and joints or Schedule 80 for threaded malleable-iron fittings and joints.
2. Piping Specialties for Each Pump:

    a. Bypass valve.
    b. Isolation valves.
    c. Unions for each connection.
    d. Check valve.
    e. Basket strainer.
    f. Pressure gages for suction and discharge connections.
    g. Hydrostatic relief valve.
    h. Pilot-operated, pressure-regulating valve.

E. Braided-jacket flexible connectors for suction and discharge connections.

F. Pump and Piping Finish: For outdoor installation, exposed metal surfaces mechanically cleaned, primed, and painted for resistance to corrosion.

G. Controls:

1. Explosion-proof controls enclosure.
2. Magnetic starter package with automatic alternator.
3. Pressure-activated start and stop.

4. Lag pump starts if lead pump fails.
5. Audible and visual indication of pump failure.

H. Capacities and Characteristics for Each Pump:

1. Capacity: As directed.
2. Minimum Working Pressure: 350 psig (2413 kPa).
3. Continuous Fluid Temperature: 250 deg F (121 deg C).
4. Total Dynamic Head: As directed.
5. Inlet and Outlet Size: As directed.
6. Return Size: As directed.
7. Pump Speed: As directed.
8. Motor Speed: As directed.
9. Motor Horsepower: As directed.
10. Electrical Characteristics:

    a. Volts: 240 or 480 as directed.
    b. Phase: Single or Three as directed.
    c. Hertz: 60.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed.
    f. Maximum Overcurrent Protection: As directed.

2.12 VAPORIZERS

A. Description: Factory-fabricated, -assembled, and -tested vaporizer with heat exchanger sealed pressure-tight, built on a steel base; including insulated jacket, flue-gas vent, liquid fuel supply and vapor connections, and controls. Assembly shall be FMG labeled and comply with NFPA 58 and NFPA 70.

B. Fabricate base and attachment to vaporizers with reinforcement strong enough to resist vaporizer movement during a seismic event when steel base is anchored to a concrete base.

C. Casing:

1. Mineral-fiber insulation, a minimum of 2 inches (50 mm) thick, surrounding the heat exchanger.
2. Integral one-piece skid with forklift access holes.
3. Lifting lugs on top of vaporizer.
4. Flue rain cap and bird screen.
5. Sheet metal jacket with screw-fastened closures and baked-enamel or powder-coat protective finish as directed.
6. Mounting base to secure boiler to concrete base.
7. Control Compartment Enclosure: NEMA 250, Type 4, enclosure housing control panels for LPG-fired vaporizers. Explosion-proof control compartment construction required for electric vaporizers.

D. LPG Liquid and Vapor Circuit Specialties:

1. Y-type strainer with drain valve at inlet.

2. Vaporizer coil safety pressure relief valve.
3. Vaporizer coil blowdown valve.
4. Vapor outlet isolation valve.
5. Pressure gages, a minimum of 2-1/2 inches (63 mm) in diameter, at liquid inlet and vapor discharge. Gages shall have operating-temperature ranges so normal operating range is at approximately 50 percent of full range.
6. Inlet safety solenoid valve to close with off-normal operation alarm.
7. Backflow check valve in bypass around inlet safety solenoid valve.
8. Liquid carryover or float-type safety shutoff switch.
9. LPG Vapor Filter: Steel shell designed and manufactured per ASME Boiler and Pressure Vessel Code, Section VIII, Division 1; factory mounted on vaporizer discharge. Shells larger than 5 inches (125 mm) shall be ASME "U" stamped. Fill with stainless-steel, woven-mesh coalescing element to remove 99 percent of particles larger than 10 microns. 250-psig (1723-kPa) minimum working pressure. Finish with corrosion-resistant coating for an exterior application. Include factory-mounted and -piped, differential pressure gage with gage cocks in and out, and minimum NPS 3/4 (DN 20) full-port, ball-type drain valve.

E. Direct-Type, Water-Bath Heat Exchanger:

1. Description: Straight, steel fire tubes welded into steel headers with ASME-rated and -stamped, helical, LPG, vaporizer coil submerged in water bath. Include the following:

    a. Water bath filled with water/glycol solution designed to prevent freezing at minus 30 deg F (minus 34 deg C).
    b. Water-bath, high- and low-level sight glasses.
    c. Low-water cutoff to stop burner and annunciate alarm.
    d. Water/glycol fill and vent fitting.
    e. Minimum NPS 3/4 (DN 20) hose-end drain valves.
    f. Operating high- and low-limit aquastat controllers.
    g. Water-bath temperature gage; a minimum of 2-1/2 inches (63 mm) in diameter. Gages shall have operating-temperature ranges so normal operating range is at approximately 50 percent of full range.

2. Burner Tubes and Orifices: Stainless steel.

    a. Gas Train: Control devices and burner modulation control sequence shall be FMG labeled. Include shutoff valve, high- and low-pressure safety switches, pressure regulator, and main- and pilot-control valves.
    b. Pilot: Intermittent-electric-spark or Hot-surface pilot ignition as directed with 100 percent main-valve and pilot safety shutoff with electronic supervision of burner flame.

3. Burner Operating Controls:

    a. Operating controls shall maintain safe operating conditions. Safety controls limit operation of the burner. Microprocessor-based control system integrates safety and operating controls.
    b. Operating Water-Bath Temperature Control: Factory wired and mounted to control burner.

c. High-Temperature and High-Pressure Cutoff: Manual reset stops burner if operating conditions rise above maximum design temperature or vapor pressure.
d. Alarm Bell and Rotary Beacon: Factory mounted on control panel with silence switch; shall sound alarm for out-of-normal conditions.
e. Control Transformer: 115-V maximum control voltage.

F. Building Management System Interface: Factory-installed hardware and software to enable building management system to monitor and control set points and display vaporizer status and alarms.

G. Capacities and Characteristics:

1. Heating Fuel: As directed.
2. Vaporization Heat Exchanger:

a. Minimum Working-Pressure Rating: 250 psig (1723 kPa).
b. Test Pressure: 375 psig (2586 kPa).

3. LPG Vaporization Rate: As directed.
4. Entering-LPG Temperature: Minus 30 deg F (Minus 34 deg C).
5. Leaving-LPG Temperature: 80 deg F (26.7 deg C).
6. Discharge-LPG Pressure: 90 psig (621 kPa).
7. Burner Gas Input: As directed.
8. Electric Burner Input: As directed.
9. Water-Bath Shell Operating Pressure: Atmospheric.
10. Water-Bath Operating Temperature: 160 deg F (71 deg C).
11. Electrical Characteristics:

a. Volts: As directed.
b. Phase: Single or Three as directed.
c. Hertz: 60.
d. Minimum Circuit Ampacity: As directed.
e. Maximum Overcurrent Protection: As directed.

2.13 LABELING AND IDENTIFYING

A. Detectable Warning Tape: Acid- and alkali-resistant PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches (150 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches (750 mm) deep; colored yellow.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.2 OUTDOOR PIPING INSTALLATION

A. Comply with NFPA 58 and NFPA 54 or the International Fuel Gas Code requirements for installation as directed and purging of LPG piping.

B. Install underground, LPG piping buried at least 36 inches (900 mm) below finished grade. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

1. If LPG piping is installed less than 36 inches (914 mm) below finished grade, install it in containment conduit.

C. Install underground, PE, LPG piping according to ASTM D2774.

D. Steel Piping with Protective Coating:

1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
3. Replace pipe having damaged PE coating with new pipe.

E. Copper Tubing with Protective Coating:

1. Apply joint cover kits over tubing to cover, seal, and protect joints.
2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.

F. Install fittings for changes in direction and branch connections.

G. Install pressure gage downstream or upstream and downstream from each service regulator as directed. Pressure gages are specified in Section 230519 "Meters and Gages for HVAC Piping."

3.3 INDOOR PIPING INSTALLATION

A. Comply with NFPA 54 or the International Fuel Gas Code for installation and purging of LPG piping as directed.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.

D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

G. Locate valves for easy access.

H. Install LPG piping at uniform grade of 2 percent down toward drip and sediment traps.

I. Install piping free of sags and bends.

J. Install fittings for changes in direction and branch connections.

K. Verify final equipment locations for roughing-in.

L. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

M. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where readily accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.

1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches (75 mm) long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.

N. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.

O. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.

P. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

Q. Connect branch piping from top or side of horizontal piping.

R. Install unions in pipes NPS 2 (DN 50) and smaller, adjacent to each valve, at final connection to each piece of equipment.

S. Do not use LPG piping as grounding electrode.

T. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

U. Install pressure gage downstream or upstream and downstream from each line regulator as directed. Pressure gages are specified in Section 230519 "Meters and Gages for HVAC Piping."

V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

W. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.4 VALVE INSTALLATION

A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, or copper connector.

B. Install underground valves with valve boxes.

C. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

D. Install earthquake valves aboveground outside buildings according to listing.

E. Install anode for metallic valves in underground PE piping.

3.5 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints:

1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
2. Cut threads full and clean using sharp dies.
3. Ream threaded pipe ends to remove burrs and restore full ID of pipe.
4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints:

1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
2. Bevel plain ends of steel pipe.

3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Ch. 22, "Pipe and Tube."

F. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.

G. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D2657.

1. Plain-End Pipe and Fittings: Use butt fusion.
2. Plain-End Pipe and Socket Fittings: Use socket fusion.

3.6 HANGER AND SUPPORT INSTALLATION

A. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

C. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 1 (DN 25) and Smaller: Maximum span, 96 inches (2438 mm); minimum rod size, 3/8 inch (10 mm).
2. NPS 1-1/4 (DN 32): Maximum span, 108 inches (2743 mm); minimum rod size, 3/8 inch (10 mm).
3. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): Maximum span, 108 inches (2743 mm); minimum rod size, 3/8 inch (10 mm).

D. Install hangers for horizontal, corrugated stainless-steel tubing with the following maximum spacing and minimum rod sizes:

1. NPS 3/8 (DN 10): Maximum span, 48 inches (1220 mm); minimum rod size, 3/8 inch (10 mm).
2. NPS 1/2 (DN 15): Maximum span, 72 inches (1830 mm); minimum rod size, 3/8 inch (10 mm).
3. NPS 3/4 (DN 20) and Larger: Maximum span, 96 inches (2440 mm); minimum rod, 3/8 inch (10 mm).

3.7 CONNECTIONS

A. Connect to utility's gas main according to utility's procedures and requirements.

B. Install LPG piping electrically continuous and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

C. Install piping adjacent to appliances to allow service and maintenance of appliances.

D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches (1830 mm) of each gas-fired appliances and equipment. Install union between valve and appliances or equipment.

E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.8 TRANSPORT TRUCK UNLOADING FACILITY

A. Install transport truck unloading in a cast-in-place concrete base, 48 inches (1220 mm) square by 36 inches (914 mm) deep. Set top of concrete base at least 6 inches (150 mm) above finished grade.

B. Install remote emergency shutoff station with cable release in an accessible location, a minimum of 25 feet (7.6 m) and a maximum of 100 feet (30 m) away from transport truck unloading.

C. Install at least two 6-inch- (150-mm-) diameter metal bollards set in and filled with concrete on both sides of transport truck unloading. Bollard length shall be at least 48 inches (1220 mm) above and below grade, with concrete encasement a minimum of 12 inches (305 mm) in diameter.

3.9 STORAGE CONTAINER INSTALLATION

A. Fill storage container to at least 80 percent capacity with butane or propane as directed.

B. Install piping connections with swing joints or flexible connectors to allow for storage container settlement and for thermal expansion and contraction.

C. Ground containers according to NFPA 780. Grounding is specified in Section 264113 "Lightning Protection for Structures."

D. Set storage containers in felt pads on concrete or steel saddles. Install corrosion protection at container-to-felt contact.

E. Install tie-downs over storage containers on saddles with proper tension.

F. Set concrete saddles on dowels set in concrete base. Anchor steel saddles to concrete base.

G. Set storage container on concrete ballast base large enough to offset buoyancy of empty storage container immersed in water.

H. Install tie-down straps over container anchored in ballast base and repair damaged coating.

I. Backfill with a minimum coverage for underground or mounded storage containers according to NFPA 58.

J. Backfill with pea gravel as required in Section 312000 "Earth Moving."

K. Install cathodic protection for storage container. Cathodic protection is specified in Section 134700 "Cathodic Protection."

3.10 PUMP INSTALLATION

A. Install pumps with access space for periodic maintenance including removal of motors, impellers, and accessories.

B. Set pumps on and anchored to concrete base.

C. Install suction piping with minimum fittings and change of direction.

D. Connect liquid suction to container, supply to vaporizer, and return line to container.

3.11 VAPORIZER INSTALLATION

A. Install vaporizer with access space for periodic maintenance.

B. Set vaporizers on and anchor to concrete base.

C. Connect liquid line from pump set, and vapor supply to distribution piping.

D. Install backup connection from vapor space of container to inlet of pressure-regulating valve at vaporizer discharge to bypass the vaporizer during maintenance. Install shutoff valves to change source from vaporizer to storage container.

3.12 LABELING AND IDENTIFYING

A. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for piping and valve identification.

B. Install detectable warning tape directly above gas piping, 12 inches (305 mm) below finished grade, except 6 inches (150 mm) below subgrade under pavements and slabs.

3.13 FIELD QUALITY CONTROL

A. Test, inspect, and purge LPG according to NFPA 58 and NFPA 54 or the International Fuel Gas Code and requirements of authorities having jurisdiction as directed.

B. LPG piping will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.14 OUTDOOR PIPING SCHEDULE

A. Underground LPG liquid piping shall be one of the following:

1. Schedule 40 steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.
2. Annealed-temper copper tube, Type K (Type A) or Type L (Type B) with wrought-copper fittings and brazed joints as directed. Coat pipe and fittings with protective coating for copper tubing.

B. Aboveground LPG liquid piping shall be one of the following:

1. NPS 2 (DN 50) and Smaller: Schedule 40 or Schedule 80 steel pipe as directed, malleable-iron threaded fittings and threaded and seal welded joints. Coat pipe and fittings with protective coating for steel piping.
2. Annealed-temper copper tube, Type L (Type B), with wrought-copper fittings and brazed joints. Coat pipe and fittings with protective coating for copper tubing.

C. Underground LPG vapor piping shall be one of the following:

1. PE pipe and fittings joined by heat-fusion; service-line risers with tracer wire terminated in an accessible location.
2. Schedule 40, steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.
3. Annealed-temper copper tube, Type L (Type B) with wrought-copper fittings and brazed joints. Coat pipe and fittings with protective coating for copper tubing.

D. Aboveground LPG vapor piping shall be one of the following:

1. Schedule 40, steel pipe with malleable-iron fittings and threaded joints.
2. Schedule 40, steel pipe with wrought-steel fittings and welded joints.
3. Annealed-temper copper tube, Type L (Type B), with wrought-copper fittings and brazed joints. Coat pipe and fittings with protective coating for copper tubing.

E. Branch Piping in Cast-in-Place Concrete to Single Appliance: Annealed-temper copper, with wrought-copper fittings and brazed or flared joints as directed. Install piping embedded in concrete with no joints in concrete.

F. Containment Conduit: Schedule 40, steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

3.15 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 0.5 PSIG (3.45 kPa)

A. Aboveground, branch piping NPS 1 (DN 25) and smaller shall be one of the following:

1. Corrugated stainless-steel tubing with mechanical fittings having socket or threaded ends to match adjacent piping.
2. Annealed-temper copper tube with wrought-copper fittings and brazed or flared joints as directed.

3. Schedule 40, steel pipe with malleable-iron fittings and threaded joints.

B. Aboveground, distribution piping shall be one of the following:

1. Schedule 40, steel pipe with malleable-iron fittings and threaded joints.
2. Schedule 40, steel pipe with wrought-steel fittings and welded joints.

C. Underground, below building, piping shall be one of the following:

1. Schedule 40, steel pipe with malleable-iron fittings and threaded joints.
2. Schedule 40, steel pipe with wrought-steel fittings and welded joints.

D. Containment Conduit: Schedule 40, steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

E. Containment Conduit Vent Piping: Schedule 40, steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.

3.16 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES MORE THAN 0.5 PSIG (3.45 kPa) AND LESS THAN 5 PSIG (34.5 kPa)

A. Aboveground, branch piping NPS 1 (DN 25) and smaller shall be one of the following:

1. Corrugated stainless-steel tubing with mechanical fittings having socket or threaded ends to match adjacent piping.
2. Annealed-temper copper tube, Type L (Type B) with wrought-copper fittings and brazed or flared joints as directed.
3. Schedule 40, steel pipe with malleable-iron fittings and threaded joints.

B. Aboveground, distribution piping shall be one of the following:

1. Schedule 40, steel pipe with malleable-iron fittings and threaded joints.
2. Schedule 40, steel pipe with steel welding fittings and welded joints.

C. Underground, below building, piping shall be one of the following:

1. Schedule 40, steel pipe with malleable-iron fittings and threaded joints.
2. Schedule 40, steel pipe with wrought-steel fittings and welded joints.

D. Containment Conduit: Schedule 40, steel pipe with wrought-steel fittings and welded joints. Coat underground pipe and fittings with protective coating for steel piping.

E. Containment Conduit Vent Piping: Schedule 40, steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.

3.17 UNDERGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Connections to Existing Gas Piping: Use valve and fitting assemblies made for tapping utility's gas mains and listed by an NRTL.

B. Underground Vapor Piping: PE ball or Bronze plug valve as directed.

3.18 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Aboveground Liquid Piping:

1. Two-piece, full or regular-port, bronze ball valves with bronze trim as directed.

B. Valves for pipe NPS 2 (DN 50) and smaller at service meter shall be one of the following:

1. One-piece, bronze ball valve with bronze trim.
2. Two-piece, full or regular-port, bronze ball valves with bronze trim.
3. Bronze plug valve.

C. Distribution piping valves for pipe NPS 2 (DN 50) and smaller shall be one of the following:

1. One-piece, bronze ball valve with bronze trim.
2. Two-piece, full or regular-port as directed, bronze ball valves with bronze trim.
3. Bronze plug valve.

D. Valves in branch piping for single appliance shall be one of the following:

1. One-piece, bronze ball valve with bronze trim.
2. Two-piece, full or regular-port as directed, bronze ball valves with bronze trim.
3. Bronze plug valve.

END OF SECTION 231126

SECTION 231213 - FACILITY FUEL-OIL PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Submersible fuel-oil storage tank pumps.
2. Simplex fuel-oil pumps.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For fuel-oil pumps.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Maximum Operating-Pressure Ratings: 3-psig (21-kPa) fuel-oil supply pressure at oil-fired appliances.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.

2.2 SUBMERSIBLE FUEL-OIL STORAGE TANK PUMPS

A. Description: Comply with UL 79, UL 87, and UL 343.

1. Impeller: Turbine.
2. Housing and Volute: Cast iron.
3. Bearings: Bronze, self-lubricating.
4. Seals: Mechanical.
5. Shaft: Polished steel.
6. Suspension Piping: Telescoping to accommodate tank diameter and depth of bury.
7. Base: Steel.
8. Pressure Relief: Built in.
9. Discharge Check Valve: Built in.
10. Drive: Direct, close coupled.

B. Controls: Pump controller panel complying with UL 353 and UL 508C and with interlock and terminals for connections to fuel-oil-burning equipment.

1. Maintain minimum manifold pressure with outdoor-air temperature less than 60 deg F (16 deg C).
2. Seven-day schedule.
3. Stage multiple pumps to maintain pressure at a common supply manifold.
4. Alternate pumps to equalize run time.
5. Alarm motor failure.
6. Manual reset dry-run protection.
7. Stop pumps if fuel level falls below pump suction.
8. De-energize and sound alarm for pump, locked-rotor condition.
9. Sound alarm for open circuit and for high and low voltage.
10. Lights shall indicate normal power on, run, and off conditions.
11. Interface with automatic control system. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC" to control and indicate the following:

    a. Start/stop pump set when required by schedule, fuel-fired appliance operation, day tank level control, or weather conditions.
    b. Operating status.
    c. Alarm off-normal status.

C. Capacities and Characteristics:

1. Number of Stages: As directed.
2. Capacity: As directed.
3. Discharge Pressure: As directed.
4. Outlet Size: As directed.
5. Motor Speed: As directed.
6. Motor Horsepower: As directed.
7. Electrical Characteristics:

    a. Volts: As directed.
    b. Phase: Single or Three as directed.
    c. Hertz: 60.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed.
    f. Maximum Overcurrent Protection: As directed.

2.3 SIMPLEX FUEL-OIL TRANSFER PUMPS

A. Description: Comply with UL 343 and HI 3.1-3.5.

1. Type: Positive-displacement, rotary type.
2. Impeller: Steel gear with crescent or Carbon vane as directed.
3. Housing: Cast-iron foot mounted.
4. Bearings: Bronze, self-lubricating.
5. Shaft: Polished steel.
6. Seals: Mechanical.
7. Base: Steel.
8. Pressure Relief: Built in.
9. Discharge Check Valve: Built in.

B. Drive: As directed.

C. Controls:

1. Maintain minimum manifold pressure with outdoor-air temperature less than 60 deg F (16 deg C).
2. Seven-day schedule.
3. Alarm motor failure.
4. Manual reset dry-run protection.
5. Stop pump if fuel level falls below pump suction.
6. De-energize and sound alarm for pump, locked-rotor condition.
7. Sound alarm for open circuit and for high and low voltage.
8. Lights shall indicate normal power on, run, and off conditions.
9. Interface with automatic control system. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC" to control and indicate the following:

    a. Start/stop pump set when required by schedule, fuel-fired appliance operation, day tank level control, or weather conditions.
    b. Operating status.
    c. Alarm off-normal status.

D. Capacities and Characteristics:

1. Number of Stages: As directed.
2. Capacity: As directed
3. Inlet Vacuum: As directed.
4. Discharge Pressure: As directed.
5. Inlet and Outlet Size: As directed.
6. Motor Speed: As directed.
7. Motor Horsepower: As directed
8. Electrical Characteristics:

    a. Volts: As directed
    b. Phase: Single or Three As directed.
    c. Hertz: 60.
    d. Full-Load Amperes: As directed
    e. Minimum Circuit Ampacity: As directed.

f. Maximum Overcurrent Protection: As directed.

2.4 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Enclosure: As directed.
2. Enclosure Materials: As directed.
3. Motor Bearings: As directed.
4. Unusual Service Conditions:

    a. Ambient Temperature: As directed.
    b. Altitude: As directed.
    c. High humidity.

5. Efficiency: Premium efficient.
6. NEMA Design: As directed.
7. Service Factor: As directed.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.2 PREPARATION

A. Close equipment shutoff valves before turning off fuel oil to premises or piping section.

B. Comply with NFPA 30 and NFPA 31 requirements for prevention of accidental ignition.

3.3 FUEL-OIL PUMP INSTALLATION

A. Submersible Pumps:

1. Suspend pumps from supply piping and anchored to bottom of tank.

B. Transfer Pumps:

1. Install pumps with access space for periodic maintenance including removal of motors, impellers, and accessories.
2. Set pumps on and anchor to concrete base.
3. Pump Mounting:

a. Install base-mounted pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.
b. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
c. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

4. Equipment Mounting: Install in-line pumps with continuous-thread hanger rods and elastomeric hangers or spring hangers or spring hangers with vertical-limit stop of size required to support weight of in-line pumps as directed.

a. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
b. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

C. Install two-piece, full-port ball valves at suction and discharge of pumps. Comply with requirements in Section 230523.12 "Ball Valves for HVAC Piping."

D. Install mechanical leak-detector valves at pump discharge.

E. Install strainer on inlet side of simplex fuel-oil pumps As directed.

F. Install check valve on discharge of simplex fuel-oil pumps.

G. Install suction piping with minimum fittings and change of direction.

H. Install vacuum and pressure gage, upstream and downstream, respectively, at each pump to measure the differential pressure across the pump. Pressure gages are specified in Section 230519 "Meters and Gages for HVAC Piping."

3.4 LABELING AND IDENTIFYING

A. Install nameplates and signs on each fuel-oil pump. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment."

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Start fuel-oil transfer pumps to verify for proper operation of pump and check for leaks.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Fuel-oil pumps will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain fuel-oil pumps as directed.

END OF SECTION 231213

SECTION 231313 - FACILITY UNDERGROUND FUEL-OIL STORAGE TANKS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Composite, steel, fuel-oil USTs.
2. Jacketed, steel, fuel-oil USTs.
3. FRP fuel-oil USTs.
4. Leak-detection systems.
5. Fuel oil.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For underground fuel-oil storage tanks.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample Warranty: For special warranty.

1.4 QUALITY ASSURANCE

A. Underground Fuel-Oil Storage Tanks: Comply with requirements of the EPA and of state and local authorities having jurisdiction, including recording fuel-oil storage tanks.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of fuel-oil storage tanks that fail in materials or workmanship within specified warranty period.

1. Storage Tanks:

a. Failures include, but are not limited to, the following when used for storage of fuel oil at temperatures not exceeding 150 deg F (66 deg C):

1) Structural failures including cracking, breakup, and collapse.
2) Corrosion failure including external and internal corrosion of steel tanks.

b. Warranty Period: 30 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 STEEL, FUEL-OIL UST WITH STI-P3

A. Description: UL 58 and STI P3, double-wall, horizontal, steel tank; with cathodic protection and electrical isolation.

1. Containment Method: STI-P3, Type I, with primary and secondary walls in contact or Type II, with interstitial space as directed.

B. Construction: Fabricated with welded steel; suitable for operation at atmospheric pressure and for storing liquids with specific gravity up to 1.1; fabricated for the following loads:

1. Depth of Bury: 36 inches (900 mm) from top of tank to finished surface.
2. External Hydrostatic Pressure: To withstand general buckling with safety factor of 2:1 if hole is fully flooded.
3. Surface Loads: AASHTO's "Specifications for Highway Bridges," H-20 axle loads of 32,000 lb (14 515 kg).

C. Corrosion-Protection System: Protect tank and factory-installed piping by engineered and installed corrosion-protection system according to STI P3, with means of monitoring cathodic protection.

D. Capacities and Characteristics:

1. Capacity: As directed.
2. Diameter: As directed.
3. Length: As directed.
4. Connection Sizes:

a. Fill Line: As directed.
b. Vent Line: As directed.
c. Outlet: As directed.
d. Return: As directed.
e. Gage: As directed.

5. Manholes:

a. Number Required: As directed.
b. Diameter: As directed,

6. Fuel-Oil Grade Number: As directed.

2.2 COMPOSITE, STEEL, FUEL-OIL UST

A. Description: UL 58, double-wall, horizontal, composite tank; with coating complying with UL 1746 and STI F894.

1. Containment Method: STI F894, Type I, with primary and secondary walls in contact or Type II, with interstitial space as directed.

B. Construction: Fabricated with welded steel and factory coating according to UL 1746 and STI F894; suitable for operation at atmospheric pressure and for storing liquids with specific gravity up to 1.1; fabricated for the following loads:

1. Depth of Bury: 36 inches (900 mm) from top of tank to finished surface.
2. External Hydrostatic Pressure: To withstand general buckling with safety factor of 2:1 if hole is fully flooded.
3. Surface Loads: AASHTO's "Specifications for Highway Bridges," H-20 axle loads of 32,000 lb (14 515 kg).

C. Capacities and Characteristics:

1. Capacity: As directed.
2. Diameter: As directed.
3. Length: As directed.
4. Connection Sizes:

    a. Fill Line: As directed.
    b. Vent Line: As directed.
    c. Outlet: As directed.
    d. Return: As directed.
    e. Gage: As directed.

5. Manholes:

    a. Number Required: As directed.
    b. Diameter: As directed.

6. Fuel-Oil Grade Number: As directed.

2.3 JACKETED, STEEL, FUEL-OIL UST

A. Description: Jacketed, horizontal, steel tank; complying with UL 58, and with plastic or fiberglass jacket and corrosion-protection system according to UL 1746 and STI F922.

B. Construction: Tank fabricated with welded carbon steel, and jacket fabricated with plastic or fiberglass and vacuum-sealed interstitial space; suitable for operation at atmospheric pressure and with integral leak-detection device. Tank fabricated for the following loads:

1. Depth of Bury: 36 inches (900 mm) from top of tank to finished surface.
2. External Hydrostatic Pressure: To withstand general buckling with safety factor of 2:1 if hole is fully flooded.
3. Surface Loads: AASHTO's "Specifications for Highway Bridges," H-20 axle loads of 32,000 lb (14 515 kg).

C. Capacities and Characteristics:

1. Capacity: As directed.
2. Diameter: As directed.
3. Length: As directed.

4. Connection Sizes:

    a. Fill Line: As directed.
    b. Vent Line: As directed.
    c. Outlet: As directed.
    d. Return: As directed.
    e. Gage: As directed.

5. Manholes:

    a. Number Required: As directed.
    b. Diameter: As directed.

6. Fuel-Oil Grade Number: As directed.

2.4 FRP FUEL-OIL UST

A. Description: Horizontal, FRP UST; UL 1316, double wall, with interstitial space and integral, hydrostatic, leak-detection and monitoring system.

B. Construction: Fabricated with fiberglass-reinforced polyester resins; suitable for operation at atmospheric pressure; fabricated for the following loads:

1. Depth of Bury: 36 inches (900 mm) from top of tank to finished surface.
2. External Hydrostatic Pressure: To withstand general buckling with safety factor of 2:1 if hole is fully flooded.
3. Surface Loads: AASHTO's "Specifications for Highway Bridges," H-20 axle loads of 32,000 lb (14 515 kg).

C. Capacities and Characteristics:

1. Capacity: As directed.
2. Diameter: As directed.
3. Length: As directed.
4. Connection Sizes:

    a. Fill Line: As directed.
    b. Vent Line: As directed.
    c. Outlet: As directed.
    d. Return: As directed.
    e. Gage: As directed.

5. Manholes:

    a. Number Required: As directed.
    b. Diameter: As directed.

6. Fuel-Oil Grade Number: As directed.

2.5 FUEL-OIL UST ACCESSORIES

A. Tank Manholes: 22-inch- (560-mm-) minimum diameter; bolted, flanged, and gasketed, with extension collar; for access to inside of tank.

B. Steel Tank Masonry Supports: Two 6-by-6-by-3/8-inch (150-by-150-by-10-mm) steel angles, 72 inches (1800 mm) long, located longitudinally on tank on each side of manholes and continuously welded in place.

C. Threaded pipe connection fittings on top of tank for fill, supply, return, vent, sounding, and gaging; in locations and of sizes indicated. Include cast-iron plugs for shipping.

D. Striker Plates: Inside tank, on bottom below fill, vent, sounding, gage, and other tube openings.

E. Lifting Lugs: For handling and installation.

F. Ladders: Carbon-steel ladder inside tank, anchored to top and bottom. Include reinforcement of tank at bottom of ladder.

G. Supply Tube: Extension of supply piping fitting into tank, terminating 6 inches (150 mm) above tank bottom and cut at a 45-degree angle.

H. Sounding and Gage Tubes: Extension of fitting into tank, terminating 6 inches (150 mm) above tank bottom and cut at a 45-degree angle.

I. Containment Sumps: Fiberglass or PE with sump base as directed, add-on extension pieces as required, sump top, lid, and gasket-seal joints. Include sump entry boots for pipe penetrations through sidewalls.

J. Sump Entry Boots: Two-part pipe fitting for field assembly and of size required to fit over pipe. Include gaskets shaped to fit sump sidewall, sleeves, seals, and clamps as required for liquid-tight pipe penetrations.

K. Anchor Straps: Storage tank manufacturer's standard anchoring system, with straps, strap-insulating material, cables, and turnbuckles; of strength at least one and one-half times maximum uplift force of empty tank without backfill in place.

L. Filter Mat: Geotextile woven or spun filter fabric, in 1 or more layers, for minimum total weight of 3 oz./sq. yd. (101.7 g/sq. m).

M. Overfill Prevention Valves: Factory fabricated or shop or field assembled from manufacturer's standard components. Include drop tube, cap, fill nozzle adaptor, check valve mechanism or other devices, and vent if required to restrict flow at 95 percent of tank capacity and to provide complete shutoff of filling at 98 or 99 percent of tank capacity as directed.

2.6 LEAK-DETECTION AND MONITORING SYSTEM

A. Cable and Sensor System: Comply with UL 1238.
   1. Calibrated, leak-detection and monitoring system with probes and other sensors and remote alarm panel for fuel-oil storage tanks and fuel-oil piping.
   2. Include fittings and devices required for testing.

3. Controls: Electrical, operating on 120-V ac.
4. Remote Annunciator Panel: With visual and audible, high-tank-level and low-tank-level alarms, fuel indicator with registration in gallons (liters), and overfill alarm. Include gage volume range that covers fuel-oil storage capacity.
5. Controls: Electrical, operating on 120-V ac.

2.7 FUEL OIL

A. Fuel Oil: ASTM D396, Grade No. 1 or Grade No. 2 as directed.

B. Diesel Fuel Oil: ASTM D975, as directed.

2.8 CONCRETE MANHOLES

A. Precast Concrete Manhole Sections: ASTM C478 (ASTM C478M), base and concentric-cone sections with integral ladder or steps.

B. Cast-Iron Frame and Cover: Heavy-duty, water-resistant, cast-iron manhole frame, gasket, and bolted cover; 24-inch- (609-mm-) diameter, inside opening dimension; 8-inch (203-mm) frame riser height.

2.9 LABELING AND IDENTIFYING

A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches (152 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches (762 mm) deep; colored yellow.

2.10 SOURCE QUALITY CONTROL

A. Pressure test and inspect fuel-oil storage tanks, after fabrication and before shipment, according to ASME and the following:

1. Horizontal, Steel USTs with the STI-P3 Corrosion-Protection System: UL 58 and STI P3.
2. As direct Steel USTs: UL 58.
3. FRP USTs: UL 1316.

B. Affix standards organization's code stamp.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

B. Excavate to sufficient depth for a minimum of 36 inches (900 mm) of earth cover from top of tank to finished grade. Allow for cast-in-place, concrete-ballast base plus 6 inches (150 mm) of sand or pea gravel between ballast base and tank. Extend excavation at least 12 inches (300 mm) around perimeter of tank.

C. Backfill excavation with clean sand or pea gravel in 12-inch (305-mm) lifts and tamp backfill lift to consolidate.

D. Install filter mat between top of backfill material and earth fill.

3.2 FUEL-OIL UST INSTALLATION

A. Set tie-down eyelets for hold-down straps in concrete-ballast base and tie to reinforcing steel.

B. Place 6 inches (152 mm) of clean sand or pea gravel on top of concrete-ballast base.

C. Set tank on fill materials and install hold-down straps.

D. Connect piping.

E. Install tank leak-detection and monitoring devices.

F. Install containment sumps.

G. Install steel USTs with the STI-P3 corrosion-protection system according to STI R821 and STI R891. Protect anodes during tank placement and backfilling operations.

H. Install composite, steel USTs according to STI R913 and STI R891.

I. Install jacketed, steel USTs according to STI R923 and STI R891.

J. Install FRP USTs with FRP hold-down straps, manhole extensions, and manhole risers.

K. Fill storage tanks with fuel oil.

3.3 LEAK-DETECTION AND MONITORING SYSTEM INSTALLATION

A. Install leak-detection and monitoring system. Install alarm panel inside building where indicated.

1. Double-Wall, Fuel-Oil Storage Tanks: As directed in interstitial space.
2. Single-Wall, Fuel-Oil Storage Tanks: Install probes as indicated.
3. Double-Containment, Fuel-Oil Piping: Install leak-detection sensor As directed.

3.4 LABELING AND IDENTIFYING

A. Nameplates, pipe identification, and signs are specified in Section 230553 "Identification for HVAC Piping and Equipment."

B. Install detectable warning tape directly above UST, 12 inches (304 mm) below finished grade, except 6 inches (152 mm) below subgrade under pavements and slabs.

1. Terminate tracer wire in an accessible area and identify as "tracer wire" for future use with plastic-laminate sign.
2. Install over edges of each UST.

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Tanks: Minimum hydrostatic or compressed-air test pressures for fuel-oil storage tanks that have not been factory tested and do not bear the ASME code stamp or a listing mark acceptable to authorities having jurisdiction:

a. Double-Wall Tanks:

1) Inner Tanks: Minimum 3 psig (20.7 kPa) and maximum 5 psig (34.5 kPa).
2) Interstitial Space: Minimum 3 psig (20.7 kPa) and maximum 5 psig (34.5 kPa), or 5.3-in. Hg (18-kPa) vacuum.

b. Where vertical height of fill and vent pipes is such that the static head imposed on the bottom of the tank is greater than 10 psig (69 kPa), hydrostatically test the tank and fill and vent pipes to a pressure equal to the static head thus imposed.
c. Maintain the test pressure for one hour.

B. USTs will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 231313

SECTION 231323 - FACILITY ABOVEGROUND FUEL-OIL STORAGE TANKS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Vertical, steel, fuel-oil ASTs.
2. Horizontal, steel, fuel-oil ASTs.
3. Insulated, steel, fuel-oil ASTs.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include plans, elevations, sections, and ballast pads and anchors, and lifting or supporting points.
2. Indicate dimensions, components, and location and size of each field connection.
3. Shop Drawing Scale: 1/4 inch per foot (1:50).

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For ASTs, accessories, and components, from manufacturer.

B. Brazing certificates.

C. Welding certificates.

D. Field quality-control reports.

E. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. EPA Compliance: Comply with EPA and state and local authorities having jurisdiction. Include recording of fuel-oil storage tanks and monitoring of tanks.

B. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of fuel-oil storage tanks that fail in materials or workmanship within specified warranty period.

1. Storage Tanks:

a. Failures include, but are not limited to, the following when used for storage of fuel oil at temperatures not exceeding 150 deg F (66 deg C):

1) Structural failures including cracking, breakup, and collapse.
2) Corrosion failure including external and internal corrosion of steel tanks.

b. Warranty Period: 30 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design restraint and anchors for fuel-oil ASTs, and equipment, including comprehensive engineering analysis, using performance requirements and design criteria indicated.

B. Seismic Performance: Factory-installed support attachments for AST shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.2 VERTICAL, STEEL, FUEL-OIL AST

A. Description: UL 142, single-wall, vertical, steel tank.

B. Description: UL 142 and STI F921, double-wall, vertical, steel tank; with primary- and secondary-containment walls and interstitial space.

C. Construction: Fabricated with welded, carbon steel suitable for operation at atmospheric pressure and for storing fuel oil with specific gravity up to 1.1 and maintained temperature up to 150 deg F (66 deg C).

D. Capacities and Characteristics:

1. Capacity: As directed.

2. Diameter: As directed.
3. Length: As directed.
4. Connection Sizes:

    a. Fill Line: As directed.
    b. Vent Line: As directed.
    c. Outlet: As directed.
    d. Return: As directed.
    e. Gage: As directed.

5. Manholes:

    a. Number Required: As directed.
    b. Diameter: As directed.

6. Fuel-Oil Grade Number: As directed.

2.3 HORIZONTAL, STEEL, FUEL-OIL AST

A. Description: UL 142, single-wall, horizontal, steel tank.

B. Description: UL 142 and STI F921, double-wall, horizontal, steel tank; with primary- and secondary-containment walls and interstitial space.

C. Construction: Fabricated with welded, carbon steel; suitable for operation at atmospheric pressure and for storing fuel oil with specific gravity up to 1.1 and with maintained temperature up to 150 deg F (66 deg C).

D. Supports: Manufacturer's standard structural steel welded to tank.

E. Supports: Manufacturer's standard type and number, steel or cast-iron cradles, for field installation.

1. Number of Supports: As directed.

F. Capacities and Characteristics:

1. Capacity: As directed.
2. Diameter: As directed.
3. Length: As directed.
4. Connection Sizes:

    a. Fill Line: As directed.
    b. Vent Line: As directed.
    c. Outlet: As directed.
    d. Return: As directed.
    e. Gage: As directed.

5. Manholes:

    a. Number Required: As directed.

b. Diameter: As directed.

6. Fuel-Oil Grade Number: As directed.

2.4 INSULATED, STEEL, FUEL-OIL AST

A. Description: Thermally insulated and fire-resistant, double-wall, horizontal, steel tank; with primary- and secondary-containment walls and insulation and with interstitial space As directed.

B. Construction: Fabricated with welded, carbon steel and insulation; suitable for operation at atmospheric pressure and for storing fuel oil with specific gravity up to 1.1 and with test temperature according to UL 2085.

C. Capacities and Characteristics:

1. Capacity: As directed.
2. Diameter: As directed.
3. Length: As directed.
4. Connection Sizes:

   a. Fill Line: As directed.
   b. Vent Line: As directed.
   c. Outlet: As directed.
   d. Return: As directed.
   e. Gage: As directed.

5. Manholes:

   a. Number Required: As directed.
   b. Diameter: As directed.

6. Fuel-Oil Grade Number: As directed.

2.5 SHOP PAINTING OF AST

A. Apply manufacturer's standard prime coat to exterior steel surface of AST and supports.

B. Prepare exterior steel surface of AST and tank supports.

C. Shop Cleaning: After fabrication, blast clean according to SSPC-SP 6/NACE No. 3 or SSPC-SP 10/NACE No. 2 As directed.

D. After cleaning, remove dust or residue from cleaned surfaces.

E. If surface develops rust before prime coat is applied, repeat surface preparation.

F. Apply manufacturer's standard prime coat to shop-cleaned, dry surface same day as surface preparation.

G. Apply manufacturer's standard two-component, epoxy finish coats.

2.6 FUEL-OIL AST ACCESSORIES

A. Tank Manholes: 22-inch- (560-mm-) minimum diameter; bolted, flanged, and gasketed; centered on top of tank.

B. Tank Manholes: 22-inch- (560-mm-) minimum diameter; bolted, flanged, and gasketed; on top and at side of tank.

C. Threaded pipe connection fittings on top of tank, for fill, supply, return, vent, sounding, and gaging. Include cast-iron plugs for shipping.

D. Threaded pipe connection fittings on top or sides of tank as indicated, for fill, supply, return, vent, sounding, and gaging. Include cast-iron plugs for shipping.

E. Striker Plates: Inside tank, on bottom below fill, vent, sounding, gage, and other tube openings.

F. Lifting Lugs: For handling and installation.

G. Ladders: Carbon-steel ladder inside tank, anchored to top and bottom, and located as indicated. Include reinforcement of tank at bottom of ladder.

H. Ladders: Carbon-steel ladder outside tank, anchored to top and side wall. Comply with requirements in Section 055000 "Metal Fabrications" for exterior steel ladder.

1. Cage: Include welded steel cage around ladders for tanks 20 feet (6 m) high or higher.

I. Supply Tube: Extension of supply piping fitting into tank, terminating 6 inches (150 mm) above tank bottom and cut at a 45-degree angle (1:1 slope).

J. Sounding and Gage Tubes: Extension of fitting into tank, terminating 6 inches (150 mm) above tank bottom and cut at a 45-degree angle (1:1 slope).

2.7 LIQUID-LEVEL GAGE SYSTEM

A. Description: Calibrated liquid-level gage system complying with UL 180 with floats or UL 1238 with probes as directed or other sensors and remote annunciator panel.

B. Annunciator Panel: With visual and audible, high-tank-level and low-tank-level alarms; fuel indicator with registration in gallons (liters); and overfill alarm. Include gage volume range that covers fuel-oil storage capacity.

C. Controls: Electrical, operating on 120-V ac.

2.8 LEAK-DETECTION AND MONITORING SYSTEM

A. Cable and Sensor System: Comply with UL 1238.
1. Calibrated leak-detection and monitoring system with probes and other sensors and remote alarm panel for fuel-oil storage tanks and fuel-oil piping.
2. Include fittings and devices required for testing.
3. Controls: Electrical, operating on 120-V ac.

4. Calibrated liquid-level gage complying with UL 180 with floats or UL 1238 with probes as directed or other sensors and remote annunciator panel.
5. Remote Annunciator Panel: With visual and audible, high-tank-level and low-tank-level alarms; fuel indicator with registration in gallons (liters); and overfill alarm. Include gage volume range that covers fuel-oil storage capacity.
6. Controls: Electrical, operating on 120-V ac.

2.9 FUEL OIL

A. Fuel Oil: ASTM D396, Grade No. 1 or Grade No. 2 As directed.

B. Diesel Fuel Oil: ASTM D975, high volatility as directed.

2.10 SOURCE QUALITY CONTROL

A. Pressure test and inspect fuel-oil storage tanks, after fabrication and before shipment, according to ASME and the following:

1. Vertical or Vertical or Horizontal or Horizontal, Single-Wall Steel ASTs: UL 142.
2. Vertical or Vertical or Horizontal or Horizontal, Double-Wall Steel ASTs: UL 142, STI F921, and STI R931.
3. Horizontal, Insulated, Steel ASTs: UL 142 and UL 2085.

B. Affix standards organization's code stamp.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

B. Allow for cast-in-place, concrete base.

3.2 FUEL-OIL AST INSTALLATION

A. Install tank bases and supports.

B. Concrete Bases: Anchor AST to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

1. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (457-mm) centers around the full perimeter of the base.

3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Use 3000-psig (20.7-MPa), 28-day, compressive-strength concrete and reinforcement as specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" As directed.

C. Connect piping and vent fittings.

D. Install ground connections.

E. Install tank leak-detection and monitoring devices.

F. Install steel ASTs according to STI R912.

G. Fill storage tanks with fuel oil.

3.3 LIQUID-LEVEL GAGE SYSTEM INSTALLATION

A. Install liquid-level gage system. Install panel inside building where indicated.

3.4 LEAK-DETECTION AND MONITORING SYSTEM INSTALLATION

A. Install leak-detection and monitoring system. Install alarm panel inside building where indicated.

1. Double-Wall, Fuel-Oil Storage Tanks: As directed in interstitial space.
2. Single-Wall, Fuel-Oil Storage Tanks: Install probes as indicated.
3. Double-Containment, Fuel-Oil Piping: Install leak-detection sensor probes in fuel-oil storage tank containment sumps and at low points in piping or cable probes in interstitial space of double-containment piping as directed.
4. Install liquid-level gage.

3.5 LABELING AND IDENTIFYING

A. Nameplates, pipe identification, and signs are specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.6 FIELD PAINTING OF AST

A. Prepare and touch up damaged exterior surface of AST and supports as specified in "Shop Painting of AST" Article.

B. Prepare exterior steel surface of AST and tank supports.

C. Field Cleaning: After fabrication, blast clean according to SSPC-SP 6/NACE No. 3 or SSPC-SP 10/NACE No. 2 As directed..

D. After cleaning, remove dust or residue from cleaned surfaces.

E. If surfaces develop rust before prime coat is applied, repeat surface preparation.

F. Prepare surface of AST and supports and apply painting systems according to specifications in Section 099600 "High-Performance Coatings" for environment high-gloss or semigloss finish for ferrous metal as directed.

3.7 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Tanks: Minimum hydrostatic or compressed-air test pressures for fuel-oil storage tanks that have not been factory tested and do not bear the ASME code stamp or a listing mark acceptable to authorities having jurisdiction:

a. Single-Wall Tanks: Minimum 3 psig (20.7 kPa) and maximum 5 psig (34.5 kPa).
b. Double-Wall Tanks:

1) Inner Tanks: Minimum 3 psig (20.7 kPa) and maximum 5 psig (34.5 kPa).
2) Interstitial Space: Minimum 3 psig (20.7 kPa) and maximum 5 psig (34.5 kPa), or 5.3-in. Hg (18-kPa) vacuum.

c. Where vertical height of fill and vent pipes is such that the static head imposed on the bottom of the tank is greater than 10 psig (69 kPa), hydrostatically test the tank and fill and vent pipes to a pressure equal to the static head thus imposed.
d. Maintain the test pressure for one hour.

B. ASTs will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 231323

SECTION 232113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes pipe and fitting materials and joining methods for the following:

1. Steel pipe and fittings.
2. Plastic pipe and fittings.
3. Joining materials.
4. Transition fittings.
5. Dielectric fittings.
6. Bypass chemical feeder.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Pipe.
2. Fittings.
3. Joining materials.
4. Bypass chemical feeder.

B. Sustainable Design Submittals: As directed.

C. Delegated-Design Submittal:

1. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
2. Locations of pipe anchors and alignment guides and expansion joints and loops.
3. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.
4. Locations of and details for penetration and firestopping for fire- and smoke-rated wall and floor and ceiling assemblies.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:

1. Hot-Water Heating Piping: 100 psig (689 kPa) at 200 deg F (93 deg C) or 180 deg F (82 deg C) as directed.
2. Chilled-Water Piping: 150 psig (1034 kPa) at 73 deg F (22 deg C).
3. Condenser-Water Piping: 150 psig (1034 kPa) at 73 deg F (66 deg C).
4. Makeup-Water Piping: 80 psig (552 kPa) or 150 psig (1034 kPa) at 73 deg F (22 deg C) or 150 deg F (66 deg C) as directed.
5. Condensate-Drain Piping: 150 deg F (66 deg C) or 180 deg F (82 deg C) as directed.
6. Blowdown-Drain Piping: 180 deg F (82 deg C) or 200 deg F (93 deg C) as directed.
7. Air-Vent Piping: 180 deg F (82 deg C) or 200 deg F (93 deg C) as directed.
8. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B88, Type L (ASTM B88M, Type B) or ASTM B88, Type M (ASTM B88M, Type C) as directed.

B. Annealed-Temper Copper Tubing: ASTM B88, Type K (ASTM B88M, Type A).

C. DWV Copper Tubing: ASTM B306, Type DWV.

D. Grooved, Mechanical-Joint, Wrought-Copper Fittings: ASME B16.22.
1. Grooved-End Copper Fittings: ASTM B75 (ASTM B75M), copper tube or ASTM B584, bronze casting.
2. Grooved-End-Tube Couplings: Rigid pattern unless otherwise indicated; gasketed fitting. Ductile-iron housing with keys matching pipe and fitting grooves, prelubricated EPDM gasket rated for minimum 230 deg F (110 deg C) for use with housing, and steel bolts and nuts.

E. Wrought-Copper Unions: ASME B16.22.

2.3 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A53/A53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in "Piping Applications" Article.

C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in "Piping Applications" Article.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in "Piping Applications" Article.

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.

F. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

G. Grooved Mechanical-Joint Fittings and Couplings:
1. Joint Fittings: ASTM A536, Grade 65-45-12 ductile iron; ASTM A47/A47M, Grade 32510 malleable iron; ASTM A53/A53M, Type F, E, or S, Grade B fabricated steel; or ASTM A106/A106M, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
2. Couplings: Ductile- or malleable-iron housing and EPDM or nitrile gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.

H. Plain-End Mechanical-Joint Couplings:
1. Housing: ASTM A536 Grade 65-45-12 segmented ductile iron or type 304 stainless steel.
2. Housing Coating: None.
3. Gasket: EPDM or NBR as directed.
4. Sealing Mechanism: Double-lip sealing system or carbon steel case-hardened jaws.
5. Bolts, hex nuts, washers, or lock bars based on manufacturer's design.
6. Minimum Pressure Rating: Equal to that of the joined pipes.

2.4 PLASTIC PIPE AND FITTINGS

A. CPVC Plastic Pipe: ASTM F441/F441M, with wall thickness as indicated in "Piping Applications" Article.

1. CPVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM F438 for Schedule 40 pipe; ASTM F439 for Schedule 80 pipe.

B. PVC Plastic Pipe: ASTM D1785, with wall thickness as indicated in "Piping Applications" Article.

1. PVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM D2466 for Schedule 40 pipe; ASTM D2467 for Schedule 80 pipe.

2.5 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch (3.2-mm) maximum thickness unless otherwise indicated.

    a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
    b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

D. Solder Filler Metals: ASTM B32, lead-free alloys. Include water-flushable flux according to ASTM B813.

E. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

F. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

G. Solvent Cements for CPVC Piping: ASTM F493.

H. Solvent Cements for PVC Piping: ASTM D2564. Include primer according to ASTM F656.

2.6 TRANSITION FITTINGS

A. Plastic-to-Metal Transition Fittings:
1. One-piece fitting with one threaded brass or copper insert and one solvent-cement-joint end of material and wall thickness to match plastic pipe material.

B. Plastic-to-Metal Transition Unions:
1. Brass or copper end, solvent-cement-joint end of material and wall thickness to match plastic pipe material, rubber gasket, and threaded union.

2.7 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:
1. Description:

    a. Standard: ASSE 1079.
    b. Pressure Rating: 125 psig (860 kPa) minimum at 180 deg F (82 deg C) or 150 psig (1035 kPa) or 250 psig (1725 kPa) as directed.
    c. End Connections: Solder-joint copper alloy and threaded ferrous.

2.8 BYPASS CHEMICAL FEEDER

A. Description: Welded steel construction; 125-psig (860-kPa) working pressure; 5-gal. (19-L) capacity; with fill funnel and inlet, outlet, and drain valves.

1. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Hot-water heating piping, aboveground, NPS 2 (DN 50) and smaller, shall be any of the following:

1. Type L (Type B) or Type M (Type C) as directed, drawn-temper copper tubing, wrought-copper fittings, and joints as directed.
2. Grade B steel pipe; Fittings; cast-iron flanges and flange fittings; and threaded joints as directed.
3. Schedule 40 or Schedule 80 CPVC plastic pipe and fittings and solvent-welded joints as directed.

B. Hot-water heating piping, aboveground, NPS 2-1/2 (DN 65) and larger, shall be any of the following:

1. Drawn-temper copper tubing as directed, wrought-copper fittings, and soldered or brazed joints as directed.
2. Steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints as directed.
3. Schedule 40 steel pipe, plain-end mechanical-coupled joints.
4. Schedule 40 or Schedule 80 CPVC plastic pipe as directed and fittings and solvent-welded joints.

C. Hot-Water Heating Piping Installed Belowground and within Slabs: Type K (Type A), annealed-temper copper tubing, wrought-copper fittings, and soldered or brazed joints as directed. Use the fewest possible joints.

D. Chilled-water piping, aboveground, NPS 2 (DN 50) and smaller, shall be any of the following:

1. Drawn-temper copper tubing, wrought-copper fittings, and joints as directed.
2. Steel pipe as directed; Fittings; cast-iron flanges and flange fittings; and threaded joints as directed.
3. Schedule 40 or Schedule 80 CPVC plastic pipe as directed and fittings and solvent-welded joints.

E. Chilled-water piping, aboveground, NPS 2-1/2 (DN 65) and larger, shall be any of the following:

1. Type L (Type B) or Type M (Type C), drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed joints as directed.
2. Steel pipe as directed; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
3. Schedule 40 steel pipe, plain-end mechanical-coupled joints.
4. Schedule 40 or Schedule 80 CPVC plastic pipe as directed and fittings and solvent-welded joints.

F. Chilled-Water Piping Installed Belowground and within Slabs: Type K (Type A), annealed-temper copper tubing, wrought-copper fittings, and soldered or brazed joints. Use the fewest possible joints.

G. Condenser-water piping, aboveground, NPS 2 (DN 50) and smaller, shall be any of the following:

1. Drawn-temper copper tubing, wrought-copper fittings, and joints as directed.
2. Steel pipe; fittings as directed; cast-iron flanges and flange fittings; and threaded joints.
3. Schedule 40 or Schedule 80 CPVC plastic pipe and fittings and solvent-welded joints as directed.

H. Condenser-water piping, aboveground, NPS 2-1/2 (DN 65) and larger, shall be any of the following:

1. Drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed joints.
2. Steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
3. Schedule 40 steel pipe, plain-end mechanical-coupled joints.
4. Schedule 40 or Schedule 80 CPVC plastic pipe and fittings and solvent-welded joints as directed.

I. Condenser-Water Piping Installed Belowground and within Slabs: Type K (Type A), annealed-temper copper tubing, wrought-copper fittings, and soldered or brazed joints as directed. Use the fewest possible joints.

J. Makeup-water piping installed aboveground shall be either of the following:

1. Drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed joints as directed.
2. Schedule 40 or Schedule 80 CPVC plastic pipe and fittings, and solvent-welded joints.

K. Makeup-Water Piping Installed Belowground and within Slabs: Type K (Type A), annealed-temper copper tubing, wrought-copper fittings, and soldered joints. Use the fewest possible joints.

L. Condensate-Drain Piping: Type M (Type C) or Type DWV as directed, drawn-temper copper tubing, wrought-copper fittings, and soldered joints or Schedule 40 PVC plastic pipe and fittings and solvent-welded joints.

M. Condensate-Drain Piping: Schedule 40 PVC plastic pipe and fittings and solvent-welded joints.

N. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

O. Air-Vent Piping:

1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.
2. Outlet: Type K (Type A), annealed-temper copper tubing with soldered or flared joints.

P. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.

3.2 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Select system components with pressure rating equal to or greater than system operating pressure.

K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Install drains, consisting of a tee fitting, NPS 3/4 (DN 20) ball valve, and short NPS 3/4 (DN 20) threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

O. Install branch connections to mains using mechanically formed tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

P. Install valves according to the following:

1. Section 230523.11 "Globe Valves for HVAC Piping."
2. Section 230523.12 "Ball Valves for HVAC Piping."
3. Section 230523.13 "Butterfly Valves for HVAC Piping."
4. Section 230523.14 "Check Valves for HVAC Piping."
5. Section 230523.15 "Gate Valves for HVAC Piping."

Q. Install unions in piping, NPS 2 (DN 50) and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 (DN 65) and larger, at final connections of equipment and elsewhere as indicated.

S. Install shutoff valve immediately upstream of each dielectric fitting.

T. Comply with requirements in Section 230516 "Expansion Fittings and Loops for HVAC Piping" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.

U. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.

V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

W. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.3 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 (DN 50) and Smaller: Use dielectric nipples or unions as directed.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Use dielectric as directed.

D. Dielectric Fittings for NPS 5 (DN 125) and Larger: Use dielectric flange kits.

3.4 HANGERS AND SUPPORTS

A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hanger, support, and anchor devices. Comply with the following requirements for maximum spacing of supports.

B. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.

C. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet (6 m) long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet (6 m) or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet (6 m) or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
6. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4 (DN 20): Maximum span, 7 feet (2.1 m).
2. NPS 1 (DN 25): Maximum span, 7 feet (2.1 m).
3. NPS 1-1/2 (DN 40): Maximum span, 9 feet (2.7 m).
4. NPS 2 (DN 50): Maximum span, 10 feet (3 m).
5. NPS 2-1/2 (DN 65): Maximum span, 11 feet (3.4 m).
6. NPS 3 (DN 80) and Larger: Maximum span, 12 feet (3.7 m).

E. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4 (DN 20): Maximum span, 5 feet (1.5 m); minimum rod size, 1/4 inch (6.4 mm).
2. NPS 1 (DN 25): Maximum span, 6 feet (1.8 m); minimum rod size, 1/4 inch (6.4 mm).
3. NPS 1-1/4 (DN 32): Maximum span, 7 feet (2.1 m); minimum rod size, 3/8 inch (10 mm).
4. NPS 1-1/2 (DN 40): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).
5. NPS 2 (DN 50): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).
6. NPS 2-1/2 (DN 65): Maximum span, 9 feet (2.7 m); minimum rod size, 3/8 inch (10 mm).
7. NPS 3 (DN 80) and Larger: Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (10 mm).

F. Plastic Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.

G. Support vertical runs at roof, at each floor, and at 10-foot (3-m) intervals between floors.

3.5 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Soldered Joints: Apply ASTM B813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B32.

D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.

E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

F. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

G. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements.
2. CPVC Piping: Join according to ASTM D2846/D2846M Appendix.
3. PVC Pressure Piping: Join ASTM D1785 schedule number, PVC pipe and PVC socket fittings according to ASTM D2672. Join other-than-schedule number PVC pipe and socket fittings according to ASTM D2855.
4. PVC Nonpressure Piping: Join according to ASTM D2855.

H. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.

I. Plain-End Mechanical-Coupled Joints: Prepare, assemble, and test joints in accordance with manufacturer's written installation instructions.

J. Mechanically Formed, Copper-Tube-Outlet Joints: Use manufacturer-recommended tool and procedure, and brazed joints.

3.6 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install ports for pressure gages and thermometers at coil inlet and outlet connections. Comply with requirements in Section 230519 "Meters and Gages for HVAC Piping."

3.7 CHEMICAL TREATMENT

A. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water.

B. Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.

C. Fill systems that have antifreeze or glycol solutions with the following concentrations:

1. Hot-Water Heating Piping: Percent of ethylene or propylene glycol as directed.
2. Chilled-Water Piping: Percent ethylene or propylene glycol as directed.

3.8 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.

4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

END OF SECTION 232113

SECTION 232113.13 - UNDERGROUND HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Copper tube and fittings.
2. Steel pipes and fittings.
3. Ductile-iron pipe and fittings.
4. Plastic pipe and fittings.
5. Transition fittings.
6. Conduit piping system.
7. Cased piping system.

1.2 ACTION SUBMITTALS

A. Product Data: For the following:

1. Conduit piping.
2. Cased piping.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: For underground hydronic piping. Signed and sealed by a professional engineer.

1. Calculate requirements for expansion compensation for underground piping.
2. Show expansion compensators, offsets, and loops with appropriate materials to allow piping movement in the required locations. Show anchors and guides that restrain piping movement with calculated loads and show concrete thrust block dimensions.
3. Show pipe sizes, locations, and elevations. Show piping in trench, conduit, and cased pipe with details showing clearances between piping, and show insulation thickness.

1.3 INFORMATIONAL SUBMITTALS

A. Material Test Reports: For conduit or cased piping as directed.

B. Source quality-control reports.

C. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Provide components and installation capable of producing hydronic piping systems with the following minimum working-pressure ratings:

1. Hot-Water Piping: 100 psig (690 kPa) or 150 psig (1035 kPa) as directed at 200 deg F (93 deg C).
2. Chilled-Water Piping: 100 psig (690 kPa) or 150 psig (1035 kPa) as directed at 200 deg F (93 deg C).
3. Condenser-Water Piping: 100 psig (690 kPa) or 150 psig (1035 kPa) as directed at 150 deg F (66 deg C).

2.2 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B88, Type L (ASTM B88M, Type B) or ASTM B88, Type M (ASTM B88M, Type C) as directed.

B. Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

D. Solder Filler Metals: ASTM B32, lead-free alloys. Include water-flushable flux according to ASTM B813.

E. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

2.3 STEEL PIPES AND FITTINGS

A. Steel Pipe: ASTM A53/A53M, black or galvanized with plain ends; type, grade, and wall thickness as indicated in "Piping Application" Article.

B. Cast-Iron, Threaded Fittings: ASME B16.4; Class 125 and Class 250.

C. Malleable-Iron, Threaded Fittings: ASME B16.3, Class 150 and Class 300.

D. Malleable-Iron Unions: ASME B16.39; as directed.

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Class 125 and Class 250; raised ground face, and bolt holes spot faced.

F. Wrought-Steel Fittings: ASTM A234/A234M, wall thickness to match adjoining pipe.

G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

H. Steel Welding Fittings: ASME B16.9 and ASTM A234/A234M, seamless or welded.

1. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

I. Grooved-End-Pipe Couplings for Galvanized-Steel Piping: AWWA C606 for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gaskets suitable for hot and cold water, and bolts and nuts.

J. Nipples: ASTM A733, made of same materials and wall thicknesses as pipe in which they are installed.

K. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and -bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

L. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

2.4 DUCTILE-IRON PIPE AND FITTINGS

A. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151/A21.51, with mechanical-joint bell and plain spigot end.

1. Standard-Pattern, Mechanical-Joint Fittings: AWWA C110/A21.10, ductile or gray iron.
2. Compact-Pattern, Mechanical-Joint Fittings: AWWA C153/A21.53, ductile iron.

a. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

2.5 PLASTIC PIPE AND FITTINGS

A. CPVC Plastic:

1. Pipe: ASTM F441/F441M, Schedules 40 and 80, plain ends as indicated in "Piping Application" Article.

2. Pipe Fittings: Socket-type pipe fittings, ASTM F438 for Schedule 40 pipe; ASTM F439 for Schedule 80 pipe.

B. PVC Plastic:

1. Pipe: ASTM D1785, Schedules 40 and 80, plain ends as indicated in "Piping Application" Article.
2. Pipe Fittings: Socket-type pipe fittings, ASTM D2466 for Schedule 40 pipe; ASTM D2467 for Schedule 80 pipe.
3. Solvent Cements: ASTM D2564. Include primer according to ASTM F656.

C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

2.6 TRANSITION FITTINGS

A. Plastic-to-Metal Transition Fittings: CPVC and PVC one-piece fitting with one threaded brass or copper insert and one Schedule 80 solvent-cemented-joint end.

2.7 CONDUIT PIPING SYSTEM

A. Description: Factory-fabricated and -assembled, airtight and watertight, drainable, pressure-tested piping with conduit, inner pipe supports, and insulated carrier piping. Fabricate so insulation can be dried in place by forcing dry air through conduit.

B. Carrier Pipe: As directed.

C. Carrier Pipe Insulation:

1. Mineral-Wool Pipe Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C547, Type I 850 deg F (454 deg C) or Type II, 1200 deg F (649 deg C) as directed, Grade A.

    a. Bands: ASTM A666, Type 304, stainless steel, 3/4 inch (19 mm) wide, 0.020 inch (0.5 mm) thick.

2. Calcium Silicate Pipe Insulation: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C533, Type I.

    a. Bands: ASTM A666, Type 304, stainless steel, 3/4 inch (19 mm) wide, 0.020 inch (0.5 mm) thick.

3. Polyisocyanurate Foam Pipe Insulation: Unfaced, preformed, rigid cellular polyisocyanurate material intended for use as thermal insulation.

    a. Comply with ASTM C591, Type I or Type IV, except thermal conductivity (k-value) shall not exceed 0.19 Btu x in./h x sq. ft. x deg F (0.027 W/m x K) at 75 deg F (24 deg C) after 180 days of aging.

b. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less for thickness up to 1-1/2 inches (38 mm) as tested by ASTM E84.
c. Fabricate shapes according to ASTM C450 and ASTM C585.

4. Polyurethane Foam Pipe Insulation: Unfaced, preformed, rigid cellular polyurethane material intended for use as thermal insulation.

a. Comply with ASTM C591, Type I or Type IV, except thermal conductivity (k-value) shall not exceed 0.19 Btu x in./h x sq. ft. x deg F (0.027 W/m x K) at 75 deg F (24 deg C) after 180 days of aging.
b. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less for thickness up to 1-1/2 inches (38 mm) as tested by ASTM E84.
c. Fabricate shapes according to ASTM C450 and ASTM C585.

D. Minimum Clearance:

1. Between Carrier Pipe Insulation and Conduit: 1 inch (25 mm).
2. Between Insulation of Multiple Carrier Pipes: 3/16 inch (4.75 mm).
3. Between Bottom of Carrier Pipe Insulation and Conduit: 1 inch (25 mm).
4. Between Bottom of Bare, Carrier Pipe and Casing: 1-3/8 inches (35 mm).

E. Conduit: Spiral wound, steel.

1. Finish: With two coats of fusion-bonded epoxy, minimum 20 mils (0.50 mm) thick.
2. Cover: With polyurethane foam insulation with an HDPE jacket; thickness indicated in "Piping Application" Article.
3. Piping Supports within Conduit: Corrugated galvanized steel with a maximum spacing of 10 feet (3 m).
4. Fittings: Factory-fabricated and -insulated elbows and tees. Elbows may be bent pipe equal to carrier pipe. Tees shall be factory fabricated and insulated and shall be compatible with the carrier pipe.
5. Expansion Offsets and Loops: Size casing to contain piping expansion.
6. Accessories include the following:

a. Water Shed: Terminal end protector for carrier pipes entering building through floor, 3 inches (75 mm) deep and 2 inches (50 mm) larger than casing; terminate casing 20 inches (500 mm) above the floor level.
b. Guides and Anchors: Steel plate welded to carrier pipes and to casing, complete with vent and drainage openings inside casing.
c. End Seals: Steel plate welded to carrier pipes and to casing, complete with drain and vent openings on vertical centerline.
d. Gland Seals: Packed stuffing box and gland follower mounted on steel plate, welded to end of casing, permitting axial movement of carrier piping, with drain and vent connections on vertical centerline.
e. Joint Kit: Half-shell, pourable or split insulation and shrink-wrap sleeve.

F. Manholes: Black steel with lifting eyes.

1. Finish: Spray-applied urethane, minimum 30 mils (0.75 mm) thick.

2. Access: 30-inch- (750-mm-) diameter waterproof cover with gasket, ladder, and two 6-inch (150-mm) vents, one high and one low, extending above grade with rain caps.
3. Conduit Stub-Outs and Seals: Welded steel with drain and vent openings.
4. Sump: 12 inches (300 mm)in diameter, 12 inches (300 mm)deep.
5. Floatation Anchor: Oversized bottom keyed into concrete base.

G. Source Quality Control: Factory test conduit to 15 psig (105 kPa) for a minimum of two minutes with no change in pressure. Factory test carrier pipe to 150 percent of the operating pressure of system. Furnish test certificates.

2.8 CASED PIPING SYSTEM

A. Description: Factory-fabricated piping with carrier pipe, insulation, and casing.

B. Carrier Pipe: As directed.

C. Carrier Pipe Insulation:

1. Polyurethane Foam Pipe Insulation: Rigid, cellular, high-pressure injected between carrier pipe and jacket.

a. Comply with ASTM C591; thermal conductivity (k-value) shall not exceed 0.14 Btu x in./h x sq. ft. x deg F (0.020 W/m x K) at 75 deg F (24 deg C) after 180 days of aging.

D. Casing: As directed.

E. Casing accessories include the following:

1. Joint Kit: Half-shell, pourable or split insulation, casing sleeve, and shrink-wrap sleeve.
2. Expansion Blanket: Elastomeric foam, formed to fit over piping.
3. End Seals: Shrink wrap the casing material to seal watertight around casing and carrier pipe.

F. Manholes: Black steel with lifting eyes.

1. Finish: Spray-applied urethane, minimum 30 mils (0.75 mm) thick.
2. Access: 30-inch- (750-mm-) diameter waterproof cover with gasket, ladder, and two 6-inch (150-mm) vents, one high and one low, extending above grade with rain caps.
3. Conduit Stub-Outs and Seals: Welded steel with drain and vent openings.
4. Sump: 12 inches (300 mm) in diameter, 12 inches (300 mm) deep.
5. Floatation Anchor: Oversized bottom keyed into concrete base.

G. Source Quality Control: Factory test the carrier pipe to 150 percent of the operating pressure of system. Furnish test certificates.

PART 3 - EXECUTION

3.1 EARTHWORK

A. See Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING APPLICATION

A. Hot-Water Heating Piping:

1. NPS 2 (DN 50) and smaller shall be any of the following:

a. Drawn-temper copper tubing, wrought-copper fittings, and joints as directed.
b. Steel pipe as directed; Fittings; cast-iron flanges and flange fittings; and threaded joints as directed.
c. Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.
d. Schedule 40 or Schedule 80 CPVC plastic pipe as directed and fittings and solvent-welded joints.

2. NPS 2-1/2 (DN 65) and larger shall be any of the following:

a. Drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed joints as directed.
b. Steel pipe as directed, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
c. Schedule 40 or Schedule 80 CPVC plastic pipe as directed and fittings and solvent-welded joints.

3. Conduit piping with carrier-pipe insulation as directed and with coated or coated and insulated conduit as directed.

a. Carrier Pipe Insulation Thickness: 1 inch (25 mm) or 2 inches (50 mm) as directed.
b. Conduit Insulation Thickness: 1 inch (25 mm) or 2 inches (50 mm) as directed.

4. Cased piping with polyurethane carrier-pipe insulation.

a. Piping Insulation Thickness: 1 inch (25 mm) or 2 inches (50 mm) as directed.

B. Chilled-Water Piping:

1. NPS 2 (DN 50) and smaller shall be any of the following:

a. Drawn-temper copper tubing, wrought-copper fittings, and joints as directed.
b. Steel pipe; Fittings as directed; cast-iron flanges and flange fittings; and threaded joints.
c. Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.
d. Schedule 40 or Schedule 80 CPVC plastic pipe as directed and fittings and solvent-welded joints.

2. NPS 2-1/2 (DN 65) and larger shall be any of the following:

    a. Drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed joints as directed.
    b. Steel pipe as directed, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
    c. Mechanical-joint, ductile-iron pipe; standard- or compact- pattern mechanical-joint fittings; and mechanical joints.
    d. Schedule 40 or Schedule 80 CPVC plastic pipe as directed and fittings and solvent-welded joints.

3. Conduit piping as directed with carrier-pipe insulation and with conduit as directed.

    a. Piping Insulation Thickness: 1 inch (25 mm) or 2 inches (50 mm) as directed.
    b. Conduit Insulation Thickness: 1 inch (25 mm) or 2 inches (50 mm) as directed.

4. Cased piping with polyurethane carrier-pipe insulation.

    a. Piping Insulation Thickness: 1 inch (25 mm) or 2 inches (50 mm) as directed.

C. Condenser-Water Piping:

1. NPS 2 (DN 50) and smaller shall be any of the following:

    a. Drawn-temper copper tubing, wrought-copper fittings, and joints as directed.
    b. Steel pipe as directed; fittings as directed; cast-iron flanges and flange fittings; and threaded joints.
    c. Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.
    d. Schedule 40 or Schedule 80 CPVC plastic pipe as directed and fittings and solvent-welded joints.

2. NPS 2-1/2 (DN 65) and larger shall be any of the following:

    a. Drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed joints as directed.
    b. Steel pipe as directed, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
    c. Mechanical-joint, ductile-iron pipe; standard- or compact- pattern mechanical-joint fittings; and mechanical joints.
    d. Schedule 40 or Schedule 80 CPVC plastic pipe as directed and fittings and solvent-welded joints.

3. Conduit piping with carrier-pipe insulation as directed and coated or coated and insulated conduit as directed.

    a. Piping Insulation Thickness: 1 inch (25 mm) or 2 inches (50 mm) as directed.
    b. Conduit Insulation Thickness: 1 inch (25 mm) or 2 inches (50 mm) as directed.

4. Cased piping with polyurethane carrier-pipe insulation.

a. Piping Insulation Thickness: 1 inch (25 mm) or 2 inches (50 mm) as directed.

3.3 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Remove standing water in the bottom of trench.

C. Do not backfill piping trench until field quality-control testing has been completed and results approved.

D. Install piping at uniform grade of 0.2 percent. Install drains, consisting of a tee fitting, NPS 3/4 (DN 20) ball valve, and short NPS 3/4 (DN 20) threaded nipple with cap, at low points and elsewhere as required for system drainage. Install manual air vents at high points.

E. In conduits, install drain valves at low points and manual air vents at high points.

F. Install components with pressure rating equal to or greater than system operating pressure.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. See Section 230517 "Sleeves and Sleeve Seals for HVAC Piping" for sleeves and mechanical sleeve seals through exterior building walls.

J. Secure anchors with concrete thrust blocks. Concrete is specified in Section 033000 "Cast-in-Place Concrete."

K. See Section 134700 "Cathodic Protection" for cathodic devices and connections to piping and conduit systems.

3.4 JOINT CONSTRUCTION

A. See Section 330500 "Common Work Results for Utilities" for basic piping joint construction.

B. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.

C. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

D. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

E. Soldered Joints: Apply ASTM B813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B32.

F. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Ch. 35, "Pipe and Tubing," using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.

G. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

H. Welded Joints: Construct joints according to AWS D10.12M/D10.12.

I. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

J. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements.
2. CPVC Piping: Join according to ASTM D2846/D2846M Appendix.
3. PVC Pressure Piping: Join ASTM D1785 schedule number, PVC pipe and PVC socket fittings according to ASTM D2672. Join other-than-schedule number PVC pipe and socket fittings according to ASTM D2855.

K. Pressure-Sealed Joints: Use manufacturer-recommended tool and procedure. Leave insertion marks on pipe after assembly.

L. Conduit and Cased Piping Joints: Assemble sections and finish joints with pourable or split insulation and exterior jacket sleeve and apply shrink-wrap seals.

3.5 IDENTIFICATION

A. Install continuous plastic underground warning tapes during back filling of trenches for underground hydronic piping. Locate tapes 6 to 8 inches (150 to 200 mm) below finished grade, directly over piping. See Section 312000 "Earth Moving" for warning-tape materials and devices and their installation.

3.6 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Prepare hydronic piping for testing according to ASME B31.9 and as follows:

a. Leave joints, including welds, uninsulated and exposed for examination during test.
b. Fill system with water. Where there is risk of freezing, air or a safe, compatible liquid may be used.
c. Use vents installed at high points to release trapped air while filling system.

2. Test hydronic piping as follows:

a. Subject hydronic piping to hydrostatic test pressure that is not less than 1.5 times the design pressure.
b. After hydrostatic test pressure has been applied for 10 minutes, examine joints for leakage. Remake leaking joints using new materials and repeat hydrostatic test until no leaks exist.

3. Test conduit as follows:

a. Seal vents and drains and subject conduit to 15 psig (105 kPa) for four hours with no loss of pressure. Repair leaks and retest as required.

B. Prepare test and inspection reports.

END OF SECTION 232113.13

SECTION 232113.33 - GROUND-LOOP HEAT-PUMP PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes piping for horizontal or vertical as directed, direct-buried, ground-loop, heat-pump systems.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Startup performance results.

PART 2 - PRODUCTS

2.1 PIPES AND FITTINGS

A. HDPE Pipe: ASTM D3035.

B. Molded PE Fittings: ASTM D2683 or ASTM D3261, ASTM F1055 PE resin, socket, butt-fusion or electro-fusion type, made to match PE pipe dimensions and class.

C. U-Bend Assembly: Factory fabricated with embossed depth stamp every 24 inches (600 mm) or 36 inches (900 mm) from U-bend as directed.

D. Ground-Loop, Heat-Pump Piping Minimum Working Pressure: 160 psig (1100 kPa) or 200 psig (1380 kPa) as directed.

E. Ground-Loop, Heat-Pump Piping Operating Temperature: Between 23 and 104 deg F (minus 5 and plus 40 deg C).

2.2 BOREHOLE BACKFILL

A. Seal Material: Bentonite clay with thermal conductivity greater than 1.07 Btu/h x sq. ft. x deg F (0.7 W/sq. m x K) according to ASTM D5334.

B. Permeability: Not more than 1 nm/s according to ASTM D5084

2.3 ANTIFREEZE SOLUTION

A. Propylene glycol with corrosion inhibitors and environmental stabilizer additives.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavating, trenching, warning tape, and backfilling are specified in Section 312000 "Earth Moving."

3.2 HORIZONTAL PIPING INSTALLATION

A. Separate trenches by 10 feet (3 m) minimum unless otherwise indicated. Remove rocks in trenches that could contact pipe.

B. Backfill

C. Extend pipe from trench onto bottom of body of water at an elevation that is at least 12 inches (300 mm) below frost line. Seal membrane or impervious liner under body of water after installing piping.

D. Install HDPE piping in trenches according to ASTM D2774 or ASTM F645.

1. Clean HDPE pipe and fittings and make heat-fusion joints according to ASTM D2657. Minimize number of joints.

E. Purge, flush, and pressure test piping before backfilling trenches.

F. Install continuous detectable warning tape for underground piping. Locate tape a minimum of 24 inches (600 mm) below finished grade, directly over piping. Underground warning tapes are specified in Section 312000 "Earth Moving."

3.3 VERTICAL PIPING INSTALLATION

A. Install HDPE piping in boreholes according to ASTM D2774 or ASTM F645.

1. Clean HDPE pipe and fittings and make heat-fusion joints according to ASTM D2657. Minimize number of joints.

B. Purge, flush, and pressure test piping before backfilling boreholes.

C. Completely fill the borehole from bottom to top with backfill material.

D. Install the header piping 4 to 6 inches (100 to 150 mm) deep and install the horizontal piping from the header to the boreholes.

E. Extend the horizontal piping and connect to ground-loop heat-pump piping systems at outside face of building wall in locations and pipe sizes indicated.

1. Terminate water-service piping at building wall until building ground-loop heat-pump piping systems are installed. Terminate piping with caps. Make connections to building ground-loop heat-pump piping systems when those systems are installed.

F. Backfill the horizontal piping and header trenches.

G. Fill the entire piping loop with water or antifreeze solution.

H. Maintain records of backfilling on-site.

I. Mark borehole locations, header pipes, and horizontal runs with metallic locator tape as specified in Section 230553 "Identification for HVAC Piping and Equipment."

J. Seal penetrations through building walls.

K. Wall sleeves are specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

L. Mechanical sleeve seals are specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

3.4 ANTIFREEZE SOLUTION FILL

A. Fill system with required quantity of propylene glycol and water to provide minus 10 deg F (minus 23 deg C) freezing temperature.

3.5 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

3.6 FIELD QUALITY CONTROL

A. Piping Tests: Fill piping 24 hours before testing and apply test pressure to stabilize piping. Use potable water only.

B. Hydrostatic Tests: Test at not less than 1-1/2 times the pipe working-pressure rating or 300 percent of system design pressure, whichever is more, allowing for static pressure of borehole depth.

1. Increase pressure in 50-psig (345-kPa) increments and inspect each joint between increments. Hold at test pressure for 30 minutes. Slowly increase to next test pressure increment and hold for 30 minutes. After testing at maximum test pressure, reduce pressure to 30 psig (207 kPa). Hold for 90 minutes, and measure pressure at 30-minute intervals. Repair leaks and retest until no leaks exist.
2. Maintain a minimum pipe velocity of 24 in./s (610 mm/s) for a minimum of 15 minutes to remove all air.

C. Prepare test and inspection reports.

END OF SECTION 232113.33

SECTION 232116 - HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Hydronic specialty valves.
2. Air-control devices.
3. Strainers.
4. Connectors.

B. Related Requirements:

1. Section 230516 "Expansion Fittings and Loops for HVAC Piping" for expansion fittings and loops.
2. Section 230523.11 "Globe Valves for HVAC Piping" for specification and installation requirements for globe valves common to most piping systems.
3. Section 230523.12 "Ball Valves for HVAC Piping" for specification and installation requirements for ball valves common to most piping systems.
4. Section 230523.13 "Butterfly Valves for HVAC Piping" for specification and installation requirements for butterfly valves common to most piping systems.
5. Section 230523.14 "Check Valves for HVAC Piping" for specification and installation requirements for check valves common to most piping systems.
6. Section 230523.15 "Gate Valves for HVAC Piping" for specification and installation requirements for gate valves common to most piping systems.
7. Section 230923.11 "Control Valves" for automatic control valve and sensor specifications, installation requirements, and locations.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product:

1. Include construction details and material descriptions for hydronic piping specialties.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.
3. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.4 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

B. Safety Valves and Pressure Vessels: Shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 HYDRONIC SPECIALTY VALVES

A. Plastic Ball Valves:
1. Body: One-, two-, or three-piece CPVC or PVC to match piping.
2. Ball: Full-port CPVC or PVC to match piping.
3. Seats: PTFE.
4. Seals: EPDM.
5. End Connections: Socket, union, or flanged.
6. Handle Style: Tee shape.
7. CWP Rating: Equal to piping service.
8. Maximum Operating Temperature: Equal to piping service.
9. Comply with MSS SP-122.

B. Plastic Butterfly Valves:
1. Body: PVC or CPVC to match piping wafer type for installation between flanges.
2. Disc: EPDM-coated steel.
3. Seats: PTFE.
4. Handle Style: Locking lever.
5. CWP Rating: Equal to piping service.
6. Maximum Operating Temperature: Equal to piping service.

C. Plastic Check Valves:
1. Body: One-, two-, or three-piece PVC or CPVC to match piping.
2. Ends: Socket or flanged.
3. Seats: PTFE.
4. Check Style: Swing or ball type.
5. CWP Rating: Equal to piping service.
6. Maximum Operating Temperature: Equal to piping service.

D. Bronze, Calibrated-Orifice, Balancing Valves:
1. Body: Bronze, ball or plug type with calibrated orifice or venturi.
2. Ball: Brass or stainless steel.
3. Plug: Resin.
4. Seat: PTFE.
5. End Connections: Threaded or socket.
6. Pressure Gage Connections: Integral seals for portable differential pressure meter.
7. Handle Style: Lever, with memory stop to retain set position.
8. CWP Rating: Minimum 125 psig (860 kPa).

9. Maximum Operating Temperature: 250 deg F (121 deg C).

E. Diaphragm-Operated, Pressure-Reducing Valves: ASME labeled.
1. Body: Bronze or brass.
2. Disc: Glass and carbon-filled PTFE.
3. Seat: Brass.
4. Stem Seals: EPDM O-rings.
5. Diaphragm: EPT.
6. Low inlet-pressure check valve.
7. Inlet Strainer: Removable without system shutdown.
8. Valve Seat and Stem: Noncorrosive.
9. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

F. Diaphragm-Operated Safety Valves: ASME labeled.
1. Body: Bronze or brass.
2. Disc: Glass and carbon-filled PTFE.
3. Seat: Brass.
4. Stem Seals: EPDM O-rings.
5. Diaphragm: EPT.
6. Wetted, Internal Work Parts: Brass and rubber.
7. Inlet Strainer: Removable without system shutdown.
8. Valve Seat and Stem: Noncorrosive.
9. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

G. Automatic Flow-Control Valves:
1. Body: Brass or ferrous metal.
2. Flow Control Assembly, provide either of the following:

a. Piston and Spring Assembly: Stainless steel or Corrosion resistant as directed, tamper proof, self-cleaning, and removable.
b. Elastomeric Diaphragm and Polyphenylsulfone Orifice Plate: Operating ranges within 2- to 80-psig (14- to 550-kPa) differential pressure.

3. Combination Assemblies: Include bonze or brass-alloy ball valve.
4. Identification Tag: Marked with zone identification, valve number, and flow rate.
5. Size: Same as pipe in which installed.
6. Performance: Maintain constant flow within plus or minus 10 percent regardless of system pressure fluctuations.
7. Minimum CWP Rating: 175 psig (1207 kPa) or 300 psig (2070 kPa) as directed.
8. Maximum Operating Temperature: 200 deg F (93 deg C) or 250 deg F (121 deg C) as directed.

2.2 AIR-CONTROL DEVICES

A. Manual Air Vents:
1. Body: Bronze.
2. Internal Parts: Nonferrous.

3. Operator: Screwdriver or thumbscrew.
4. Inlet Connection: NPS 1/2 (DN 15).
5. Discharge Connection: NPS 1/8 (DN 6).
6. CWP Rating: 150 psig (1035 kPa).
7. Maximum Operating Temperature: 225 deg F (107 deg C).

B. Expansion Tanks:
1. Tank: Welded steel, rated for 125-psig (860-kPa) working pressure and 375 deg F (191 deg C) maximum operating temperature, with taps in bottom of tank for tank fitting and taps in end of tank for gage glass. Tanks shall be factory tested after taps are fabricated and shall be labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Air-Control Tank Fitting: Cast-iron body, copper-plated tube, brass vent tube plug, and stainless-steel ball check, 100-gal. (379-L) unit only; sized for compression-tank diameter. Provide tank fittings for 125-psig (860-kPa) working pressure and 250 deg F (121 deg C) maximum operating temperature.
3. Tank Drain Fitting: Brass body, nonferrous internal parts; 125-psig (860-kPa) working pressure and 240 deg F (116 deg C) maximum operating temperature; constructed to admit air to compression tank, drain water, and close off system.
4. Gage Glass: Full height with dual manual shutoff valves, 3/4-inch- (20-mm-) diameter gage glass, and slotted-metal glass guard.

C. In-Line Air Separators:
1. Tank: One-piece cast iron with an integral weir constructed to decelerate system flow to maximize air separation.
2. Maximum Working Pressure: Up to 175 psig (1207 kPa).
3. Maximum Operating Temperature: Up to 300 deg F (149 deg C).

2.3 STRAINERS

A. Y-Pattern Strainers:

1. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: Stainless-steel, -mesh strainer as directed, or perforated stainless-steel basket.
4. CWP Rating: 125 psig (860 kPa).

2.4 CONNECTORS

A. Stainless-Steel Bellow, Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.
3. Performance: Capable of 3/4-inch (20-mm) misalignment.
4. CWP Rating: 150 psig (1035 kPa).
5. Maximum Operating Temperature: 250 deg F (121 deg C).

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

A. Install shutoff-duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.

B. Install throttling-duty or calibrated-orifice, balancing valves at each branch connection to return main as directed.

C. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.

D. Install check valves at each pump discharge and elsewhere as required to control flow direction.

E. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

F. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.2 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

B. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.

C. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 (DN 50) and larger.

D. Install expansion tanks above the air separator. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.

1. Install tank fittings that are shipped loose.
2. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, fittings, plus tank full of water. Do not overload building components and structural members.

E. Install expansion tanks on the floor. Vent and purge air from hydronic system and ensure that tank is properly charged with air to suit system Project requirements.

END OF SECTION 232116

SECTION 232123 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Close-coupled, in-line centrifugal pumps.
2. Close-coupled, end-suction centrifugal pumps.
3. Separately coupled, horizontally mounted, in-line centrifugal pumps.
4. Separately coupled, vertically mounted, in-line centrifugal pumps.
5. Separately coupled, base-mounted, end-suction centrifugal pumps.
6. Automatic condensate pump units.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of pump.

B. Shop Drawings: For each pump.

1. Show pump layout and connections.
2. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
3. Include diagrams for power, signal, and control wiring.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS

A. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically.

B. Capacities and Characteristics:

1. Capacity: As directed.
2. Total Dynamic Head: As directed.
3. Maximum Operating Pressure: 175 psig (1204 kPa) or 250 psig (1720 kPa).
4. Maximum Continuous Operating Temperature: 225 deg F (107 deg C) or 250 deg F (120 deg C) as directed.

5. Inlet and Outlet Size: As directed.
6. Impeller Size: As directed.
7. Motor Speed: As directed.
8. Motor Horsepower: As directed.
9. Electrical Characteristics:

    a. Volts: As directed.
    b. Phase: Single or Three as directed.
    c. Hertz: 60.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed.
    f. Maximum Overcurrent Protection: As directed.

C. Pump Construction:

1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet, replaceable bronze wear rings, and threaded companion-flange or union-end connections as directed.
2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
3. Pump Shaft: Steel, with copper-alloy shaft sleeve or Stainless steel as directed.
4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and bellows as directed and gasket. Include water slinger on shaft between motor and seal.
5. Seal: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
6. Pump Bearings: Permanently lubricated ball bearings or Oil lubricated; bronze-journal or thrust type as directed.

D. Motor: Single speed and rigidly mounted to pump casing.

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

    a. Enclosure: As directed.
    b. Enclosure Materials: As directed.
    c. Motor Bearings: Permanently lubricated or Grease-lubricated ball bearings as directed.
    d. Unusual Service Conditions:

        1) Ambient Temperature: As directed.
        2) Altitude: As directed above sea level.
        3) High humidity.

    e. Efficiency: Premium efficient.

f. NEMA Design: As directed.
g. Service Factor: As directed.

2.2 CLOSE-COUPLED, END-SUCTION CENTRIFUGAL PUMPS

A. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally.

B. Capacities and Characteristics:

1. Capacity: As directed.
2. Total Dynamic Head: As directed.
3. Maximum Operating Pressure: 175 psig (1204 kPa).
4. Maximum Continuous Operating Temperature: 225 deg F (107 deg C) or 250 deg F (120 deg C) as directed.
5. Inlet and Outlet Size: As directed.
6. Impeller Size: As directed.
7. Motor Speed: As directed.
8. Motor Horsepower: As directed.
9. Electrical Characteristics:

a. Volts: As directed.
b. Phase: Single or Three as directed.
c. Hertz: 60.
d. Full-Load Amperes: As directed.
e. Minimum Circuit Ampacity: As directed.
f. Maximum Overcurrent Protection: As directed.

C. Pump Construction:

1. Casing: Radially split, cast iron, with replaceable bronze wear rings, drain plug at bottom and air vent at top of volute, threaded gage tappings at inlet and outlet, and threaded companion-flange or flanged connections.
2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
3. Pump Shaft: Steel, with copper-alloy shaft sleeve or Stainless steel as directed.
4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N or EPT bellows and gasket as directed. Include water slinger on shaft between motor and seal.
5. Pump Bearings: Permanently lubricated ball bearings or Oil lubricated as directed; bronze-journal or thrust type.

D. Motor: Single speed and rigidly mounted to pump casing with integral pump support.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

    a. Enclosure: As directed.
    b. Enclosure Materials: As directed.
    c. Motor Bearings: Permanently lubricated or Grease-lubricated ball bearings as directed.
    d. Unusual Service Conditions:

        1) Ambient Temperature: As directed.
        2) Altitude: As directed above sea level.
        3) High humidity.

    e. Efficiency: Premium efficient.
    f. NEMA Design: As directed.
    g. Service Factor: As directed.

2.3 SEPARATELY COUPLED, HORIZONTALLY MOUNTED, IN-LINE CENTRIFUGAL PUMPS

A. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally.

B. Capacities and Characteristics:

1. Capacity: As directed.
2. Total Dynamic Head: As directed.
3. Maximum Operating Pressure: 175 psig (1204 kPa).
4. Maximum Continuous Operating Temperature: 225 deg F (107 deg C) or 250 deg F (120 deg C) as directed.
5. Inlet and Outlet Size: As directed.
6. Impeller Size: As directed.
7. Motor Speed: As directed.
8. Motor Horsepower: As directed.
9. Electrical Characteristics:

    a. Volts: As directed.
    b. Phase: Single or Three as directed.
    c. Hertz: 60.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed.
    f. Maximum Overcurrent Protection: As directed.

C. Pump Construction:

1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet, and threaded companion-flange or union-end connections as directed.

2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, and keyed to shaft. For pumps not frequency-drive controlled, trim impeller to match specified performance.
3. Pump Shaft: Steel, with copper-alloy shaft sleeve or Stainless steel as directed.
4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and bellows and gasket as directed. Include water slinger on shaft between motor and seal.
5. Pump Bearings: Permanently lubricated ball bearings or Oil lubricated; bronze-journal or thrust type as directed.

D. Shaft Coupling: Molded-rubber insert with interlocking spider or Interlocking frame with interconnecting springs capable of absorbing vibration as directed.

E. Motor: Single speed and resiliently or rigidly mounted to pump casing as directed.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

    a. Enclosure: As directed.
    b. Enclosure Materials: As directed.
    c. Motor Bearings: Permanently lubricated or Grease-lubricated ball bearings as directed.
    d. Unusual Service Conditions:

        1) Ambient Temperature: As directed.
        2) Altitude: As directed above sea level.
        3) High humidity.

    e. Efficiency: Premium efficient.
    f. NEMA Design: As directed.
    g. Service Factor: As directed.

2.4 SEPARATELY COUPLED, VERTICALLY MOUNTED, IN-LINE CENTRIFUGAL PUMPS

A. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted vertically.

B. Capacities and Characteristics:

1. Capacity: As directed.
2. Total Dynamic Head: As directed.
3. Maximum Operating Pressure: 175 psig (1204 kPa) or 250 psig (1720 kPa) as directed.
4. Maximum Continuous Operating Temperature: 225 deg F (107 deg C) or 250 deg F (120 deg C) as directed.
5. Inlet and Outlet Size: As directed.

6. Impeller Size: As directed.
7. Motor Speed: As directed.
8. Motor Horsepower: As directed.
9. Electrical Characteristics:

    a. Volts: As directed.
    b. Phase: Single or Three as directed.
    c. Hertz: 60.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed.
    f. Maximum Overcurrent Protection: As directed.

C. Pump Construction:

1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet, replaceable bronze wear rings, and threaded companion-flange or union-end connections as directed.
2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For pumps not frequency-drive controlled, trim impeller to match specified performance.
3. Pump Shaft: Steel, with copper-alloy shaft sleeve or Stainless steel as directed.
4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and bellows and gasket as directed. Include water slinger on shaft between motor and seal.
5. Seal: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
6. Pump Bearings: Permanently lubricated ball bearings or Oil lubricated; bronze-journal or thrust type as directed.

D. Shaft Coupling: Axially split spacer coupling.

E. Motor: Single speed and rigidly mounted to pump casing with lifting eyebolt and supporting lugs in motor enclosure.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

    a. Enclosure: As directed.
    b. Enclosure Materials: As directed.
    c. Motor Bearings: As directed ball bearings.
    d. Unusual Service Conditions:

        1) Ambient Temperature: As directed.
        2) Altitude: As directed above sea level.
        3) High humidity.

e. Efficiency: Premium efficient.
f. NEMA Design: As directed.
g. Service Factor: As directed.

2.5 SEPARATELY COUPLED, BASE-MOUNTED, END-SUCTION CENTRIFUGAL PUMPS

A. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal.

B. Capacities and Characteristics:

1. Capacity: As directed.
2. Total Dynamic Head: As directed.
3. Maximum Operating Pressure: 175 psig (1204 kPa) or 250 psig (1720 kPa) as directed.
4. Maximum Continuous Operating Temperature: 225 deg F (107 deg C) or 250 deg F (120 deg C) as directed.
5. Inlet and Outlet Size: As directed.
6. Impeller Size: As directed.
7. Motor Speed: As directed.
8. Motor Horsepower: As directed.
9. Electrical Characteristics:

    a. Volts: As directed.
    b. Phase: Single or Three.
    c. Hertz: 60.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed.
    f. Maximum Overcurrent Protection: As directed.

C. Pump Construction:

1. Casing: Radially split, cast iron, with replaceable bronze wear rings, threaded gage tappings at inlet and outlet, drain plug at bottom and air vent at top of volute, and threaded companion-flange or flanged connections as directed. Provide integral mount on volute to support the casing and provide attached piping to allow removal and replacement of impeller without disconnecting piping or requiring the realignment of pump and motor shaft.
2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For pumps not frequency-drive controlled, trim impeller to match specified performance.
3. Pump Shaft: Steel, with copper-alloy shaft sleeve or Stainless steel as directed.
4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and bellows and gasket as directed.
5. Seal: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
6. Pump Bearings: Grease-lubricated ball bearings in cast-iron housing with grease fittings.

D. Shaft Coupling: Molded-rubber insert and interlocking spider capable of absorbing vibration. Couplings shall be drop-out type to allow disassembly and removal without removing pump shaft or motor or EPDM coupling sleeve for variable-speed applications as directed

E. Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.

F. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A36/A36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.

G. Motor: Single speed, secured to mounting frame, with adjustable alignment.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

    a. Enclosure: As directed.
    b. Enclosure Materials: As directed.
    c. Motor Bearings: Ball bearings as directed.
    d. Unusual Service Conditions:

        1) Ambient Temperature: As directed.
        2) Altitude: As directed above sea level.
        3) High humidity.

    e. Efficiency: Premium efficient.
    f. NEMA Design: As directed
    g. Service Factor: As directed.

2.6 AUTOMATIC CONDENSATE PUMP UNITS

A. Description: Packaged units with corrosion-resistant pump, plastic tank with cover, and automatic controls. Include factory- or field-installed check valve and a 72-inch- (1800-mm-) minimum, electrical power cord with plug.

B. Capacities and Characteristics:

1. Capacity: As directed.
2. Total Dynamic Head: As directed.
3. Maximum Height to Inlet: As directed.
4. Inlet and Outlet Size: As directed.
5. Motor Speed: As directed.
6. Motor Horsepower: As directed.
7. Electrical Characteristics:

a. Volts: 120.
b. Phase: Single.
c. Hertz: 60.
d. Full-Load Amperes: As directed.
e. Minimum Circuit Ampacity: As directed.
f. Maximum Overcurrent Protection: As directed.

2.7 PUMP SPECIALTY FITTINGS

A. Suction Diffuser:

1. Angle pattern.
2. 175-psig (1204-kPa) or 300-psig (2060-kPa) as directed pressure rating, cast or ductile-iron body as directed and end cap, pump-inlet fitting.
3. Bronze startup and bronze or stainless-steel permanent strainers.
4. Bronze or stainless-steel straightening vanes.
5. Drain plug.
6. Factory-fabricated support.

B. Triple-Duty Valve:

1. Angle or straight pattern.
2. 175-psig (1204-kPa) or 300-psig (2060-kPa) pressure rating, cast or ductile-iron body, pump-discharge fitting.
3. Drain plug and bronze-fitted shutoff, balancing, and check valve features.
4. Brass gage ports with integral check valve and orifice for flow measurement.

PART 3 - EXECUTION

3.1 PUMP INSTALLATION

A. Comply with HI 1.4.

B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

D. Automatic Condensate Pump Units: Install units for collecting condensate and extend to open drain.

E. Equipment Mounting:

1. Install base-mounted pumps on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" r Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

F. Equipment Mounting: Install in-line pumps with continuous-thread hanger rods required to support weight of in-line pumps as directed.

1. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
2. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

3.2 ALIGNMENT

A. Engage a factory-authorized service representative to perform or Perform alignment service as directed.

B. Comply with requirements in Hydronics Institute standards for alignment of pump and motor shaft. Add shims to the motor feet and bolt motor to base frame. Do not use grout between motor feet and base frame.

C. Comply with pump and coupling manufacturers' written instructions.

D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.3 CONNECTIONS

A. Comply with requirements for piping specified in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties."

B. Drawings indicate general arrangement of piping, fittings, and specialties.

C. Where installing piping adjacent to pump, allow space for service and maintenance.

D. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

E. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

F. Install on discharge side of pumps as directed.

G. Install Y-type strainer or suction diffuser as directed and shutoff valve on suction side of pumps.

H. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

I. Install pressure gages on pump suction and discharge or at integral pressure-gage tapping or install single gage with multiple-input selector valve.

J. Install check valve and gate or ball valve on each condensate pump unit discharge.

K. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

L. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

END OF SECTION 232123

SECTION 232213 - STEAM AND CONDENSATE HEATING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes pipe and fittings for LP steam less than 15 psig (104 kPa) and condensate piping.

1. Steel pipe and fittings.
2. Joining materials.

B. Related Requirements:

1. Section 232216 "Steam and Condensate Heating Piping Specialties" for strainers, flash tanks, special-duty valves, steam traps, thermostatic air vents and vacuum breakers, and steam and condensate meters.

1.2 ACTION SUBMITTALS

A. Sustainable Design Submittals:

B. Delegated-Design Submittal:

1. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
2. Locations of pipe anchors and alignment guides and expansion joints and loops.
3. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.
4. Locations of and details for penetration and firestopping for fire- and smoke-rated wall and floor and ceiling assemblies.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME B31.1, "Power Piping," and ASME B31.9, "Building Services Piping," for materials, products, and installation.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:

1. LP Steam Piping: As directed.
2. Condensate Piping: at 250 deg F (121 deg C).
3. Makeup-Water Piping: 80 psig (552 kPa) or 150 psig (1034 kPa) at 150 deg F (66 deg C).
4. Blowdown-Drain Piping: Equal to pressure of the piping system to which it is attached.
5. Air-Vent and Vacuum-Breaker Piping: Equal to pressure of the piping system to which it is attached.
6. Safety-Valve-Inlet and -Outlet Piping: Equal to pressure of the piping system to which it is attached.

2.2 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A53/A53M, black steel, plain ends, welded and seamless, Grade B, and Schedule as indicated in piping applications articles.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125, 150, and 300 as indicated in piping applications articles.

C. Malleable-Iron Threaded Fittings: ASME B16.3; Classes 150 and 300 as indicated in piping applications articles.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in piping applications articles.

E. Cast-Iron Threaded Flanges and Flanged Fittings: ASME B16.1, Classes 125 and 250 as indicated in piping applications articles; raised ground face, and bolt holes spot faced.

2.3 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch (3.2-mm) maximum thickness unless otherwise indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

PART 3 - EXECUTION

3.1 LP STEAM PIPING APPLICATIONS

A. LP Steam Piping: Schedule 40 or Schedule 80 as directed, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

B. Condensate Piping above Grade: Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

C. Condensate Piping below Grade: Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

3.2 ANCILLARY PIPING APPLICATIONS

A. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

B. Vacuum-Breaker Piping: Outlet, same as service where installed.

C. Safety-Valve-Inlet and -Outlet Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed.

3.3 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless otherwise indicated.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping free of sags and bends.

G. Install fittings for changes in direction and branch connections.

H. Install piping to allow application of insulation.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

K. Install drains, consisting of a tee fitting, NPS 3/4 (DN 20) full port-ball valve, and short NPS 3/4 (DN 20) threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

L. Install steam supply piping at a minimum uniform grade of 0.2 percent downward in direction of steam flow.

M. Install condensate return piping at a minimum uniform grade of 0.4 percent downward in direction of condensate flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side down.

O. Install branch connections to mains using mechanically formed tee fittings in main pipe, with the branch connected to top of main pipe.

P. Install valves according to the following Sections or other Sections as needed:

1. Section 230523.11 "Globe Valves for HVAC Piping."
2. Section 230523.12 "Ball Valves for HVAC Piping."
3. Section 230523.13 "Butterfly Valves for HVAC Piping."
4. Section 230523.14 "Check Valves for HVAC Piping."
5. Section 230523.15 "Gate Valves for HVAC Piping."

Q. Install unions in piping, NPS 2 (DN 50) and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 (DN 65) and larger, at final connections of equipment and elsewhere as indicated.

S. Install shutoff valve immediately upstream of each dielectric fitting.

T. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS 3/4 (DN 20) nipple and full port ball valve in blowdown connection of strainers NPS 2 (DN 50) and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2 (DN 50).

U. Comply with requirements in Section 230516 "Expansion Fittings and Loops for HVAC Piping" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.

V. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.

W. Install drip legs at low points and natural drainage points such as ends of mains, bottoms of risers, and ahead of pressure regulators, and control valves.

1. On straight runs with no natural drainage points, install drip legs at intervals not exceeding 300 feet (90 m).

2. Size drip legs same size as main. In steam mains NPS 6 (DN 150) and larger, drip leg size can be reduced, but to no less than NPS 4 (DN 100).

X. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

Y. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

Z. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.4 STEAM AND CONDENSATE PIPING SPECIALTIES INSTALLATION

A. Comply with requirements in Section 232216 "Steam and Condensate Heating Piping Specialties" for installation requirements for strainers, flash tanks, special-duty valves, steam traps, thermostatic air vents and vacuum breakers, and steam and condensate meters.

3.5 HANGERS AND SUPPORTS

A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for installation of hangers and supports. Comply with requirements below for maximum spacing.

B. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.

C. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet (6 m) long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet (6 m) or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet (6 m) or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.

D. Install hangers for steel steam supply piping with the following maximum spacing:

1. NPS 3/4 (DN 20): Maximum span, 9 feet (2.7 m).
2. NPS 1 (DN 25): Maximum span, 9 feet (2.7 m).
3. NPS 1-1/2 (DN 40): Maximum span, 12 feet (3.7 m).
4. NPS 2 (DN 50): Maximum span, 13 feet (4 m).
5. NPS 2-1/2 (DN 65): Maximum span, 14 feet (4.3 m).
6. NPS 3 (DN 80) and Larger: Maximum span, 15 feet (4.6 m).

E. Install hangers for steel steam condensate piping with the following maximum spacing:

1. NPS 3/4 (DN 20): Maximum span, 7 feet (2.1 m).

2. NPS 1 (DN 25): Maximum span, 7 feet (2.1 m).
3. NPS 1-1/2 (DN 40): Maximum span, 9 feet (2.7 m).
4. NPS 2 (DN 50): Maximum span, 10 feet (3 m).
5. NPS 2-1/2 (DN 65): Maximum span, 11 feet (3.4 m).
6. NPS 3 (DN 80) and Larger: Maximum span, 12 feet (3.7 m).

F. Support vertical runs at roof, at each floor, and at 10-foot (3-m) intervals between floors.

3.6 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.7 TERMINAL EQUIPMENT CONNECTIONS

A. Size for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install traps and control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install vacuum breakers downstream from control valve, close to coil inlet connection.

E. Install a drip leg at coil outlet.

3.8 FIELD QUALITY CONTROL

A. Prepare steam and condensate piping according to ASME B31.1, "Power Piping," and ASME B31.9, "Building Services Piping," and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.

3. Flush system with clean water. Clean strainers.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.

B. Testing Agency: Owner will engage or Engage a qualified testing agency to perform tests and inspections as directed.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength.
3. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.

E. Prepare test and inspection reports.

END OF SECTION 232213

SECTION 232216 - STEAM AND CONDENSATE HEATING PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following piping specialties for steam and condensate piping:

1. Strainers.
2. Flash tanks.
3. Stop-check valves.
4. Safety valves.
5. Pressure-reducing valves.
6. Steam traps.
7. Thermostatic air vents and vacuum breakers.
8. Flexible connectors.
9. Steam meters.
10. Condensate meters.

B. Related Requirements:

1. Section 230523.11 "Globe Valves for HVAC Piping" for specification and installation requirements for globe valves common to most piping systems.
2. Section 230523.12 "Ball Valves for HVAC Piping" for specification and installation requirements for ball valves common to most piping systems.
3. Section 230523.13 "Butterfly Valves for HVAC Piping" for specification and installation requirements for butterfly valves common to most piping systems.
4. Section 230523.14 "Check Valves for HVAC Piping" for specification and installation requirements for check valves common to most piping systems.
5. Section 230523.15 "Gate Valves for HVAC Piping" for specification and installation requirements for gate valves common to most piping systems.
6. Section 230923.11. "Control Valves" for automatic control valve and sensor specifications, installation requirements, and locations.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Strainer.
2. Flash tank.
3. Valve.
4. Steam trap.
5. Air vent and vacuum breaker.
6. Connector.
7. Meter.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.4 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:

1. HP Steam Piping: As directed.
2. LP Steam Piping: As directed.
3. Condensate Piping: As directed at 250 deg F (121 deg C).
4. Makeup-Water Piping: 80 psig (552 kPa) or 150 psig (1034 kPa) at 73 deg F (22 deg C) or 150 deg F (66 deg C) as directed.
5. Blowdown-Drain Piping: Equal to pressure of the piping system to which it is attached.
6. Air-Vent and Vacuum-Breaker Piping: Equal to pressure of the piping system to which it is attached.
7. Safety-Valve-Inlet and -Outlet Piping: Equal to pressure of the piping system to which it is attached.

2.2 STRAINERS

A. Y-Pattern Strainers:

1. Body: ASTM A126, Class B cast iron, with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for strainers NPS 2 (DN 50) and smaller; flanged ends for strainers NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: Stainless-steel, As directed-mesh strainer or perforated stainless-steel basket.
4. Tapped blowoff plug.
5. CWP Rating: 250-psig (1725-kPa) working steam pressure.

2.3 STOP-CHECK VALVES

A. Stop-Check Valves:
1. Body and Bonnet: Malleable iron.
2. End Connections: Flanged.
3. Disc: Cylindrical with removable liner and machined seat.
4. Stem: Brass alloy.
5. Operator: Outside screw and yoke with cast-iron handwheel.

6. Packing: PTFE-impregnated packing with two-piece packing gland assembly.
7. Pressure Class: 250.

2.4 STEAM SAFETY VALVES

A. Bronze or Brass Steam Safety Valves: ASME labeled.
1. Disc Material: Forged copper alloy.
2. End Connections: Threaded inlet and outlet.
3. Spring: Fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.
4. Pressure Class: 250.
5. Drip-Pan Elbow: Cast iron and having threaded inlet and outlet, with threads complying with ASME B1.20.1.
6. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.

2.5 PRESSURE-REDUCING VALVES

A. Capacities and Characteristics:

1. Steam Flow Rate: As directed.
2. Inlet Pressure: As directed.
3. Outlet Set Pressure: AS directed.
4. Pressure Loss (Wide Open): As directed.

B. ASME labeled.

C. Size, Capacity, and Pressure Rating: Factory set for inlet and outlet pressures indicated.

D. Description: Pilot-actuated diaphragm type, with adjustable pressure range and positive shutoff.

E. Body: Cast iron.

F. End Connections: Threaded connections for valves NPS 2 (DN 50) and smaller and flanged connections for valves NPS 2-1/2 (DN 65) and larger.

G. Trim: Hardened stainless steel.

H. Head and Seat: Replaceable, main head stem guide fitted with flushing and pressure-arresting device cover over pilot diaphragm.

I. Gaskets: Non-asbestos materials.

2.6 STEAM TRAPS

A. Thermostatic Steam Traps:
1. Body: Bronze angle-pattern body with integral union tailpiece and screw-in cap.
2. Trap Type: Balanced pressure.

3. Bellows: Stainless steel or monel.
4. Head and Seat: Replaceable, hardened stainless steel.
5. Pressure Class: 125.

B. Float and Thermostatic Steam Traps:
1. Body and Bolted Cap: ASTM A126 cast iron.
2. End Connections: Threaded.
3. Float Mechanism: Replaceable, stainless steel.
4. Head and Seat: Hardened stainless steel.
5. Trap Type: Balanced pressure.
6. Thermostatic Bellows: Stainless steel or monel.
7. Thermostatic air vent capable of withstanding 45 deg F (25 deg C) of superheat and resisting water hammer without sustaining damage.
8. Vacuum Breaker: Thermostatic with phosphor bronze bellows, and stainless-steel cage, valve, and seat.
9. Maximum Operating Pressure: 125 psig (860 kPa).

2.7 THERMOSTATIC AIR VENTS AND VACUUM BREAKERS

A. Thermostatic Air Vents:
1. Body: Cast iron, bronze, or stainless steel.
2. End Connections: Threaded.
3. Float, Valve, and Seat: Stainless steel.
4. Thermostatic Element: Phosphor bronze bellows in a stainless-steel cage.
5. Pressure Rating: 125 psig (861 kPa) or 300 psig (2068 kPa) as directed.
6. Maximum Temperature Rating: 350 deg F (177 deg C) as directed.

B. Vacuum Breakers:
1. Body: Cast iron, bronze, or stainless steel.
2. End Connections: Threaded.
3. Sealing Ball, Retainer, Spring, and Screen: Stainless steel.
4. O-Ring Seal: Ethylene propylene rubber.
5. Pressure Rating: 125 psig (861 kPa) or 300 psig (2068 kPa) as directed.
6. Maximum Temperature Rating: 350 deg F (177 deg C).

2.8 FLEXIBLE CONNECTORS

A. Stainless-Steel Bellows, Flexible Connectors:
1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforced, protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.
3. Performance: Capable of 3/4-inch (20-mm) misalignment.
4. CWP Rating: 150 psig (1035 kPa).
5. Maximum Operating Temperature: 250 deg F (121 deg C).

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

A. Install shutoff duty valves at branch connections to steam supply mains, at steam supply connections to equipment, and at the outlet of steam traps.

B. Install safety valves on pressure-reducing stations and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without valves, to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

3.2 PIPING INSTALLATION

A. Install piping to permit valve servicing.

B. Install drains, consisting of a tee fitting, NPS 3/4 (DN 20) full-port ball valve, and short NPS 3/4 (DN 20) threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

C. Install valves according to:

1. Section 230523.11 "Globe Valves for HVAC Piping."
2. Section 230523.12 "Ball Valves for HVAC Piping."
3. Section 230523.13 "Butterfly Valves for HVAC Piping."
4. Section 230523.14 "Check Valves for HVAC Piping."
5. Section 230523.15 "Gate Valves for HVAC Piping."

D. Install unions in piping, NPS 2 (DN 50) and smaller, adjacent to valves, at final connections of equipment and elsewhere as indicated.

E. Install flanges in piping, NPS 2-1/2 (DN 65) and larger, at final connections of equipment and elsewhere as indicated.

F. Install shutoff valve immediately upstream of each dielectric fitting.

G. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS 3/4 (DN 20) nipple and full-port ball valve in blowdown connection of strainers NPS 2 (DN 50) and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2 (DN 50).

3.3 STEAM-TRAP INSTALLATION

A. Install steam traps in accessible locations as close as possible to connected equipment.

B. Install full-port ball valve, strainer, and union upstream from trap; install union, check valve, and full-port ball valve downstream from trap unless otherwise indicated.

3.4 PRESSURE-REDUCING VALVE INSTALLATION

A. Install pressure-reducing valves in accessible location for maintenance and inspection.

B. Install bypass piping around pressure-reducing valves, with globe valve equal in size to area of pressure-reducing valve seat ring, unless otherwise indicated.

C. Install gate valves on both sides of pressure-reducing valves.

D. Install unions or flanges on both sides of pressure-reducing valves having threaded- or flanged-end connections, respectively.

E. Install pressure gages on low-pressure side of pressure-reducing valves after the bypass connection according to Section 230519 "Meters and Gages for HVAC Piping."

F. Install strainers upstream for pressure-reducing valve.

G. Install safety valve downstream from pressure-reducing valve station.

3.5 SAFETY VALVE INSTALLATION

A. Install safety valves as directed

B. Pipe safety-valve discharge without valves to atmosphere outside the building.

C. Install drip-pan elbow fitting adjacent to safety valve and pipe drain connection to nearest floor drain.

D. Install exhaust head with drain to waste, on vents equal to or larger than NPS 2-1/2 (DN 65).

3.6 TERMINAL EQUIPMENT CONNECTIONS

A. Install traps and control valves in accessible locations close to connected equipment.

B. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

C. Install vacuum breakers downstream from control valve, close to coil inlet connection.

END OF SECTION 232216

SECTION 232223 - STEAM CONDENSATE PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes steam condensate pumps.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For each pump.

1. Show pump layout and connections.
2. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
3. Include diagrams for power, signal, and control wiring.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 SINGLE-STAGE, CENTRIFUGAL PUMPS WITH FLOOR-MOUNTED RECEIVER

A. Description: Factory-fabricated, packaged, electric-driven pumps; with receiver, pumps, controls, and accessories suitable for operation with steam condensate.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. ASME Compliance: Fabricate and label steam condensate receivers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

B. Configuration: Simplex or Duplex floor-mounted pump as directed with receiver and float switches; rated to pump 200 deg F (93 deg C) steam condensate.

C. Receiver:

1. Floor mounted.
2. Close-grained cast iron or Welded steel as directed.
3. Externally adjustable float switches.
4. Flanges for pump mounting.

5. Water-level gage and dial thermometer.
6. Pressure gage at pump discharge.
7. Bronze fitting isolation valve between pump and receiver.
8. Lifting eyebolts.
9. Inlet vent and an overflow.
10. Cast-iron inlet strainer with vertical self-cleaning bronze screen and large dirt pocket.

D. Pumps:

1. Centrifugal, close coupled, vertical design.
2. Permanently aligned.
3. Bronze fitted.
4. Replaceable bronze case ring.
5. Mechanical seals rated at 250 deg F (120 deg C).
6. Mounted on receiver flange.

E. Motor:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Enclosure: As directed.
3. Enclosure Materials: As directed.
4. Motor Bearings: Permanently lubricated or Grease-lubricated ball bearings as directed.
5. Unusual Service Conditions:

    a. Ambient Temperature: As directed.
    b. Altitude: As directed above sea level.
    c. High humidity.

6. Efficiency: Premium efficient.
7. NEMA Design: As directed.
8. Service Factor: As directed.

F. Control Panel:

1. Factory wired between pumps and float switches, for single external electrical connection.
2. Provide fused, control-power transformer if voltage exceeds 230 V ac.
3. NEMA 250, enclosure with hinged door and grounding lug, mounted on pump as directed.
4. Motor controller for each pump.
5. Electrical pump alternator to operate pumps in lead-lag sequence and allow both pumps to operate on receiver high level.
6. Manual lead-lag control to override electrical pump alternator and manually select the lead pump.
7. Momentary-contact "TEST" push button on cover for each pump.
8. Numbered terminal strip.
9. Disconnect switch.

G. Capacities and Characteristics:

1. Unit Total Capacity: As directed.
2. Capacity, Each Pump:

    a. Flow: As directed.
    b. Discharge Head: As directed.
    c. Discharge Size: As directed.
    d. Speed: As directed.
    e. Motor Horsepower: As directed.

3. Receiver:

    a. Capacity: As directed.
    b. Inlet Size: As directed.
    c. Height to Inlet: As directed.

4. Electrical Characteristics:

    a. Volts: As directed.
    b. Phase: Single.
    c. Hertz: 60.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed.
    f. Maximum Overcurrent Protection: As directed.

2.2 TWO-STAGE, CENTRIFUGAL PUMPS WITH FLOOR-MOUNTED RECEIVER

A. Description: Factory-fabricated, packaged, electric-driven pumps; with receiver, pumps, controls, and accessories suitable for operation with steam condensate.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. ASME Compliance: Fabricate and label steam condensate receivers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

B. Configuration: Duplex floor-mounted pumps with receiver and float switches; rated to pump minimum 210 deg F (99 deg C) steam condensate with a minimum of 2 feet (6 kPa) of NPSH.

C. Receiver:

1. Floor mounted.
2. Close-grained cast iron or Welded steel as directed.
3. Externally adjustable float switches.
4. Flanges for pump mounting.
5. Water-level gage and dial thermometer.
6. Pressure gage at pump discharge.
7. Bronze gate valves between receiver and pump discharge.
8. Lifting eyebolts.
9. Inlet vent and an overflow.

10. Cast-iron inlet strainer with self-cleaning bronze screen, dirt pocket, and cleanout plug on receiver inlet.

D. Pumps:

1. Centrifugal, two stage, close coupled.
2. Vertical design, permanently aligned, and bronze fitted.
3. Axial-flow first-stage bronze impeller.
4. Enclosed second-stage bronze impeller with replaceable bronze case rings.
5. Stainless-steel shafts.
6. Mechanical seals rated at250 deg F (120 deg C).
7. Rated to operate with a minimum of 2 feet (6 kPa) of NPSH.
8. Mounted on receiver flanges.

E. Motor:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Enclosure: As directed.
3. Enclosure Materials: As directed.
4. Motor Bearings: Permanently lubricated or Grease-lubricated ball bearings as directed.
5. Unusual Service Conditions:

    a. Ambient Temperature: As directed.
    b. Altitude: As directed above sea level.
    c. High humidity.

6. Efficiency: Premium efficient.
7. NEMA Design: As directed.
8. Service Factor: As directed.

F. Control Panel:

1. Factory wired between pumps and float switches, for single external electrical connection.
2. Provide fused, control-power transformer if voltage exceeds 230 V ac.
3. NEMA 250, enclosure with hinged door and grounding lug, mounted on pump as directed.
4. Motor controller for each pump.
5. Electrical pump alternator to operate pumps in lead-lag sequence and allow both pumps to operate on receiver high level.
6. Manual lead-lag control to override electrical pump alternator and manually select the lead pump.
7. Momentary-contact "TEST" push button on cover for each pump.
8. Numbered terminal strip.
9. Disconnect switch.

G. Capacities and Characteristics:

1. Unit Total Capacity: As directed.

2. Capacity, Each Pump:

    a. Flow: As directed.
    b. Discharge Head: As directed.
    c. Discharge Size: As directed.
    d. Speed: As directed.
    e. Motor Horsepower: As directed.

3. Receiver:

    a. Capacity: As directed.
    b. Inlet Size: As directed.
    c. Height to Inlet: As directed.

4. Electrical Characteristics:

    a. Volts: As directed.
    b. Phase: Single or Three as directed.
    c. Hertz: 60.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed.
    f. Maximum Overcurrent Protection: As directed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install pumps according to HI 1.1-1.2, HI 1.3, and HI 1.4.

B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.

C. Support pumps and piping separately so piping is not supported by pumps.

D. Install thermometers and pressure gages.

E. Equipment Mounting:

1. Install pumps on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete." As directed.
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment"
3. Comply with requirements for vibration isolation devices specified in Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."

3.2 CONNECTIONS

A. Comply with requirements for piping specified in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties."

B. Where installing piping adjacent to machine, allow space for service and maintenance.

C. Install a globe and check valve and pressure gage before inlet of each pump and a gate and check valve at pump outlet.

D. Pipe drain to nearest floor drain for overflow and drain piping connections.

E. Install full-size vent piping to outdoors, terminating in 180-degree elbow at point above highest steam system connection or as indicated.

F. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

G. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

END OF SECTION 232223

SECTION 232300 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Refrigerant pipes and fittings.
2. Refrigerant piping valves and specialties.
3. Refrigerants.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of valve, refrigerant piping, and refrigerant piping specialty.

B. Sustainable Design Submittals:

C. Shop Drawings:

1. Show piping size and piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.
2. Show interface and spatial relationships between piping and equipment.
3. Shop Drawing Scale: 1/4 inch equals 1 foot (1:50).

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.5 QUALITY ASSURANCE

A. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

B. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-134a:

1. Suction Lines for Air-Conditioning Applications: 115 psig (793 kPa).
2. Suction Lines for Heat-Pump Applications: 225 psig (1551 kPa).
3. Hot-Gas and Liquid Lines: 225 psig (1551 kPa).

B. Line Test Pressure for Refrigerant R-407C:

1. Suction Lines for Air-Conditioning Applications: 230 psig (1586 kPa).
2. Suction Lines for Heat-Pump Applications: 380 psig (2620 kPa).
3. Hot-Gas and Liquid Lines: 380 psig (2620 kPa).

C. Line Test Pressure for Refrigerant R-410A:

1. Suction Lines for Air-Conditioning Applications: 300 psig (2068 kPa).
2. Suction Lines for Heat-Pump Applications: 535 psig (3689 kPa).
3. Hot-Gas and Liquid Lines: 535 psig (3689 kPa).

2.2 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B88, Type K or L (ASTM B88M, Type A or B) or ASTM B280, Type ACR as directed.

B. Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

D. Solder Filler Metals: ASTM B32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.

E. Brazing Filler Metals: AWS A5.8/A5.8M.

F. Flexible Connectors:

1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
2. End Connections: Socket ends.
3. Offset Performance: Capable of minimum 3/4-inch (20-mm) misalignment in minimum 7-inch- (180-mm-) long assembly.
4. Working Pressure Rating: Factory test at minimum 500 psig (3450 kPa).
5. Maximum Operating Temperature: 250 deg F (121 deg C).

2.3 VALVES AND SPECIALTIES

A. Diaphragm Packless Valves:

1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
2. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
3. Operator: Rising stem and hand wheel.
4. Seat: Nylon.
5. End Connections: Socket, union, or flanged.
6. Working Pressure Rating: 500 psig (3450 kPa).
7. Maximum Operating Temperature: 275 deg F (135 deg C).

B. Packed-Angle Valves:
1. Body and Bonnet: Forged brass or cast bronze.
2. Packing: Molded stem, back seating, and replaceable under pressure.
3. Operator: Rising stem.
4. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
5. Seal Cap: Forged-brass or valox hex cap.
6. End Connections: Socket, union, threaded, or flanged.
7. Working Pressure Rating: 500 psig (3450 kPa).
8. Maximum Operating Temperature: 275 deg F (135 deg C).

C. Check Valves:
1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
3. Piston: Removable polytetrafluoroethylene seat.
4. Closing Spring: Stainless steel.
5. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
6. End Connections: Socket, union, threaded, or flanged.
7. Maximum Opening Pressure: 0.50 psig (3.4 kPa).
8. Working Pressure Rating: 500 psig (3450 kPa).
9. Maximum Operating Temperature: 275 deg F (135 deg C).

D. Service Valves:
1. Body: Forged brass with brass cap including key end to remove core.
2. Core: Removable ball-type check valve with stainless-steel spring.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Copper spring.
5. Working Pressure Rating: 500 psig (3450 kPa).

E. Solenoid Valves: Comply with AHRI 760 and UL 429; listed and labeled by a National Recognized Testing Laboratory (NRTL).
1. Body and Bonnet: Plated steel.
2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch (16-GRC) conduit adapter, and as directed-V ac coil.
6. Working Pressure Rating: 400 psig (2760 kPa).
7. Maximum Operating Temperature: 240 deg F (116 deg C).

F. Safety Relief Valves: Comply with 2010 ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.

2. Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Working Pressure Rating: 400 psig (2760 kPa).
6. Maximum Operating Temperature: 240 deg F (116 deg C).

G. Thermostatic Expansion Valves: Comply with AHRI 750.
1. Body, Bonnet, and Seal Cap: Forged brass or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos.
4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
5. Suction Temperature: 40 deg F (4.4 deg C).
6. Superheat: Adjustable or Nonadjustable as directed.
7. Reverse-flow option (for heat-pump applications).
8. End Connections: Socket, flare, or threaded union.
9. Working Pressure Rating: 700 psig (4820 kPa) or 450 psig (3100 kPa) as directed.

H. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.
1. Body, Bonnet, and Seal Cap: Ductile iron or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos.
4. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
5. Seat: Polytetrafluoroethylene.
6. Equalizer: Internal or External as directed.
7. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch (16-GRC) conduit adapter and as directed-V ac coil.
8. End Connections: Socket.
9. Set Pressure: As directed.
10. Throttling Range: Maximum 5 psig (34 kPa).
11. Working Pressure Rating: 500 psig (3450 kPa).
12. Maximum Operating Temperature: 240 deg F (116 deg C).

I. Straight-Type Strainers:
1. Body: Welded steel with corrosion-resistant coating.
2. Screen: 100-mesh stainless steel.
3. End Connections: Socket or flare.
4. Working Pressure Rating: 500 psig (3450 kPa).
5. Maximum Operating Temperature: 275 deg F (135 deg C).

J. Angle-Type Strainers:
1. Body: Forged brass or cast bronze.
2. Drain Plug: Brass hex plug.
3. Screen: 100-mesh monel.
4. End Connections: Socket or flare.
5. Working Pressure Rating: 500 psig (3450 kPa).
6. Maximum Operating Temperature: 275 deg F (135 deg C).

K. Moisture/Liquid Indicators:
1. Body: Forged brass.
2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.

3. Indicator: Color coded to show moisture content in parts per million (ppm).
4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
5. End Connections: Socket or flare.
6. Working Pressure Rating: 500 psig (3450 kPa).
7. Maximum Operating Temperature: 240 deg F (116 deg C).

L. Replaceable-Core Filter Dryers: Comply with AHRI 730.
1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated alumina or charcoal as directed.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 (DN 8) connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: 2 psig (14 kPa).
8. Rated Flow: As directed.
9. Working Pressure Rating: 500 psig (3450 kPa).
10. Maximum Operating Temperature: 240 deg F (116 deg C).

M. Permanent Filter Dryers: Comply with AHRI 730.
1. Body and Cover: Painted-steel shell.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated alumina or charcoal as directed.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 (DN 8) connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: 2 psig (14 kPa).
8. Rated Flow: As directed.
9. Working Pressure Rating: 500 psig (3450 kPa).
10. Maximum Operating Temperature: 240 deg F (116 deg C).

2.4 REFRIGERANTS

A. ASHRAE 34, R-134a: Tetrafluoroethane.

B. ASHRAE 34, R-407C: Difluoromethane/Pentafluoroethane/1,1,1,2-Tetrafluoroethane.

C. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-134a

A. Suction Lines: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints as directed.

B. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints as directed.

C. Safety-Relief-Valve Discharge Piping: Copper, drawn-temper tubing and wrought-copper fittings with soldered joints as directed.

3.2 PIPING APPLICATIONS FOR REFRIGERANT R-407C

A. Suction Lines: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints as directed.

B. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints as directed.

C. Safety-Relief-Valve Discharge Piping: Copper, drawn-temper tubing and wrought-copper fittings with soldered joints as directed.

3.3 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Suction Lines: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints as directed.

B. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type ACR or Type L (B), annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

C. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints as directed.

D. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints as directed.

E. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints as directed.

F. Safety-Relief-Valve Discharge Piping: Copper, Type ACR or Type L (B), annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

G. Safety-Relief-Valve Discharge Piping: Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

H. Safety-Relief-Valve Discharge Piping: Copper, drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.

I. Safety-Relief-Valve Discharge Piping: Copper, drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.

3.4 VALVE AND SPECIALTY APPLICATIONS

A. Install diaphragm packless or packed-angle valves in suction as directed and discharge lines of compressor.

B. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.

C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.

D. Except as otherwise indicated, install diaphragm packless or packed-angle valves on inlet and outlet side of filter dryers as directed.

E. Install a full-size, three-valve bypass around filter dryers.

F. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.

G. Install thermostatic expansion valves as close as possible to distributors on evaporators.

1. Install valve so diaphragm case is warmer than bulb.
2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

H. Install safety relief valves where required by 2010 ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

I. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

J. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for the device being protected:

1. Solenoid valves.
2. Thermostatic expansion valves.
3. Hot-gas bypass valves.
4. Compressor.

K. Install filter dryers in liquid line between compressor and thermostatic expansion valve, and in the suction line at the compressor.

L. Install receivers sized to accommodate pump-down charge.

M. Install flexible connectors at compressors.

3.5 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

B. Install refrigerant piping according to ASHRAE 15.

C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Refer to Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC" for solenoid valve controllers, control wiring, and sequence of operation.

K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Section 083113 "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.

M. Install refrigerant piping in protective conduit where installed belowground.

N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

O. Slope refrigerant piping as follows:

1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Install traps and double risers to entrain oil in vertical runs.
4. Liquid lines may be installed level.

P. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

Q. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

R. Identify refrigerant piping and valves according to Section 230553 "Identification for HVAC Piping and Equipment."

S. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

T. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

U. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.6 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Soldered Joints: Construct joints according to ASTM B828 or CDA's "Copper Tube Handbook."

D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."

1. Use Type BCuP (copper-phosphorus) alloy for joining copper socket fittings with copper pipe.
2. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze or steel.

3.7 HANGERS AND SUPPORTS

A. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet (6 m) long.
2. Roller hangers and spring hangers for individual horizontal runs 20 feet (6 m) or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet (6 m) or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.

5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for copper tubing with the following maximum spacing and minimum rod diameters:

1. NPS 1/2 (DN 15): Maximum span, 60 inches (1500 mm); minimum rod, 1/4 inch (6.4 mm).
2. NPS 5/8 (DN 18): Maximum span, 60 inches (1500 mm); minimum rod, 1/4 inch (6.4 mm).
3. NPS 1 (DN 25): Maximum span, 72 inches (1800 mm); minimum rod, 1/4 inch (6.4 mm).
4. NPS 1-1/4 (DN 32): Maximum span, 96 inches (2400 mm); minimum rod, 3/8 inch (9.5 mm).
5. NPS 1-1/2 (DN 40): Maximum span, 96 inches (2400 mm); minimum rod, 3/8 inch (9.5 mm).
6. NPS 2 (DN 50): Maximum span, 96 inches (2400 mm); minimum rod, 3/8 inch (9.5 mm).
7. NPS 2-1/2 (DN 65): Maximum span, 108 inches (2700 mm); minimum rod, 3/8 inch (9.5 mm).
8. NPS 3 (DN 80): Maximum span, 10 feet (3 m); minimum rod, 3/8 inch (9.5 mm).
9. NPS 4 (DN 100): Maximum span, 12 feet (3.7 m); minimum rod, 1/2 inch (13 mm).

D. Support multifloor vertical runs at least at each floor.

3.8 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in "Performance Requirements" Article.

    a. Fill system with nitrogen to the required test pressure.
    b. System shall maintain test pressure at the manifold gage throughout duration of test.
    c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
    d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

B. Prepare test and inspection reports.

3.9 SYSTEM CHARGING

A. Charge system using the following procedures:

1. Install core in filter dryers after leak test but before evacuation.

2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers (67 Pa). If vacuum holds for 12 hours, system is ready for charging.
3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig (14 kPa).
4. Charge system with a new filter-dryer core in charging line.

3.10 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:

1. Open shutoff valves in condenser water circuit.
2. Verify that compressor oil level is correct.
3. Open compressor suction and discharge valves.
4. Open refrigerant valves except bypass valves that are used for other purposes.
5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 232300

SECTION 232500 - HVAC WATER TREATMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following HVAC water-treatment systems:

1. Manual and automatic chemical-feed equipment and controls.
2. Ozone-generator biocide equipment and controls.
3. Stainless-steel pipes and fittings.
4. UV-irradiation unit, biocide equipment, and controls.
5. Chemical treatment test equipment.
6. Chemicals.
7. HVAC makeup-water softeners.
8. RO equipment for HVAC makeup water.
9. Water filtration equipment.

1.2 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Closed hydronic systems shall have the following water qualities:

1. pH: Maintain a value within 9.0 to 10.5.
2. "P" Alkalinity: Maintain a value within 100 to 500 ppm.
3. Boron: Maintain a value within 100 to 200 ppm.
4. Chemical Oxygen Demand: Maintain a maximum value of 100 ppm.

5. Soluble Copper: Maintain a maximum value of 0.20 ppm.
6. TSS: Maintain a maximum value of 10 ppm.
7. Ammonia: Maintain a maximum value of 20 ppm.
8. Free Caustic Alkalinity: Maintain a maximum value of 20 ppm.
9. Microbiological Limits:

    a. Total Aerobic Plate Count: Maintain a maximum value of 1000 organisms/mL.
    b. Total Anaerobic Plate Count: Maintain a maximum value of 100 organisms/mL.
    c. Nitrate Reducers: Maintain a maximum value of 100 organisms/mL.
    d. Sulfate Reducers: Maintain a maximum value of zero organisms/mL.
    e. Iron Bacteria: Maintain a maximum value of zero organisms/mL.

10. Other requirements.

B. Open hydronic systems, including condenser or fluid-cooler spray water as directed, shall have the following water qualities:

1. pH: Maintain a value within 8.0 to 9.1.
2. "P" Alkalinity: Maintain a maximum value of 100 ppm.
3. Chemical Oxygen Demand: Maintain a maximum value of 100 ppm.
4. Soluble Copper: Maintain a maximum value of 0.20 ppm.
5. TSS: Maintain a maximum value of 10 ppm.
6. Ammonia: Maintain a maximum value of 20 ppm.
7. Free "OH" Alkalinity: Maintain a maximum value of zero ppm.
8. Microbiological Limits:

    a. Total Aerobic Plate Count: Maintain a maximum value of 10,000 organisms/mL.
    b. Total Anaerobic Plate Count: Maintain a maximum value of 1000 organisms/mL.
    c. Nitrate Reducers: Maintain a maximum value of 100 organisms/mL.
    d. Sulfate Reducers: Maintain a maximum value of zero organisms/mL.
    e. Iron Bacteria: Maintain a maximum value of zero organisms/mL.

9. Polymer Testable: Maintain a minimum value within 10 to 40.

C. Passivation for Galvanized Steel: For the first 60 days of operation.

1. pH: Maintain a value within 7 to 8.
2. Calcium Carbonate Hardness: Maintain a value within 100 to 300 ppm.
3. Calcium Carbonate Alkalinity: Maintain a value within 100 to 300 ppm.

2.3 MANUAL CHEMICAL-FEED EQUIPMENT

A. Bypass Feeders: Steel, with corrosion-resistant exterior coating, minimum 3-1/2-inch (89-mm) fill opening in the top, and NPS 3/4 (DN 20) bottom inlet and top side outlet. Quarter turn or threaded fill cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel.

1. Capacity: 2 gal. (7.6 L) or 5 gal. (19 L).
2. Minimum Working Pressure: 125 psig (860 kPa) or 175 psig (1210 kPa) as directed.

2.4 AUTOMATIC CHEMICAL-FEED EQUIPMENT

A. Water Meter:

1. AWWA C700, oscillating-piston, magnetic-drive, totalization meter.
2. Body: Bronze.
3. Minimum Working-Pressure Rating: 150 psig (1035 kPa).
4. Maximum Pressure Loss at Design Flow: 3 psig (20 kPa).
5. Registration: Gallons (Liters) or cubic feet (cubic meters).
6. End Connections: Threaded.
7. Controls: Flow-control switch with normally open contacts; rated for maximum 10 A, 250-V ac, and that will close at adjustable increments of total flow.

B. Inhibitor Injection Timers:

1. Microprocessor-based controller with digital display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. Programmable timers with infinite adjustment over full range, and mounted in cabinet with hand-off-auto switches and status lights.
3. Test switch.
4. Hand-off-auto switch for chemical pump.
5. Illuminated legend to indicate feed when pump is activated.
6. Programmable lockout timer with indicator light. Lockout timer to deactivate the pump and activate alarm circuits.
7. Digital display makeup totalizer to measure amount of makeup and bleed-off water from two water meter inputs.

C. pH Controller:

1. Microprocessor-based controller, 1 percent accuracy in a range from zero to 14 units. Incorporate solid-state integrated circuits and digital display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. Digital display and touch pad for input.
3. Sensor probe adaptable to sample stream manifold.
4. High, low, and normal pH indication.
5. High or low-pH-alarm-light trip points, field adjustable; with silence switch.
6. Hand-off-auto switch for acid pump.
7. Internal adjustable hysteresis or deadband.

D. TSS Controller:

1. Microprocessor-based controller, 1 percent accuracy in a range from zero to 5000 micromhos. Incorporate solid-state integrated circuits and digital display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. Digital display and touch pad for input.

3. Sensor probe adaptable to sample stream manifold.
4. High, low, and normal conductance indication.
5. High- or low-conductance-alarm-light trip points, field adjustable; with silence switch.
6. Hand-off-auto switch for solenoid bleed-off valve.
7. Bleed-off valve activated indication.
8. Internal adjustable hysteresis or deadband.
9. Bleed Valves:

    a. Cooling Systems: Forged-brass body, globe pattern, general-purpose solenoid with continuous-duty coil, or motorized valve.
    b. Steam Boilers: Motorized ball valve, steel body, and TFE seats and seals.

E. Biocide Feeder Timer:

1. Microprocessor-based controller with digital display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. 24-hour timer with 14-day skip feature to permit activation any hour of day.
3. Precision, solid-state, bleed-off lockout timer and clock-controlled biocide pump timer. Prebleed and bleed lockout timers.
4. Solid-state alternator to enable use of two formulations.
5. 24-hour display of time of day.
6. 14-day display of day of week.
7. Battery backup so clock is not disturbed by power outages.
8. Hand-off-auto switches for biocide pumps.
9. Biocide A and Biocide B pump running indication.

F. Chemical Solution Tanks:

1. Chemical-resistant reservoirs fabricated from high-density opaque polyethylene with minimum 110 percent containment vessel.
2. Molded cover with recess for mounting pump.
3. Capacity: As directed.

G. Chemical Solution Injection Pumps:

1. Self-priming, positive displacement; rated for intended chemical with minimum 25 percent safety factor for design pressure and temperature.
2. Adjustable flow rate.
3. Metal and thermoplastic construction.
4. Built-in relief valve.
5. Fully enclosed, continuous-duty, single-phase motor. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

    a. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

H. Chemical Solution Tubing: Polyethylene tubing with compression fittings and joints except ASTM A269, Type 304, stainless steel for steam boiler injection assemblies.

I. Injection Assembly:

1. Quill: Minimum NPS 1/2 (DN 15) with insertion length sufficient to discharge into at least 25 percent of pipe diameter.
2. Ball Valve: Three or Two-piece stainless steel, as described in "Stainless-Steel Pipes and Fittings" Article; selected to fit quill.
3. Packing Gland: Mechanical seal on quill of sufficient length to allow quill removal during system operation.
4. Assembly Pressure/Temperature Rating: Minimum 600 psig (4137 kPa) at 200 deg F (93 deg C).

2.5 CHEMICALS

A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment and that can attain water quality specified in "Performance Requirements" Article.

B. Water Softener Chemicals:

1. Mineral: High-capacity, sulfonated-polystyrene ion-exchange resin that is stable over entire pH range with good resistance to bead fracture from attrition or shock. Resin exchange capacity minimum 30,000 grains/cu. ft. (69 kg/cu. m) of calcium carbonate of resin when regenerated with 15 lb (6.8 kg) of salt.
2. Salt for Brine Tanks: High-purity sodium chloride, free of dirt and foreign material. Rock and granulated forms are unacceptable.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION

A. Install chemical application equipment on concrete bases level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate.

B. Install seismic restraints for equipment and floor-mounting accessories and anchor to building structure. See Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.

C. Install interconnecting control wiring for chemical treatment controls and sensors.

D. Mount sensors and injectors in piping circuits.

E. Bypass Feeders: Install in closed hydronic systems, including and equipped with the following:

1. Install bypass feeder in a bypass circuit around circulating pumps unless otherwise indicated on Drawings.
2. Install water meter in makeup-water supply.
3. Install test-coupon assembly in bypass circuit around circulating pumps unless otherwise indicated on Drawings.
4. Install a gate or full-port ball isolation valves on inlet, outlet, and drain below feeder inlet.
5. Install a swing check on inlet after the isolation valve.

F. Install automatic chemical-feed equipment for condenser water and include the following:

1. Install makeup-water softener.
2. Install water meter in makeup-water supply.
3. Install inhibitor injection pumps and solution tanks with injection timer sensing contacts in water meter.

    a. Pumps shall operate for timed interval on contact closure at water meter in makeup-water supply connection.

4. Install TSS controller with sensor and bleed valves.

    a. Bleed valves shall cycle to maintain maximum TSS concentration.

5. Install pH sensor and controller with injection pumps and solution tanks.

    a. Injector pumps shall operate to maintain required pH.

6. Install biocide feeder alternating timer with two sets of injection pumps and solution tanks.

    a. Injection pumps shall operate to feed biocide on an alternating basis.

G. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

H. Where installing piping adjacent to equipment, allow space for service and maintenance.

I. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Dielectric fittings are specified in Section 232113 "Hydronic Piping."

J. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Section 230523.11 "Globe Valves for HVAC Piping," Section 230523.12 "Ball Valves for HVAC Piping," Section 230523.13 "Butterfly Valves for HVAC Piping," and Section 230523.15 "Gate Valves for HVAC Piping."

K. See Section 221119 "Domestic Water Piping Specialties" for backflow preventers required in makeup-water connections to potable-water systems.

L. Confirm applicable electrical requirements in electrical Sections for connecting electrical equipment.

M. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

N. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of HVAC system's startup procedures.
4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
7. Cap and subject piping to static water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
8. Repair leaks and defects with new materials and retest piping until no leaks exist.

B. Equipment will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.4 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.

END OF SECTION 232500

SECTION 232513 - WATER TREATMENT FOR CLOSED-LOOP HYDRONIC SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following water treatment for closed-loop hydronic systems:

1. Manual or Automatic chemical-feed equipment as directed.
2. Chemicals.

1.2 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Closed hydronic systems shall have the following water qualities:

1. pH: Maintain a value within 9.0 to 10.5.
2. "P" Alkalinity: Maintain a value within 100 to 500 ppm.
3. Boron: Maintain a value within 100 to 200 ppm.
4. Chemical Oxygen Demand: Maintain a maximum value of 100 ppm.
5. Soluble Copper: Maintain a maximum value of 0.20 ppm.
6. TSS: Maintain a maximum value of 10 ppm.
7. Ammonia: Maintain a maximum value of 20 ppm.
8. Free Caustic Alkalinity: Maintain a maximum value of 20 ppm.
9. Microbiological Limits:

a. Total Aerobic Plate Count: Maintain a maximum value of 1000 organisms/mL.
b. Total Anaerobic Plate Count: Maintain a maximum value of 100 organisms/mL.
c. Nitrate Reducers: Maintain a maximum value of 100 organisms/mL.
d. Sulfate Reducers: Maintain a maximum value of zero organisms/mL.
e. Iron Bacteria: Maintain a maximum value of zero organisms/mL.

2.3 MANUAL CHEMICAL-FEED EQUIPMENT

A. Bypass Feeders: Steel, with corrosion-resistant exterior coating, minimum 3-1/2-inch (89-mm) fill opening in the top, and NPS 3/4 (DN 20) bottom inlet and top side outlet. Quarter turn or threaded fill cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel.

1. Capacity: 2 gal. (7.6 L) or 5 gal. (19 L) as directed.
2. Minimum Working Pressure: 125 psig (860 kPa) or 175 psig (1210 kPa) as directed.

2.4 AUTOMATIC CHEMICAL-FEED EQUIPMENT

A. Water Meter:

1. AWWA C700, oscillating-piston, magnetic-drive, totalization meter.
2. Body: Bronze.
3. Minimum Working-Pressure Rating: 150 psig (1035 kPa).
4. Maximum Pressure Loss at Design Flow: 3 psig (20 kPa).
5. Registration: Gallons (Liters) or cubic feet (cubic meters).
6. End Connections: Threaded.
7. Controls: Flow-control switch with normally open contacts; rated for maximum 10 A, 250-V ac; and that will close at adjustable increments of total flow.
8. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Chemical Solution Tanks:

1. Chemical-resistant reservoirs fabricated from high-density opaque polyethylene with minimum 110 percent containment vessel.
2. Molded cover with recess for mounting pump.
3. Capacity: As directed.

C. Chemical Solution Injection Pumps:

1. Self-priming, positive displacement; rated for intended chemical with minimum 25 percent safety factor for design pressure and temperature.
2. Adjustable flow rate.
3. Metal and thermoplastic construction.
4. Built-in relief valve.
5. Fully enclosed, continuous-duty, single-phase motor. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

6. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Chemical Solution Tubing: Polyethylene tubing with compression fittings and joints except ASTM A269, Type 304, stainless steel for steam boiler injection assemblies.

E. Injection Assembly:

1. Quill: Minimum NPS 1/2 (DN 15) with insertion length sufficient to discharge into at least 25 percent of pipe diameter.
2. Ball Valve: Three or Two-piece, stainless steel; selected to fit quill as directed.
3. Packing Gland: Mechanical seal on quill of sufficient length to allow quill removal during system operation.
4. Assembly Pressure/Temperature Rating: Minimum 600 psig (4137 kPa) at 200 deg F (93 deg C).

2.5 CHEMICALS

A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment and that can attain water quality specified in "Performance Requirements" Article.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION

A. Install chemical application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate.

B. Install seismic restraints for equipment and floor-mounting accessories and anchor to building structure. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.

C. Install water testing equipment on wall near water chemical application equipment.

D. Install interconnecting control wiring for chemical treatment controls and sensors.

E. Mount sensors and injectors in piping circuits.

F. Bypass Feeders: Install in closed hydronic systems as directed, and equipped with the following:

1. Install bypass feeder in a bypass circuit around circulating pumps unless otherwise indicated on Drawings.
2. Install water meter in makeup-water supply.
3. Install test-coupon assembly in bypass circuit around circulating pumps unless otherwise indicated on Drawings.
4. Install a gate or full-port ball isolation valves on inlet, outlet, and drain below the feeder inlet.
5. Install a swing check on the inlet after the isolation valve.

G. Where installing piping adjacent to equipment, allow space for service and maintenance.

H. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Comply with requirements in Section 232116 "Hydronic Piping Specialties"

I. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Section 230523.11 "Globe Valves for HVAC Piping," Section 230523.12 "Ball Valves for HVAC Piping," Section 230523.13 "Butterfly Valves for HVAC Piping," and Section 230523.15 "Gate Valves for HVAC Piping."

J. Comply with requirements in Section 221119 "Domestic Water Piping Specialties" for backflow preventers required in makeup-water connections to potable-water systems.

K. Confirm applicable electrical requirements in electrical Sections for connecting electrical equipment.

L. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

M. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of hydronic systems' startup procedures.
4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.

7. Cap and subject piping to static water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
8. Repair leaks and defects with new materials and retest piping until no leaks exist.

B. Equipment will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 232513

SECTION 232516 - WATER TREATMENT FOR OPEN-LOOP HYDRONIC SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following HVAC water-treatment systems:

1. Manual chemical-feed equipment.
2. Automatic chemical-feed equipment.
3. Chemicals.

1.2 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for each type of product.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of equipment without creating a hazard to operating personnel or the environment.

B. Base HVAC water treatment on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

C. Open HVAC systems shall have the following water qualities:

1. pH: Maintain a value within 8.0 to 9.1.
2. "P" Alkalinity: Maintain a maximum value of 100 ppm.
3. Chemical Oxygen Demand: Maintain a maximum value of 100 ppm.
4. Soluble Copper: Maintain a maximum value of 0.20 ppm.
5. TSS: Maintain a maximum value of 10 ppm.
6. Ammonia: Maintain a maximum value of 20 ppm.

7. Free "OH" Alkalinity: Maintain a maximum value of zero ppm.
8. Microbiological Limits:

    a. Total Aerobic Plate Count: Maintain a maximum value of 10,000 organisms/mL.
    b. Total Anaerobic Plate Count: Maintain a maximum value of 1000 organisms/mL.
    c. Nitrate Reducers: Maintain a maximum value of 100 organisms/mL.
    d. Sulfate Reducers: Maintain a maximum value of zero organisms/mL.
    e. Iron Bacteria: Maintain a maximum value of zero organisms/mL.

9. Polymer Testable: Maintain a minimum value within 10 to 40.

D. Passivation for Galvanized Steel: For the first 60 days of operation.

1. pH: Maintain a value within 7 to 8.
2. Calcium Carbonate Hardness: Maintain a value within 100 to 300 ppm.
3. Calcium Carbonate Alkalinity: Maintain a value within 100 to 300 ppm.

2.3 MANUAL CHEMICAL-FEED EQUIPMENT

A. Bypass Feeders: Steel, with corrosion-resistant exterior coating, minimum 3-1/2-inch (89-mm) fill opening in the top, and NPS 3/4 (DN 20) bottom inlet and top side outlet. Quarter turn or threaded fill cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel.

1. Capacity: 2 gal. (7.6 L) or 5 gal. (19 L) as directed.
2. Minimum Working Pressure: 125 psig (860 kPa) or 175 psig (1210 kPa) as directed.

2.4 AUTOMATIC CHEMICAL-FEED EQUIPMENT

A. Water Meter:

1. AWWA C700, oscillating-piston, magnetic-drive, totalization meter.
2. Body: Bronze.
3. Minimum Working-Pressure Rating: 150 psig (1035 kPa).
4. Maximum Pressure Loss at Design Flow: 3 psig (20 kPa).
5. Registration: Gallons (Liters) or cubic feet (cubic meters).
6. End Connections: Threaded.
7. Controls: Flow-control switch with normally open contacts; rated for maximum 10 A, 250-V ac, and that will close at adjustable increments of total flow.
8. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Water Meter:

1. AWWA C701, turbine-type, totalization meter.
2. Body: Bronze.
3. Minimum Working-Pressure Rating: 100 psig (690 kPa).
4. Maximum Pressure Loss at Design Flow: 3 psig (20 kPa).

5. Registration: Gallons (Liters) or cubic feet (cubic meters).
6. End Connections: Threaded.
7. Control: Low-voltage signal capable of transmitting 1000 feet (305 m).
8. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Inhibitor Injection Timers:

1. Microprocessor-based controller with digital display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. Programmable timers with infinite adjustment over full range and mounted in cabinet with hand-off-auto switches and status lights.
3. Test switch.
4. Hand-off-auto switch for chemical pump.
5. Illuminated legend to indicate feed when pump is activated.
6. Programmable lockout timer with indicator light. Lockout timer to deactivate the pump and activate alarm circuits.
7. Digital display makeup totalizer to measure amount of makeup and bleed-off water from two water meter inputs.
8. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. pH Controller:

1. Microprocessor-based controller, 1 percent accuracy in a range from zero to 14 units. Incorporate solid-state integrated circuits and digital display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. Digital display and touch pad for input.
3. Sensor probe adaptable to sample stream manifold.
4. High, low, and normal pH indication.
5. High- or low-pH-alarm-light trip points, field adjustable; with silence switch.
6. Hand-off-auto switch for acid pump.
7. Internal adjustable hysteresis or deadband.
8. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. TSS Controller:

1. Microprocessor-based controller, 1 percent accuracy in a range from zero to 5000 micromhos. Incorporate solid-state integrated circuits and digital display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. Digital display and touch pad for input.

3. Sensor probe adaptable to sample stream manifold.
4. High, low, and normal conductance indication.
5. High- or low-conductance-alarm-light trip points, field adjustable; with silence switch.
6. Hand-off-auto switch for solenoid bleed-off valve.
7. Bleed-off valve activated indication.
8. Internal adjustable hysteresis or deadband.
9. Bleed Valves:

    a. Cooling Systems: Forged-brass body, globe pattern, general-purpose solenoid with continuous-duty coil, or motorized valve.
    b. Steam Boilers: Motorized ball valve, steel body, and TFE seats and seals.

F. Biocide Feeder Timer:

1. Microprocessor-based controller with digital display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. 24-hour timer with 14-day skip feature to permit activation any hour of day.
3. Precision, solid-state, bleed-off lockout timer and clock-controlled biocide pump timer. Prebleed and bleed lockout timers.
4. Solid-state alternator to enable use of two different formulations.
5. 24-hour display of time of day.
6. 14-day display of day of week.
7. Battery backup so clock is not disturbed by power outages.
8. Hand-off-auto switches for biocide pumps.
9. Biocide A and Biocide B pump running indication.

G. Chemical Solution Tanks:

1. Chemical-resistant reservoirs fabricated from high-density opaque polyethylene with minimum 110 percent containment vessel.
2. Molded cover with recess for mounting pump.
3. Capacity: As directed.

H. Chemical Solution Injection Pumps:

1. Self-priming, positive displacement; rated for intended chemical with minimum 25 percent safety factor for design pressure and temperature.
2. Adjustable flow rate.
3. Metal and thermoplastic construction.
4. Built-in relief valve.
5. Fully enclosed, continuous-duty, single-phase motor. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
6. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

I. Chemical Solution Tubing: Polyethylene tubing with compression fittings and joints except ASTM A269, Type 304, stainless steel for steam boiler injection assemblies.

J. Injection Assembly:

1. Quill: Minimum NPS 1/2 (DN 15) with insertion length sufficient to discharge into at least 25 percent of pipe diameter.
2. Ball Valve: Three or Two-piece stainless steel as described in "Stainless-Steel Pipes and Fittings" Article; selected to fit quill as directed.
3. Packing Gland: Mechanical seal on quill of sufficient length to allow quill removal during system operation.
4. Assembly Pressure/Temperature Rating: Minimum 600 psig (4137 kPa) at 200 deg F (93 deg C).

2.5 CHEMICALS

A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment and that can attain water quality specified in "Performance Requirements" Article.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION

A. Install chemical application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate.

B. Install seismic restraints for equipment and floor-mounting accessories and anchor to building structure. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.

C. Install interconnecting control wiring for chemical treatment controls and sensors.

D. Mount sensors and injectors in piping circuits.

E. Install automatic chemical-feed equipment:

1. Install water meter in makeup-water supply.
2. Install inhibitor injection pumps and solution tanks with injection timer sensing contacts in water meter.

    a. Pumps shall operate for timed interval on contact closure at water meter in makeup-water supply connection. Injection pump shall discharge into boiler feedwater tank or feedwater supply connection at boiler.

3. Install TSS controller with sensor and bleed valves.

a. Bleed valves shall cycle to maintain maximum TSS concentration.

4. Install pH sensor and controller with injection pumps and solution tanks.

a. Injector pumps shall operate to maintain required pH.

5. Install biocide feeder alternating timer with two sets of injection pumps and solution tanks.

a. Injection pumps shall operate to feed biocide on an alternating basis.

F. Where installing piping adjacent to equipment, allow space for service and maintenance.

G. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Comply with requirements in Section 232116 "Hydronic Piping Specialties" for dielectric fittings.

H. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Section 230523.11 "Globe Valves for HVAC Piping," Section 230523.12 "Ball Valves for HVAC Piping," Section 230523.13 "Butterfly Valves for HVAC Piping," and Section 230523.15 "Gate Valves for HVAC Piping."

I. Comply with requirements in Section 221119 "Domestic Water Piping Specialties" for backflow preventers required in makeup-water connections to potable-water systems.

J. Confirm applicable electrical requirements in electrical Sections for connecting electrical equipment.

K. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

L. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of HVAC systems' startup procedures.
4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.

6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
7. Cap and subject piping to static water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
8. Repair leaks and defects with new materials and retest piping until no leaks exist.

B. Equipment will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.4 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.

END OF SECTION 232516

SECTION 232519 - WATER TREATMENT FOR STEAM SYSTEM FEEDWATER

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes automatic chemical-feed equipment and chemical steam system feedwater.

1.2 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Water quality for steam systems shall minimize corrosion and scale buildup for optimum efficiency of steam and condensate equipment without creating a hazard to operating personnel or the environment.

B. Base steam systems feedwater treatment on quality of water available at Project site, steam and condensate system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

C. Steam Condensate:

1. pH: Maintain a value within 7.8 to 8.4.
2. Total Alkalinity: Maintain a value within 5 to 50 ppm.
3. Chemical Oxygen Demand: Maintain a maximum value of 15 ppm.
4. Soluble Copper: Maintain a maximum value of 0.20 ppm.
5. TSS: Maintain a maximum value of 10 ppm.

6. Ammonia: Maintain a maximum value of 20 ppm.
7. Total Hardness: Maintain a maximum value of 2 ppm.

D. Steam boiler operating at 15 psig (104 kPa) and less shall have the following water qualities:

1. "OH" Alkalinity: Maintain a value within 200 to 400 ppm.
2. TSS: Maintain a value within 600 to 3000 ppm.

E. Steam boiler operating at more than 15 psig (104 kPa) shall have the following water qualities:

1. "OH" Alkalinity: Maintain a value within 200 to 400 ppm.
2. TSS: Maintain a value within 600 to 1200 ppm to maximum 30 times TDS of water treated with reverse-osmosis equipment.

2.3 AUTOMATIC CHEMICAL-FEED EQUIPMENT

A. Water Meter:

1. AWWA C700, oscillating-piston, magnetic-drive, totalization meter.
2. Body: Bronze.
3. Minimum Working-Pressure Rating: 150 psig (1035 kPa).
4. Maximum Pressure Loss at Design Flow: 3 psig (20 kPa).
5. Registration: Gallons (Liters) or cubic feet (cubic meters).
6. End Connections: Threaded.
7. Controls: Flow-control switch with normally open contacts; rated for maximum 10 A, 250-V ac, and that will close at adjustable increments of total flow.
8. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. TSS Controller:

1. Microprocessor-based controller, 1 percent accuracy in a range from zero to 5000 micromhos. Incorporate solid-state integrated circuits and digital display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. Digital display and touch pad for input.
3. Sensor probe adaptable to sample stream manifold.
4. High, low, and normal conductance indication.
5. High- or low-conductance-alarm-light trip points, field adjustable; with silence switch.
6. Hand-off-auto switch for solenoid bleed-off valve.
7. Bleed-off valve activated indication.
8. Internal adjustable hysteresis or deadband.
9. Bleed Valves: Motorized ball valve, steel body, and TFE seats and seals.
10. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Chemical Solution Tanks:

1. Chemical-resistant reservoirs fabricated from high-density opaque polyethylene with minimum 110 percent containment vessel.
2. Molded cover with recess for mounting pump.
3. Capacity: As directed.

D. Chemical Solution Injection Pumps:

1. Self-priming, positive displacement; rated for intended chemical with minimum 25 percent safety factor for design pressure and temperature.
2. Adjustable flow rate.
3. Metal and thermoplastic construction.
4. Built-in relief valve.
5. Fully enclosed, continuous-duty, single-phase motor. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
6. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Chemical Solution Tubing: Polyethylene tubing with compression fittings and joints except ASTM A269, Type 304, stainless steel for steam boiler injection assemblies.

F. Injection Assembly:

1. Quill: Minimum NPS 1/2 (DN 15) with insertion length sufficient to discharge into at least 25 percent of pipe diameter.
2. Ball Valve: Three or Two-piece stainless steel as described in "Stainless-Steel Pipes and Fittings" Article as directed; selected to fit quill.
3. Packing Gland: Mechanical seal on quill of sufficient length to allow quill removal during system operation.
4. Assembly Pressure/Temperature Rating: Minimum 600 psig (4137 kPa) at 200 deg F (93 deg C).

2.4 CHEMICALS

A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment and that can attain water quality specified in "Performance Requirements" Article.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION

A. Install chemical application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate.

B. Install seismic restraints for equipment and floor-mounting accessories and anchor to building structure. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.

C. Install interconnecting control wiring for chemical treatment controls and sensors.

D. Mount sensors and injectors in piping circuits.

E. Install automatic chemical-feed equipment for steam boiler and steam condensate systems and include the following:

1. Install water meter in makeup-water supply.
2. Install inhibitor injection pumps and solution tanks with injection timer sensing contacts in water meter.

    a. Pumps shall operate for timed interval when contacts close at water meter in makeup-water supply connection. Injection pump shall discharge into boiler feedwater tank or feedwater supply connection at boiler.

3. Install test equipment and furnish test-kit to Owner.
4. Install TSS controller with sensor and bleed valves.

    a. Bleed valves shall cycle to maintain maximum TSS concentration.

5. Install inhibitor injection timer with injection pumps and solution tanks.

    a. Pumps shall operate for timed interval on contact closure at water meter in makeup-water supply connection. Injection pump shall discharge into main steam supply header.

F. Install automatic chemical-feed equipment for condenser or fluid-cooler spray water as directed and include the following:

1. Install water meter in makeup-water supply.
2. Install inhibitor injection pumps and solution tanks with injection timer sensing contacts in water meter.

    a. Pumps shall operate for timed interval on contact closure at water meter in makeup-water supply connection. Injection pump shall discharge into boiler feedwater tank or feedwater supply connection at boiler.

3. Install test equipment and provide test-kit to Owner. Install test-coupon assembly in bypass circuit around circulating pumps unless otherwise indicated on Drawings.
4. Install TSS controller with sensor and bleed valves.

a. Bleed valves shall cycle to maintain maximum TSS concentration.

5. Install pH sensor and controller with injection pumps and solution tanks.

a. Injector pumps shall operate to maintain required pH.

G. Where installing piping adjacent to equipment, allow space for service and maintenance.

H. Make piping connections between steam systems water-treatment equipment and dissimilar-metal piping with dielectric fittings. Comply with requirements in Section 232113 "Hydronic Piping" for dielectric fittings.

I. Install shutoff valves on steam systems water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Section 230523.11 "Globe Valves for HVAC Piping," Section 230523.12 "Ball Valves for HVAC Piping," Section 230523.13 "Butterfly Valves for HVAC Piping," and Section 230523.15 "Gate Valves for HVAC Piping."

J. Comply with requirements in Section 221119 "Domestic Water Piping Specialties" for backflow preventers required in makeup-water connections to potable-water systems.

K. Confirm applicable electrical requirements in electrical Sections for connecting electrical equipment.

L. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

M. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
3. Place steam systems water-treatment system into operation and calibrate controls during the preliminary phase of steam systems' startup procedures.
4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
7. Cap and subject piping to static water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source

and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.

8. Repair leaks and defects with new materials and retest piping until no leaks exist.

B. Equipment will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.4 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain steam systems water-treatment systems and equipment.

END OF SECTION 232519

SECTION 232523 - WATER TREATMENT FOR HUMIDIFICATION STEAM SYSTEM FEEDWATER

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes automatic chemical-feed equipment and chemicals for humidification steam system feedwater.

1.2 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Water quality for humidification steam systems shall minimize corrosion and scale buildup for optimum efficiency of humidification steam equipment without creating a hazard to operating personnel or the environment.

B. Base HVAC water treatment on quality of water available at Project site, humidification steam system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

C. Steam Condensate:

1. pH: Maintain a value within 7.8 to 8.4 ppm.
2. Total Alkalinity: Maintain a value within 5 to 50 ppm.
3. Chemical Oxygen Demand: Maintain a maximum value of 15 ppm.
4. Soluble Copper: Maintain a maximum value of 0.20 ppm.

5. TDS: Maintain a maximum value of 10 ppm.
6. Ammonia: Maintain a maximum value of 20 ppm.
7. Total Hardness: Maintain a maximum value of 2 ppm.

D. Steam boiler operating at 15 psig (104 kPa) and less shall have the following water qualities:

1. "OH" Alkalinity: Maintain a value within 200 to 400 ppm.
2. TDS: Maintain a value within 600 to 3000 ppm.

E. Steam boiler operating at more than 15 psig (104 kPa) shall have the following water qualities:

1. "OH" Alkalinity: Maintain a value within 200 to 400 ppm.
2. TDS: Maintain a value within 600 to 1200 ppm to maximum 30 times RO water TDS.

2.3 AUTOMATIC CHEMICAL-FEED EQUIPMENT

A. Water Meter:

1. AWWA C700, oscillating-piston, magnetic-drive, totalization meter.
2. Body: Bronze.
3. Minimum Working-Pressure Rating: 150 psig (1035 kPa).
4. Maximum Pressure Loss at Design Flow: 3 psig (20 kPa).
5. Registration: Gallons (Liters) or cubic feet (cubic meters).
6. End Connections: Threaded.
7. Controls: Flow-control switch with normally open contacts; rated for maximum 10 A, 250-V ac, and that will close at adjustable increments of total flow.
8. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. TSS Controller:

1. Microprocessor-based controller, 1 percent accuracy in a range from zero to 5000 micromhos. Incorporate solid-state integrated circuits and digital display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation as described in Section 230923 "Direct Digital Control (DDC) System for HVAC."
2. Digital display and touch pad for input.
3. Sensor probe adaptable to sample stream manifold.
4. High, low, and normal conductance indication.
5. High- or low-conductance-alarm-light trip points, field adjustable; with silence switch.
6. Hand-off-auto switch for solenoid bleed-off valve.
7. Bleed-off valve activated indication.
8. Internal adjustable hysteresis or deadband.
9. Bleed Valves: Motorized ball valve, steel body, and TFE seats and seals.

C. Chemical Solution Tanks:

1. Chemical-resistant reservoirs fabricated from high-density opaque polyethylene with minimum 110 percent containment vessel.

2. Molded cover with recess for mounting pump.
3. Capacity: As directed.

D. Chemical Solution Injection Pumps:

1. Self-priming, positive displacement; rated for intended chemical with minimum 25 percent safety factor for design pressure and temperature.
2. Adjustable flow rate.
3. Metal and thermoplastic construction.
4. Built-in relief valve.
5. Fully enclosed, continuous-duty, single-phase motor. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
6. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Chemical Solution Tubing: Polyethylene tubing with compression fittings and joints except ASTM A269, Type 304, stainless steel for steam boiler injection assemblies.

F. Injection Assembly:

1. Quill: Minimum NPS 1/2 (DN 15) with insertion length sufficient to discharge into at least 25 percent of pipe diameter.
2. Ball Valve: Three or Two-piece stainless steel as described in "Stainless-Steel Pipes and Fittings" Article; selected to fit quill as directed.
3. Packing Gland: Mechanical seal on quill of sufficient length to allow quill removal during system operation.
4. Assembly Pressure/Temperature Rating: Minimum 600 psig (4137 kPa) at 200 deg F (93 deg C).

2.4 CHEMICALS

A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment, and that can attain water quality specified in "Performance Requirements" Article.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION

A. Install seismic restraints for equipment and floor-mounting accessories and anchor to building structure. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.

B. Install interconnecting control wiring for chemical treatment controls and sensors.

C. Mount sensors and injectors in piping circuits.

D. Install automatic chemical-feed equipment for water and include the following:

1. Install water meter in makeup-water supply.
2. Install inhibitor injection pumps and solution tanks with injection timer sensing contacts in water meter.

    a. Pumps shall operate for timed interval on contact closure at water meter in makeup-water supply connection. Injection pump shall discharge into boiler feedwater tank or feedwater supply connection at boiler.

3. Install test equipment and provide test-kit to Owner. Install test-coupon assembly in bypass circuit around circulating pumps unless otherwise indicated on Drawings.
4. Install TSS controller with sensor and bleed valves.

    a. Bleed valves shall cycle to maintain maximum TSS concentration.

5. Install pH sensor and controller with injection pumps and solution tanks.

    a. Injector pumps shall operate to maintain required pH.

E. Where installing piping adjacent to equipment, to allow service and maintenance.

F. Make piping connections between steam systems water-treatment equipment and dissimilar-metal piping with dielectric fittings. Comply with requirements in Section 232113 "Hydronic Piping" for dielectric fittings.

G. Install shutoff valves on humidifier steam system water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Section 230523.11 "Globe Valves for HVAC Piping," Section 230523.12 "Ball Valves for HVAC Piping," Section 230523.13 "Butterfly Valves for HVAC Piping," and Section 230523.15 "Gate Valves for HVAC Piping."

H. Comply with requirements in Section 221119 "Domestic Water Piping Specialties" for backflow preventers required in makeup water connections to potable-water systems.

I. Confirm applicable electrical requirements in electrical Sections for connecting electrical equipment.

J. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

K. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
3. Place humidifier steam system water-treatment system into operation and calibrate controls during the preliminary phase of HVAC systems' startup procedures.
4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
7. Cap and subject piping to static water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
8. Repair leaks and defects with new materials and retest piping until no leaks exist.

B. Equipment will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.4 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.

END OF SECTION 232523

SECTION 232533 - HVAC MAKEUP-WATER FILTRATION EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following HVAC water filtration equipment:

1. Multimedia filters.
2. Self-cleaning strainers.
3. Cartridge-type filters.

1.2 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 MULTIMEDIA FILTERS

A. Description: Factory-fabricated and -tested, simplex, multimedia filter system of filter tank, media, strainer, circulating pump, piping, and controls for removing particles from water.

1. Filter Tank: Corrosion resistant with distribution system and media.

a. Fabricate and label FRP filter tanks to comply with ASME Boiler and Pressure Vessel Code: Section X, if indicated.
b. Pipe Connections NPS 2 (DN 50) and Smaller: Threaded according to ASME B1.20.1.
c. FRP Tank Pipe Connections NPS 2-1/2 (DN 65) and Larger: Type A, integral; Designation E, 125-psig (0.862-MPa) or Designation F, 150-psig (1.034-MPa) pressure category flanges of grade same as tank material according to ASTM D5421.

2. Motorized Valves: Flanged or grooved-end, ductile-iron butterfly type with EPDM valve seat and stem seal; with ASTM B148 aluminum bronze disc.
3. Strainer: Basket type mounted on pump suction.
4. Piping: ASTM A53/A53M, Type S, F, or E; Grade B, Schedule 40 black steel, with flanged, grooved, or threaded joints and malleable, steel welding, or ductile-iron fittings.
5. Piping: ASTM B88, Type L (ASTM B88M, Type B) copper water tube, copper-alloy solder-joint fittings, and brazed, flanged, or grooved joints.
6. Safety Valves: Automatic pressure relief.
7. Circulating Pump: Overhung impeller, close coupled, single stage, end suction, centrifugal. Comply with UL 778 and with HI 1.1-1.2 and HI 1.3.

    a. Casing: Radially split, cast iron.
    b. Pressure Rating: 125 psig (860 kPa) or 150 psig (1035 kPa) minimum as directed.
    c. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, closed, and keyed to shaft.
    d. Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve.
    e. Seal: Mechanical.
    f. Motor: ODP motor supported on the pump-bearing frame. General requirements for motors are specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

8. Controls: Automatic control of circulating pump and tank backwash; factory wired for single electrical connection.

    a. Panel: NEMA 250, Type 4 enclosure with time clock and pressure gages.
    b. Pump: Automatic and manual switching; manual switch position bypasses safeties and controls.
    c. Backwash: Automatic; with time clock and differential pressure switch.
    d. Backwash Valve: Tank mounted with valves interlocked to single actuator.

9. Support: Skid mounting. Fabricate supports and base and attachment to tank with reinforcement strong enough to resist filter movement during a seismic event when filter base is anchored to building structure.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Capacities and Characteristics:

1. Filter Design:

    a. Water Flow: As directed.
    b. Clean Pressure Loss: 5 psig (34.5 kPa) as directed.
    c. Maximum Media Flow Rate: 15 gpm/sq. ft. (10.2 L/s per sq. m) as directed.
    d. Filtration Efficiency: 98 percent.
    e. Particle-Specific Gravity: 1.8.
    f. Particle Size: As directed.

2. Filter Tank: With internal distribution piping.

    a. Pressure Rating: As directed.

b. Diameter: As directed.
c. Inlet and Outlet Size: As directed.
d. Blowdown Piping Outlet Size: As directed.

3. Filter Media: As directed.
4. Start Backwash Pressure Loss: 13 psig (90 kPa).
5. Backwash Period: 10 minutes.
6. Circulating Pump:

a. Capacity: As directed.
b. Total Dynamic Head: As directed.
c. Motor Speed: As directed.
d. Inlet Size: As directed.
e. Outlet Size: As directed.

7. Pump Motor Size and Electrical Characteristics:

a. Horsepower: As directed.
b. Volts: As directed..
c. Phase: Single or Three as directed.
d. Hertz: 60 Hz.

8. Unit Electrical Characteristics:

a. Full-Load Amperes: As directed.
b. Minimum Circuit Ampacity: As directed.
c. Maximum Overcurrent Protection: As directed.
d. Interrupting Capacity: As directed.

2.2 SELF-CLEANING STRAINERS

A. Description: Factory-fabricated and -tested, ASTM A126, Class B, cast-iron or steel, self-cleaning strainer system of tank, strainer, backwash arm or cleaning spiral, drive and motor, piping, and controls for removing particles from water.

1. Fabricate and label ASTM A126, Class B, cast-iron or steel strainer tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Pipe Connections:

a. NPS 2 (DN 50) and Smaller: Threaded according to ASME B1.20.1.
b. NPS 2-1/2 (DN 65) and Larger: Steel, Class 150 flanges according to ASME B16.5 or grooved according to AWWA C606.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Motorized Valves: Flanged or grooved-end, ductile-iron angle type with EPDM valve seat and stem seal; with ASTM B148 aluminum bronze disc.

D. Strainer: Stainless steel.

E. Piping: ASTM A53/A53M, Type S, F, or E; Grade B, Schedule 40 black steel, with flanged, grooved, or threaded joints and malleable, steel welding, or ductile-iron fittings.

F. Safety Valves: Automatic pressure relief.

G. Hydraulic drive on some units makes motorized drive unnecessary.

H. Backwash Arm Drive:

1. Drive Casing: Cast iron.
2. Worm Gears: Immersed in oil.
3. Motor: ODP motor supported on the strainer-bearing frame. General requirements for motors are specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

I. Controls: Automatic control of backwash; factory wired for single electrical connection.

1. Panel: NEMA 250, Type 4 enclosure with time clock and pressure gages.
2. Backwash Arm Drive: Automatic and manual switching; manual switch position bypasses safeties and controls.
3. Backwash: Automatic; with time clock and differential pressure switch.
4. Backwash Valve: Electric actuator.

J. Support: Skid mounting. Fabricate supports and base and attachment to tank with reinforcement strong enough to resist strainer movement during a seismic event when strainer base is anchored to building structure.

K. Capacities and Characteristics:

1. Strainer Design:

a. Water Flow: As directed.
b. Clean Pressure Loss: 5 psig (34.5 kPa).
c. Strainer Mesh: As directed.

2. Strainer Tank: With internal distribution piping.

a. Material: Cast iron or Steel As directed.
b. Pressure Rating: 150 psig (1034 kPa).
c. Inlet and Outlet Size: As directed.
d. Backwash Piping Outlet Size: As directed.

3. Start Backwash: 10 psig (69 kPa)
4. Backwash Period: 5 minutes.
5. Drive Motor Size and Electrical Characteristics:

a. Horsepower: As directed.
b. Volts: As directed.
c. Phase: Single or Three As directed.
d. Hertz: 60 Hz.

6. Unit Electrical Characteristics:

    a. Full-Load Amperes: As directed.
    b. Minimum Circuit Ampacity: As directed.
    c. Maximum Overcurrent Protection: As directed.
    d. Interrupting Capacity: As directed.

2.3 CARTRIDGE-TYPE FILTERS

A. Description: Floor-mounting housing with filter cartridges for removing particles from water.

1. Housing: Corrosion resistant; designed to separate inlet from outlet and to direct inlet through cartridge-type water filter; with base, feet, or skirt.

    a. Pipe Connections NPS 2 (DN 50) and Smaller: Threaded according to ASME B1.20.1.
    b. Steel Housing Pipe Connections NPS 2-1/2 (DN 65) and Larger: Steel, Class 150 flanges according to ASME B16.5 or grooved according to AWWA C606.
    c. Plastic Housing Pipe Connections NPS 2-1/2 (DN 65) and Larger: 150-psig (1035-kPa) plastic flanges.

2. Cartridge: Replaceable; of shape to fit housing.

B. Capacities and Characteristics:

1. Filter Design:

    a. Water Flow Rate: As directed.
    b. Filtration Efficiency: 98 percent.
    c. Particle Size: 10 or 20 microns and larger as directed.
    d. Clean Pressure Loss: 2 psig (14 kPa).
    e. Pressure Loss at Replacement: 6 psig (41 kPa).

2. Housing:

    a. Material: Carbon steel or Plastic as directed.
    b. Pressure Rating: As directed.
    c. Seal Material: Nitrile rubber.
    d. Diameter: As directed.
    e. Height or Length: As directed.
    f. Inlet and Outlet Size: As directed.
    g. Drain Size: Not applicable.

3. Cartridge:

    a. Number Required: As directed.
    b. Nominal Diameter: As directed.
    c. Nominal Length: As directed.
    d. Media Material: As directed.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION

A. Equipment Mounting:

1. Install water filtration equipment on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.
2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

B. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

C. Where installing piping adjacent to equipment, allow space for service and maintenance.

D. Make piping connections between HVAC water filtration equipment and dissimilar-metal piping with dielectric fittings. Comply with requirements in Section 232113 "Hydronic Piping." dielectric fittings.

E. Install shutoff valves on HVAC water filtration equipment inlet and outlet. Metal general-duty valves are specified in Section 230523.11 "Globe Valves for HVAC Piping," Section 230523.12 "Ball Valves for HVAC Piping," Section 230523.13 "Butterfly Valves for HVAC Piping," and Section 230523.15 "Gate Valves for HVAC Piping."

F. Comply with requirements in Section 221119 "Domestic Water Piping Specialties" for backflow preventers required in makeup-water connections to potable-water systems.

G. Confirm applicable electrical requirements in electrical Sections for connecting electrical equipment.

H. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing.

3. Place HVAC water-softener or water filtration system into operation and calibrate controls during the preliminary phase of HVAC systems' startup procedures as directed.
4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
7. Cap and subject piping to static water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
8. Repair leaks and defects with new materials and retest piping until no leaks exist.

B. Equipment will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.4 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.

END OF SECTION 232533

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Single-wall round ducts and fittings.
3. Sheet metal materials.
4. Duct liner.
5. Sealants and gaskets.
6. Hangers and supports.
7. Seismic-restraint devices.

B. Related Sections:

1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Section 233116 "Nonmetal Ducts" for fibrous-glass ducts, thermoset fiber-reinforced plastic ducts, thermoplastic ducts, PVC ducts, and concrete ducts.
3. Section 233119 "HVAC Casings" for factory- and field-fabricated casings for mechanical equipment.
4. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.
3. Seismic-restraint devices.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.

3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top and bottom of ducts.
5. Dimensions of main or all duct runs from building grid lines as directed.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

D. Delegated-Design Submittal:

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.
5. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports and seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: A single set of plans or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

B. Welding certificates.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel in accordance with the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.
3. AWS D9.1/D9.1M, "Sheet Metal Welding Code," for duct joint and seam welding.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC

Duct Construction Standards - Metal and Flexible" and with performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and ASCE/SEI 7.

1. Seismic Hazard Level (SHL): As directed.
2. Connection Level: 1 or 2.

C. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.

D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Startup."

E. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

F. Duct Dimensions: Unless otherwise indicated, all duct dimensions indicated on Drawings are inside clear dimensions and do not include insulation or duct wall thickness.

2.2 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

1. Construct ducts of galvanized sheet steel unless otherwise indicated.
2. For ducts exposed to weather, construct of Type 304 or Type 316 stainless steel indicated by manufacturer to be suitable for outdoor installation as directed.

B. Transverse Joints: Fabricate joints in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. For ducts with longest side less than 36 inches (914 mm), select joint types in accordance with Figure 2-1.
2. For ducts with longest side 36 inches (914 mm) or greater, use flange joint connector Type T-22, T-24, T-24A, T-25a, or T-25b. Factory-fabricated flanged duct connection system may be used if submitted and approved by engineer of record.
3. Where specified for specific applications, all joints shall be welded.

C. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." All longitudinal seams shall be Pittsburgh lock seams unless otherwise specified for specific application.

1. Where specified for specific applications, all joints shall be welded.

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SINGLE-WALL ROUND AND FLAT OVAL DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

1. Construct ducts of galvanized sheet steel unless otherwise indicated.
2. For ducts exposed to weather, construct of Type 304 or Type 316 stainless steel indicated by manufacturer to be suitable for outdoor installation as directed.

B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).

C. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse Joints in Ducts Larger Than 60 (1524) Inches (mm) in Diameter: Flanged.

D. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger than 90 inches (2286 mm) in diameter with butt-welded longitudinal seams.
2. Fabricate flat-oval ducts larger than 72 inches (1830 mm) in width (major dimension) with butt-welded longitudinal seams.

E. Tees and Laterals: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.4 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A653/A653M.

1. Galvanized Coating Designation: G60 (Z180) or G90 (Z275) as directed.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Carbon-Steel Sheets: Comply with ASTM A1008/A1008M, with oiled, matte finish for exposed ducts.

D. Stainless-Steel Sheets: Comply with ASTM A480/A480M, Type 304 or 316, as indicated in "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in "Duct Schedule" Article.

E. Aluminum Sheets: Comply with ASTM B209 (ASTM B209M) Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

F. Factory- or Shop-Applied Antimicrobial Coating:

1. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating shall be applied to the exterior surface.
2. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
3. Coating containing the antimicrobial compound shall have a hardness of 2H, minimum, when tested in accordance with ASTM D3363.
4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
5. Shop-Applied Coating Color: Black or White as directed.
6. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.

G. Reinforcement Shapes and Plates: ASTM A36/A36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

H. Tie Rods: Galvanized steel, 1/4-inch- (6-mm-) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch- (10-mm-) minimum diameter for lengths longer than 36 inches (900 mm).

2.5 DUCT LINER

A. Fibrous-Glass Duct Liner: Comply with ASTM C1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
   1. Maximum Thermal Conductivity:
      a. Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K) at 75 deg F (24 deg C) mean temperature.
      b. Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F (0.033 W/m x K) at 75 deg F (24 deg C) mean temperature.
   2. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
   3. Solvent or Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C916.

B. Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C534/C534M, Type II, Grade 1; and with NFPA 90A or NFPA 90B.
   1. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
   2. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

C. Fiberglass-Free Duct Liner: Made from partially recycled cotton or polyester products and containing no fiberglass. Airstream surface overlaid with fire-resistant facing to prevent surface erosion by airstream, complying with NFPA 90A or NFPA 90B. Treat natural-fiber products with antimicrobial coating.
   1. Maximum Thermal Conductivity: 0.24 Btu x in./h x sq. ft. x deg F (0.034 W/m x K) at 75 deg F (24 deg C) mean temperature when tested in accordance with ASTM C518.
   2. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with ASTM E84; certified by an NRTL.
   3. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

D. Insulation Pins and Washers:
   1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) or 0.135-inch- (3.5-mm-) diameter shank as directed, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.
   2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick as directed; with beveled edge sized as required to hold insulation securely in place, but not less than 1-1/2 inches (38 mm) in diameter.

E. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."

1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
3. Butt transverse joints without gaps, and coat joint with adhesive.
4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm (12.7 m/s)or greater.
7. Secure liner with mechanical fasteners 4 inches (100 mm) from corners and at intervals not exceeding 12 inches (300 mm) transversely; at 3 inches (75 mm) from transverse joints and at intervals not exceeding 18 inches (450 mm) longitudinally.
8. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:

    a. Fan discharges.
    b. Intervals of lined duct preceding unlined duct.
    c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm (12.7 m/s) or where indicated.

9. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.

    a. Sheet Metal Inner Duct Perforations: 3/32-inch (2.4-mm) diameter, with an overall open area of 23 percent.

10. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.6 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
2. Tape Width: As directed.
3. Sealant: Modified styrene acrylic.
4. Water resistant.

5. Mold and mildew resistant.
6. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
10. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive or negative.
11. Service: Indoor or outdoor.
12. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Flanged Joint Sealant: Comply with ASTM C920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

F. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg (0.14 L/s per sq. m at 250 Pa) and shall be rated for10-inch wg (2500-Pa) static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.7 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Galvanized-steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A492.

F. Steel Cable End Connections: Galvanized-steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

2.8 SEISMIC-RESTRAINT DEVICES

A. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports as directed.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

B. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

C. Restraint Cables: ASTM A603, galvanized or ASTM A492, stainless-steel cables with end connections made of galvanized-steel assemblies with brackets as directed, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.

D. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or Reinforcing steel angle clamped to hanger rod as directed.

E. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested in accordance with ASTM E488/E488M.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and coordination drawings.

B. Install ducts in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install ducts in maximum practical lengths with fewest possible joints.

D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

G. Install ducts with a clearance of 1 inch (25 mm), plus allowance for insulation thickness.

H. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

I. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches (38 mm).

J. Install fire, combination fire/smoke, and smoke dampers where indicated on Drawings and as required by code, and by local authorities having jurisdiction. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers and specific installation requirements of the damper UL listing.

K. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in air ducts where indicated on Drawings.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

M. Elbows: Use long-radius elbows wherever they fit.

1. Fabricate 90-degree rectangular mitered elbows to include turning vanes.

2. Fabricate 90-degree round elbows with a minimum of three segments for 12 inches (300 mm) and smaller and a minimum of five segments for 14 inches (350 mm) and larger.

N. Branch Connections: Use lateral or conical branch connections.

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 ADDITIONAL INSTALLATION REQUIREMENTS FOR TYPE 1 COMMERCIAL KITCHEN GREASE HOOD EXHAUST DUCT

A. Install ducts in accordance with NFPA 96, "Ventilation Control and Fire Protection of Commercial Cooking Operation"; SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; and SMACNA's "Kitchen Ventilation Systems and Food Service Equipment Fabrication and Installation Guidelines" unless otherwise indicated.

B. Install all ducts without dips and traps that may hold grease and sloped a minimum of 2 percent to drain grease back to the hood.

C. All ducts exposed to view shall be constructed of stainless steel as per "Duct Schedule" Article. All ducts concealed from view shall be stainless or carbon steel as per "Duct Schedule" Article as directed.

D. All joints shall be welded and shall be telescoping, bell, or flange joint as per NFPA 96.

E. Install fire-rated access panel assemblies at each change in direction and at maximum intervals of 20 (6) or 12 (3.7) feet (m) in horizontal ducts as directed, and at every floor for vertical ducts, or as indicated on Drawings.

F. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and authorities having jurisdiction.

3.4 ADDITIONAL INSTALLATION REQUIREMENTS FOR EXHAUST DUCTS SERVING COMMERCIAL DISHWASHERS AND OTHER HIGH-HUMIDITY LOCATIONS

A. Install dishwasher exhaust ducts and other exhaust ducts from wet, high-humidity locations without dips and traps that may hold water. Slope ducts a minimum of 2 percent back to dishwasher or toward drain.

B. Provide a drain pocket at each low point and at the base of each riser with a 1-inch (25-mm) trapped copper drain from each drain pocket to open site floor drain.

C. Minimize number of transverse seams.

D. Do not locate longitudinal seams on bottom of duct.

3.5 ADDITIONAL INSTALLATION REQUIREMENTS FOR LABORATORY EXHAUST AND FUME HOOD EXHAUST DUCTS

A. Install ducts in accordance with NFPA 45, "Fire Protection for Laboratories Using Chemicals."

B. Install exhaust ducts without dips and traps that may hold water. Slope ducts a minimum of 2 percent back to hood or inlet. Where indicated on Drawings, install trapped drain piping.

C. Connect duct to fan, fume hood, and other equipment indicated on Drawings.

3.6 DUCTWORK EXPOSED TO WEATHER

A. All external joints are to be welded or have secure watertight mechanical connections as directed. Seal all openings to provide weatherproof construction.

B. Construct ductwork to resist external loads of wind, snow, ice, and other effects of weather. Provide necessary supporting structures.

C. Single Wall:

1. Ductwork shall be Type 304 or Type 316 stainless steel as directed.
2. Ductwork shall be galvanized steel.

    a. If duct outer surface is uninsulated, protect outer surface with suitable paint. Paint materials and application requirements are specified in Section 099113 "Exterior Painting."

3. Where ducts have external insulation, provide weatherproof aluminum jacket. See Section 230713 "Duct Insulation."

3.7 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Seal ducts at a minimum to the following seal classes in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. Outdoor, Supply-Air Ducts: Seal Class A.
3. Outdoor, Exhaust Ducts: Seal Class C.
4. Outdoor, Return-Air Ducts: Seal Class C.
5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class B.
6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): Seal Class A.
7. Unconditioned Space, Exhaust Ducts: Seal Class C.
8. Unconditioned Space, Return-Air Ducts: Seal Class B.
9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class C.
10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): Seal Class B.
11. Conditioned Space, Exhaust Ducts: Seal Class B.
12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.8 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (100 mm) thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches (610 mm) of each elbow and within 48 inches (1220 mm) of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet (5 m).

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.9 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply as directed

1. Space lateral supports a maximum of 40 (12) feet (m) o.c., and longitudinal supports a maximum of 80 (24) feet (m) o.c.
2. Brace a change of direction longer than 12 feet (3.7 m).

B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install cable restraints on ducts that are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved as directed.

F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

G. Drilling for and Setting Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.10 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.11 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

3.12 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
2. Test the following systems:

    a. Ducts with a Pressure Class Higher Than 3-Inch wg (750 Pa): Test representative duct sections, selected by Architect from sections installed, totaling no less than 25 percent of total installed duct area for each designated pressure class.
    b. Supply Ducts with a Pressure Class as directed: Test representative duct sections, totaling no less than 50 or 100 percent of total installed duct area for each designated pressure class as directed.
    c. Return Ducts with a Pressure Class as directed: Test representative duct sections, totaling no less than 50 or 100 percent of total installed duct area for each designated pressure class as directed.
    d. Exhaust Ducts with a Pressure Class as directed: Test representative duct sections totaling no less than 50 or 100 percent of total installed duct area for each designated pressure class.
    e. Outdoor-Air Ducts with a Pressure Class as directed: Test representative duct sections totaling no less than 50 or 100 percent of total installed duct area for each designated pressure class as directed.

3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Testing of each duct section is to be performed with access doors, coils, filters, dampers, and other duct-mounted devices in place as designed. No devices are to be removed or blanked off so as to reduce or prevent additional leakage.
5. Test for leaks before applying external insulation.
6. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
7. Give seven days' advance notice for testing.

C. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.
2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness in accordance with "Description of Method 3 - NADCA Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."

    a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.13 DUCT CLEANING

A. Clean new duct system(s) before testing, adjusting, and balancing.

B. For cleaning of existing ductwork, see Section 230130.52 "Existing HVAC Air Distribution System Cleaning."

C. Use duct cleaning methodology as indicated in NADCA ACR.

D. Use service openings for entry and inspection.

1. Provide openings with access panels appropriate for duct static-pressure and leakage class at dampers, coils, and any other locations where required for inspection and cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

E. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

F. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.

5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

G. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans in accordance with NADCA ACR. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents in accordance with manufacturer's written instructions after removal of surface deposits and debris.

3.14 STARTUP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.15 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

1. Fabricate all ducts to achieve SMACNA pressure class, seal class, and leakage class as indicated below.
2. Underground Ducts: Concrete-encased, galvanized sheet or stainless steel as directed.

B. Supply Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

    a. Pressure Class: Positive 1- (250) or 2- (500) inch wg (Pa).
    b. Minimum SMACNA Seal Class: As directed.
    c. SMACNA Leakage Class for Rectangular: As directed.
    d. SMACNA Leakage Class for Round and Flat Oval: As directed.

2. Ducts Connected to Constant-Volume Air-Handling Units:

a. Pressure Class: Positive 2- (500) or 3- (750) inch wg (Pa) as directed.
b. Minimum SMACNA Seal Class: A or B as directed.
c. SMACNA Leakage Class for Rectangular: As directed.
d. SMACNA Leakage Class for Round and Flat Oval: As directed.

3. Ducts Connected to Variable-Air-Volume Air-Handling Units:

a. Pressure Class: Positive 3- (750) or 4- (1000) inch wg (Pa) as directed.
b. Minimum SMACNA Seal Class: A or B as directed.
c. SMACNA Leakage Class for Rectangular: As directed.
d. SMACNA Leakage Class for Round and Flat Oval: As directed.

4. Ducts Connected to Equipment Not Listed Above:

a. Pressure Class: Positive As directed.
b. Minimum SMACNA Seal Class: As directed.
c. SMACNA Leakage Class for Rectangular: As directed.
d. SMACNA Leakage Class for Round and Flat Oval: As directed.

C. Return Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

a. Pressure Class: Positive or negative 1- (250) or 2- (500) inch wg (Pa) as directed.
b. Minimum SMACNA Seal Class: As directed.
c. SMACNA Leakage Class for Rectangular: As directed.
d. SMACNA Leakage Class for Round and Flat Oval: As directed.

2. Ducts Connected to Air-Handling Units:

a. Pressure Class: Positive or negative 2- (500) or 3- (750) inch wg (Pa) as directed.
b. Minimum SMACNA Seal Class: As directed.
c. SMACNA Leakage Class for Rectangular: As directed.
d. SMACNA Leakage Class for Round and Flat Oval: As directed.

3. Ducts Connected to Equipment Not Listed above:

a. Pressure Class: Positive or negative As directed.
b. Minimum SMACNA Seal Class: As directed.
c. SMACNA Leakage Class for Rectangular: As directed.
d. SMACNA Leakage Class for Round and Flat Oval: As directed.

D. Exhaust Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:

a. Pressure Class: Negative As directed.
b. Minimum SMACNA Seal Class: As directed.
c. SMACNA Leakage Class for Rectangular: As directed.
d. SMACNA Leakage Class for Round and Flat Oval: As directed.

2. Ducts Connected to Air-Handling Units As directed:

    a. Pressure Class: Positive or negative 2- (500) or 3- (750) inch wg (Pa) as directed.
    b. Minimum SMACNA Seal Class: As directed.
    c. SMACNA Leakage Class for Rectangular: As directed.
    d. SMACNA Leakage Class for Round and Flat Oval: As directed.

3. Ducts Connected to Commercial Kitchen Hoods: Comply with NFPA 96.

    a. Exposed to View: Type 304, stainless-steel sheet, No. 4 or No. 3 finish as directed.
    b. Concealed: Type 304, stainless-steel sheet, No. 2D finish or Carbon-steel sheet].
    c. Welded seams and joints.
    d. Pressure Class: Positive or negative as directed.
    e. Airtight/watertight.

4. Ducts Connected to Dishwashers, Dishwasher Hoods, and Other High-Humidity Locations:

    a. Type 304, stainless-steel sheet.
    b. Exposed to View: No. 4 or No. 3 finish as directed.
    c. Concealed: No. 2D finish.
    d. Welded longitudinal seams; welded or flanged transverse joints with watertight EPDM gaskets.
    e. Pressure Class: Positive or negative 2- (500) or 3- (750) inch wg (Pa) as directed.
    f. Airtight/watertight.

5. Ducts Connected to Fans Exhausting Fume Hood, Laboratory, and Process (ASHRAE 62.1, Class 3 and Class 4) Air:

    a. Type 316 or Type 304, stainless-steel sheet as directed.

        1) Exposed to View: No. 4 or No. 3 finish as directed.
        2) Concealed: No. 2B or No. 2D finish as directed.

    b. PVC-coated, galvanized sheet steel with thicker coating on duct interior.
    c. Pressure Class: Positive or negative as directed.
    d. Minimum SMACNA Seal Class A or Welded seams and joints.
    e. SMACNA Leakage Class 2.
    f. Airtight/watertight.

6. Ducts Connected to Equipment Not Listed above:

    a. Pressure Class: Positive or negative as directed.
    b. Minimum SMACNA Seal Class: A or B if negative pressure; A if positive pressure as directed.
    c. SMACNA Leakage Class for Rectangular: As directed.
    d. SMACNA Leakage Class for Round and Flat Oval: As directed.

E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

a. Pressure Class: Positive or negative 1- (250) or 2- (500) inch wg (Pa) as directed.
b. Minimum SMACNA Seal Class: As directed.
c. SMACNA Leakage Class for Rectangular: 8 or 16 as directed.
d. SMACNA Leakage Class for Round and Flat Oval: 8 or 16 as directed.

2. Ducts Connected to Air-Handling Units:

a. Pressure Class: Positive or negative 2- (500) or 3- (750) inch wg (Pa) as directed.
b. Minimum SMACNA Seal Class: A or B as directed.
c. SMACNA Leakage Class for Rectangular: As directed.
d. SMACNA Leakage Class for Round and Flat Oval: As directed.

3. Ducts Connected to Equipment Not Listed Above:

a. Pressure Class: Positive or negative 2- (500) or 3- (750) or 4- (1000) inch wg (Pa) as directed.
b. Minimum SMACNA Seal Class: A or B as directed.
c. SMACNA Leakage Class for Rectangular: As directed.
d. SMACNA Leakage Class for Round and Flat Oval: As directed.

F. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: As directed.
2. Stainless-Steel Ducts:

a. Exposed to Airstream: Match duct material.
b. Not Exposed to Airstream: Galvanized or Match duct material as directed.

3. Aluminum Ducts: Aluminum orgalvanized steel coated with zinc chromate.

G. Liner:

1. Supply-Air Ducts: As directed.
2. Return-Air Ducts: As directed.
3. Exhaust-Air Ducts: As directed.
4. Supply Fan Plenums: As directed.
5. Return- and Exhaust-Fan Plenums: As directed.
6. Transfer Ducts: As directed.

H. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Velocity 1000 fpm (5 m/s) or Lower:

1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
2) Mitered Type RE 4 without vanes.

b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s):

1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

c. Velocity 1500 fpm (7.6 m/s) or Higher:

1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."

a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.

1) Velocity 1000 fpm (5 m/s) or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
2) Velocity 1000 to 1500 fpm (5 to 7.6 m/s): 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
3) Velocity 1500 fpm (7.6 m/s) or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
4) Radius-to Diameter Ratio: 1.5.

b. Round Elbows, 12 (305) Inches (mm) and Smaller in Diameter: Stamped or pleated.
c. Round Elbows, 14 (356) Inches (mm) and Larger in Diameter: Standing seam Welded as directed.

I. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."

a. Rectangular Main to Rectangular Branch: 45-degree entry.
b. Rectangular Main to Round Branch: Conical spin in.

2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.

a. Velocity 1000 fpm (5 m/s) or Lower: 90-degree tap.
b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s): Conical tap.
c. Velocity 1500 fpm (7.6 m/s) or Higher: 45-degree lateral.

END OF SECTION 233113

SECTION 233116 - NONMETAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fibrous-glass ducts and fittings.
2. Phenolic-foam ducts and fittings.

B. Related Requirements:

1. Section 230130.52 "Existing HVAC Air-Distribution System Cleaning" for cleaning of existing HVAC air-distribution equipment, ducts, plenums, and system components.
2. Section 230548 "Vibration and Seismic Controls for HVAC" for vibration-isolated and restrained ductwork hangers and supports.
3. Section 230548.13 "Vibration Controls for HVAC" for vibration-isolated ductwork and hangers.
4. Section 233113 "Metal Ducts" for single- and double-wall, rectangular and round ducts.
5. Section 233119 "HVAC Casings" for factory- and field-fabricated casings for mechanical equipment.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of the following products:

1. Fibrous-glass duct materials.
2. Phenolic-foam duct materials.

B. Sustainable Design Submittals:

C. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.

D. Delegated-Design Submittal: For nonmetal ducts, signed and sealed by a qualified professional engineer.

1. Duct materials and thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports and seismic restraints.
5. Design calculations for selecting hangers and supports and seismic restraints or Include analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale and coordinated with each other, using input from installers of the items involved.

B. Seismic Qualification Data: Certificates, for nonmetal ducts, accessories, and components, from manufacturer.

C. Welding certificates.

D. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Hanger and Support Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for steel hangers and supports.
2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum hangers and supports.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

D. Mockups:

1. Before installing duct systems, build mockups representing static-pressure classes 3-inch wg (750 Pa) and higher. Build mockups to comply with the following requirements, using materials indicated for the completed Work:

    a. Five transverse joints.
    b. One access door(s).
    c. Two typical branch connections, each with at least one elbow.
    d. Two typical flexible duct or flexible-connector connections for each duct and apparatus.
    e. One 90-degree turn(s) with turning vanes.
    f. One fire damper(s).
    g. One smoke damper(s).
    h. Perform leakage tests specified in "Field Quality Control" Article. Revise mockup construction and perform additional tests as required to achieve specified minimum acceptable results.

2. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including duct closure, reinforcements, and hangers and supports, shall comply with the following and with the Works' performance requirements and design criteria:

1. SMACNA's "Fibrous Glass Duct Construction Standards."
2. SMACNA's "Phenolic Duct Construction Standards."
3. Static-Pressure Classes:

    a. Supply Ducts (except in Mechanical Rooms): 2-inch wg (500 Pa).
    b. Supply Ducts (Upstream from Air Terminal Units): 2-inch wg (500 Pa).
    c. Supply Ducts (Downstream from Air Terminal Units): 1-inch wg (250 Pa).
    d. Supply Ducts (in Mechanical Equipment Rooms): 2-inch wg (500 Pa).
    e. Return Ducts (Negative Pressure): 1-inch wg (250 Pa).
    f. Exhaust Ducts (Negative Pressure): 1-inch wg (250 Pa).

B. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions to comply with ASCE/SEI 7. SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."

1. Seismic Hazard Level: As directed.

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1, Section 5.4 - "Airstream Surfaces."

D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

E. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

F. NFPA Compliance:

1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

2.2 FIBROUS-GLASS DUCTS AND FITTINGS

A. Fibrous-Glass Duct Materials: Resin-bonded fiberglass, faced on the outside surface with fire-resistive FSK vapor retarder and with a smooth fiberglass mat finish on the air-side surface.

1. Duct Board: Factory molded into rectangular boards.
2. Temperature Limits: 40 to 250 deg F (5 to 121 deg C) inside ducts; 150 deg F (66 deg C) ambient temperature surrounding ducts.
3. Maximum Thermal Conductivity: 0.24 Btu x in./h x sq. ft. x deg F (0.035 W/m x K) at 75 deg F (24 deg C) mean temperature.

4. Moisture Absorption: Not exceeding 5 percent by weight at 120 deg F (49 deg C) and 95 percent relative humidity for 96 hours when tested according to ASTM C1104/C1104M.
5. Acoustical Performance: Conform to sound absorption coefficients listed in NAIMA AH116.
6. Permeability: 0.02 perms (1.15 ng/Pa x s x sq. m) maximum when tested according to ASTM E96/E96M, Procedure A.
7. Antimicrobial Agent: Compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
8. Noise-Reduction Coefficient: 0.65 minimum when tested according to ASTM C423, Mounting A.
9. Fire/Smoke Resistance: Duct material shall comply with UL 181, Class 1, maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested by an NRTL according to ASTM E84.
10. Required Markings: EI stiffness rating, UL label, and other markings required by UL 181 on each full sheet of duct board.

B. Closure Materials:

1. Pressure-Sensitive Tape: Comply with UL 181A; imprinted by manufacturer with coding "181A-P," manufacturer's name, and a date code.

    a. Tape: Aluminum foil-scrim tape imprinted with listing information.
    b. Minimum Tape Width: 2-1/2 inches (64 mm); 3 inches (76 mm) for duct board thicker than 1 inch (25 mm).
    c. Staples: 1/2-inch (13-mm) outward clinching, 2 inches (51 mm) o.c. in tabs, one tab per joint.
    d. Water resistant.
    e. Mold and mildew resistant.

2. Heat-Activated Tape: Comply with UL 181A; imprinted by manufacturer with coding "181A-H," manufacturer's name, and a date code.

    a. Tape: Aluminum foil-scrim tape imprinted with listing information.
    b. Minimum Tape Width: 3 inches (76 mm).
    c. Heat-Sensitive Imprint: Printed indicator on tape to show proper heating during application has been achieved.
    d. Water resistant.
    e. Mold and mildew resistant.

3. Two-Part Tape Sealing System: Comply with UL 181A; imprinted by manufacturer with coding "181A-M," manufacturer's name, and a date code.

    a. Tape: Woven glass fiber impregnated with mineral gypsum.
    b. Minimum Tape Width: 3 inches (76 mm).
    c. Sealant: Modified styrene acrylic.
    d. Water resistant.
    e. Mold and mildew resistant.

C. Fabrication:

1. Comply with: SMACNA's "Fibrous Glass Duct Construction Standards," Ch. 3, "Specifications and Closure," and Ch. 4, "Fittings and Connections" or NAIMA AH116, "Fibrous Glass Duct Construction Standards," Section II, "Fabrication of Straight Duct Modules," Section III, "Fabrication of Fittings from Modules or Flat Board," and Section IV, "Closure" as directed for the following:

    a. Joints, seams, transitions, elbows, and branch connections.
    b. Reinforcements, including channel and tie rod reinforcement materials, spacing, and fabrications.

2. Fabricate 90-degree mitered elbows to include turning vanes.

D. Reinforcements: Comply with requirements in SMACNA's "Fibrous Glass Duct Construction Standards," Ch. 5, "Reinforcement" or NAIMA AH116, "Fibrous Glass Duct Construction Standards," Section V, "Reinforcement" as directed for channel- and tie-rod reinforcement materials, spacing, and fabrication.

2.3 PHENOLIC-FOAM DUCTS AND FITTINGS

A. Duct Panel: CFC-free phenolic-foam bonded on both sides with factory-applied, 0.001-inch-(0.025-mm-) thick, aluminum foil reinforced with fiberglass scrim.

1. Temperature Limits:

    a. Maximum 176 deg F (80 deg C).
    b. Minimum: Minus 4 deg F (Minus 20 deg C).

2. Maximum Thermal Conductivity: 0.15 Btu x in./h x sq. ft. x deg F (0.021 W/m x K) at 75 deg F (24 deg C) mean temperature.
3. Permeability: 0.0002 perms (0.0115 ng/Pa x s x sq. m) maximum when tested according to ASTM E96/E96M, Procedure A.
4. Antimicrobial Agent: Compound shall be tested for efficacy by an NRTL, and registered by the EPA for use in HVAC systems.
5. Noise-Reduction Coefficient: 0.65 minimum when tested according to ASTM C423, Mounting A.
6. Fire/Smoke Resistance: Duct material shall comply with UL 181, Class 1, maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested by an NRTL according to ASTM E84.
7. Required Markings: UL label and other markings required by UL 181 on each full sheet of duct panel; UL ratings for closure materials.

B. Closure Materials:

1. V-Groove Adhesive: Silicone.

2. Pressure-Sensitive Tape: Comply with UL 181A; imprinted by manufacturer with coding "181A-P," manufacturer's name, and a date code.

    a. Tape: Aluminum foil tape imprinted with listing information.
    b. Minimum Tape Width: 3 inches (76 mm).

c. Water resistant.
d. Mold and mildew resistant.

3. Polymeric Sealing System:

a. Structural Membrane: Woven glass fiber.
b. Minimum Tape Width: 3 inches (76 mm).
c. Sealant: Water based.
d. Color: White.
e. Water resistant.
f. Mold and mildew resistant.

C. Fabrication:

1. Fabricate joints, seams, transitions, reinforcement, elbows, branch connections, access doors and panels, and damage repairs according manufacturer's written instructions.
2. Fabricate 90-degree mitered elbows to include turning vanes.

2.4 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Zinc-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables: ASTM A603, galvanized or ASTM A492, stainless-steel cables with end connections made of zinc-plated or stainless-steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device as directed.

E. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

F. Trapeze and Riser Supports: Steel shapes complying with ASTM A36/A36M.

2.5 SEISMIC-RESTRAINT DEVICES

A. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports as directed.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

B. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

C. Restraint Cables: ASTM A603, galvanized or ASTM A492, stainless-steel cables with end connections made of zinc plated or stainless-steel assemblies with brackets, swivel, and bolts designed for restraining cable service; with an automatic-locking and clamping device or double-cable clips as directed.

D. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or Reinforcing steel angle clamped to hanger rod as directed.

E. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E488/E488M.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install duct sections in maximum practical lengths with fewest possible joints.

C. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

D. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

E. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

F. Install ducts with a minimum clearance of 1 inch (25 mm), plus allowance for insulation thickness.

G. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

H. Where ducts pass through non-fire-rated interior partitions and exterior walls, and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges. Overlap openings on four sides by at least 1-1/2 inches (38 mm).

I. Install fire, combination fire/smoke, and smoke dampers where indicated on Drawings and as required by code and by authorities having jurisdiction. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers and specific installation requirements of the fire damper UL listing.

J. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in air ducts where indicated on Drawings.

K. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

L. Elbows: Use long-radius elbows wherever they fit.

1. Fabricate 90-degree rectangular mitered elbows to include turning vanes, and 90-degree round elbows with a minimum of three segments for 12 inches (300 mm) and smaller and a minimum of five segments for 14 inches (350 mm) and larger.

M. Branch Connections: Use lateral or conical branch connections.

N. Install fibrous-glass ducts and fittings to comply with NAIMA AH116, "Fibrous Glass Duct Construction Standards" or SMACNA's "Fibrous Glass Duct Construction Standards" as directed

O. Install phenolic-foam ducts and fittings to comply with SMACNA's "Phenolic Duct Construction Standards."

P. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.2 HANGER AND SUPPORT INSTALLATION

A. Install hangers and supports for fibrous-glass ducts and fittings to comply with SMACNA's "Fibrous Glass Duct Construction Standards," Ch. 6, "Hangers and Supports" or NAIMA AH116, "Fibrous Glass Duct Construction Standards," Section VI, "Hangers and Supports" as directed

B. Install hangers and supports for phenolic-foam ducts and fittings to comply with SMACNA's "Phenolic Duct Construction Standards" Ch. 6, "Hangers and Supports" and with manufacturer's written instructions.

C. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (100 mm) thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

D. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.3 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems" or ASCE/SEI 7.

1. Space lateral supports a maximum of 40 feet (12 m) o.c., and longitudinal supports a maximum of 80 feet (24 m) o.c.
2. Brace a change of direction longer than 12 feet (3.7 m).

B. Select sizes of components so strength will be adequate to carry present and future static and seismic loads within restraint device capacity.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install cable restraints where ducts are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved as directed.

F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure to flanges of beams, to upper truss chords of bar joists, or to concrete members.

G. Drilling for and Setting Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and water and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.

2. Where static pressure and leakage values shown below differ from those in the SMACNA manual, the more stringent values shall apply.
3. Test the following systems:

    a. Ducts with a Pressure Class Higher Than 3-Inch wg (750 Pa): Test representative duct sections, selected by Architect from sections installed, totaling no less than 25 percent of total installed duct area for each designated pressure class.
    b. Supply Ducts with a Pressure Class as directed: Test representative duct sections, selected by Architect from sections installed, totaling no less than 50 or 100 percent of total installed duct area for each designated pressure class as directed.
    c. Return Ducts with a Pressure Class as directed: Test representative duct sections, selected by Architect from sections installed, totaling no less than 50 or 100 percent of total installed duct area for each designated pressure class.
    d. Exhaust Ducts with a Pressure Class of as directed: Test representative duct sections, selected by Architect from sections installed, totaling no less than 50 or 100 percent of total installed duct area for each designated pressure class as directed.
    e. Outdoor Air Ducts with a Pressure Class as directed: Test representative duct sections, selected by Architect from sections installed, totaling no less than 50 or 100 percent of total installed duct area for each designated pressure class as directed.

4. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
6. Give seven days' advance notice for testing.

E. Duct System Cleanliness Tests:

1. Test protocols shall be performed according to NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems," "Section 5 - Cleanliness Verification and Documentation."
2. Visually inspect duct system to ensure that no visible contaminants are present.
3. Test sections of fibrous-glass duct system chosen randomly by Owner for cleanliness according to "Method 2 Protocol."
4. Test sections of Phenolic-foam duct systems chosen randomly by Owner, for cleanliness according to "Method 3 - NADCA Vacuum Test."

    a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

F. Duct system will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

3.5 DUCT CLEANING

A. Clean duct system(s) before testing, adjusting, and balancing.

B. Use service openings for entry and inspection.

1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch duct as recommended by duct manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:

1. All duct cleaning shall be performed according to NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of ducts or duct accessories.
4. Clean fibrous-glass duct with HEPA vacuuming equipment; do not permit duct to get wet. Replace fibrous-glass duct that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.

6. Provide drainage and cleanup for washdown procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removing surface deposits and debris.

3.6 DUCT SCHEDULE

A. Indoor Ducts and Fittings:

1. Fibrous-Glass Rectangular Ducts and Fittings:

    a. Minimum Flexural Rigidity: As directed.
    b. Minimum Board Thickness: As directed.

2. Phenolic-Foam Rectangular Ducts and Fittings:

    a. Minimum Panel Thickness: As directed.
    b. Aluminum Cladding: Minimum 0.025 inch (0.635 mm) thick.
    c. Joints: Secure joints with adhesive or clips according to duct manufacturer's written instructions, then tape joints with aluminum vapor tape.
    d. Sealing: All joints shall be sealed with a generous and continuous bead of silicone sealant and pressed into corners using a smooth radius tool.

B. Outdoor Ducts and Fittings:

1. Provide suitable external surface protection as recommended by manufacturer.
2. Phenolic-Foam Rectangular Ducts and Fittings:

    a. Minimum Panel Thickness: 7/8 inch (22 mm) or 1-3/32 inches (28 mm) as directed.
    b. Aluminum Cladding: Minimum 0.032 inch (0.813 mm) thick.
    c. Joints: Secure joints with adhesive or clips according to duct manufacturer's written instructions, then tape joints with aluminum vapor tape.
    d. Sealing: All joints shall be sealed with a generous and continuous bead of silicone sealant and pressed into corners using a smooth radius tool.

END OF SECTION 233116

SECTION 233119.13 - SHOP-FABRICATED HVAC CASINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Shop-fabricated casings.
2. Casing interstitial insulation.
3. Casing liner.
4. Sealant materials.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

C. Shop Drawings: For HVAC casings.

1. Include plans, elevations, sections, and attachment details.
2. Include details of HVAC casing assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

a. Sheet metal thickness(es).
b. Insulation.
c. Reinforcement and spacing.
d. Seam and joint construction.
e. Access doors including frames, hinges, and latches.
f. Fan, filter, coil, humidifier, and other apparatus being installed in and mounted on casing.
g. Locations for access to internal components.
h. Hangers and supports including methods for building attachment, vibration isolation, seismic restraints, and casing attachment.
i. Interior lighting, including switches.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for shop-fabricated HVAC casings, accessories, and components, from fabricator.

B. Product Certificates: For each type of casing.

1. For insulation properties, for the insulation material, and complete panel assembly, from fabricator.

2. For static-pressure ratings of complete panel assembly, from fabricator.
3. Product Certificates: For acoustical performance of each casing, from fabricator.

    a. Show sound-absorption coefficients in each octave band. Coefficients to be equal to or lower than those scheduled when tested in accordance with ASTM C423.
    b. Show airborne sound transmission losses. Losses to be equal to or lower than those scheduled when tested in accordance with ASTM E90.

4. Casing Performance: Submit calculations indicating that the proposed casing construction will achieve the required static-pressure classification, acoustical performance, and structural performance.

C. Field quality-control reports.

1.4 COORDINATION

A. Coordinate sizes and locations of concrete bases and roof curbs with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.

1. Verify that base height is sufficient to accommodate required drain trap depth.

B. Coordinate sizes and locations of steel supports. Supports are specified in Section 055000 "Metal Fabrications."

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."

1. Verify that roof curb height is sufficient to accommodate required drain trap depth.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Static-Pressure Classes:

1. Upstream from Fan(s): 2 (500) inch wg (Pa).
2. Downstream from Fan(s): As directed.

B. Thermal Performance for Assembled Casing Panel:

1. 2-Inch (50-mm) Panel: 0.12 (0.68) Btu/h x sq. ft. x deg F (W/sq. m x K).
2. 4-Inch (100-mm) Panel: 0.06 (0.34) Btu/h x sq. ft. x deg F (W/sq. m x K).

C. Acoustical Performance for Assembled Casing Panel:

1. NRC: 1.09 or 0.94 in accordance with ASTM C423 as directed.

2. STC: 40 or 34 in accordance with ASTM E90 as directed.

D. Structural Performance:

1. Fabricate casings to withstand 133 percent of the indicated static pressure without structural failure. Wall and roof deflection at the indicated static pressure shall not exceed 1/8 (0.97) inch/foot (mm/m).

a. Fabricate outdoor casings to withstand wind load of 15 (720) lbf/sq. ft (N/sq. m).
b. Fabricate outdoor casings to withstand snow load of 30 (1440) lbf/sq. ft. (N/sq. m).

E. Flammability:

1. Insulation and Other Materials Exposed to the Airstream:

a. All materials exposed to the airstream to comply with requirements of NFPA 90A or NFPA 90B when tested in accordance with ASTM E84.

F. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

G. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

H. Seismic Performance: HVAC casings shall withstand the effects of earthquake motions determined in accordance with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems" and ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 or 1.0.
3. Insert requirements for Component Amplification Factor and Component Response Modification Factor.

2.2 GENERAL CASING FABRICATION REQUIREMENTS

A. General Casing Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 9, "Equipments and Casings," for acceptable construction details related to required static-pressure classes.

B. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 9, "Equipment and Casings," for acceptable materials, material thicknesses, and casing construction methods unless otherwise indicated. Sheet metal materials to be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

1. Fabricate casings with more than 3-inch wg (750-Pa) negative static pressure in accordance with SMACNA's "Rectangular Industrial Duct Construction Standards."

2. Fabricate casings with more than 2-inch wg (500-Pa) positive static pressure in accordance with SMACNA's "Rectangular Industrial Duct Construction Standards."

C. Galvanized Sheet Steel: Comply with ASTM A653/A653M.

1. Exterior-Surface Galvanized Coating Designation: G60 (Z180) or G90 (Z275) as directed.
2. Interior-Surface Galvanized Coating Designation:

    a. Sections Not Exposed to Moisture: G60 (Z180) or G90 (Z275) as directed.
    b. Sections Housing and Downstream from Cooling Coil and Humidifiers: G90 (Z275).

D. Shop-Applied Antimicrobial Coating:

1. Apply to the interior sheet metal surfaces of casing in contact with the airstream. Apply untreated clear coating to the exterior surface.
2. Use only antimicrobial compound tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
3. Coating Hardness: 2H minimum when tested in accordance with ASTM D3363.
4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 in accordance with UL 723; certified by an NRTL.
5. Applied Coating Color: As directed.

E. Reinforcement Shapes and Plates: ASTM A36/A36M, steel plates, shapes, and bars; black and galvanized.

F. Sealing Requirement: SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Seal Class A. Seal all seams, joints, connections, and abutments to building.

G. Access Doors: Fabricate access doors in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 9-15, "Casing Access Doors - 2-inch wg (500 Pa)," and Figure 9-16, "Casing Access Doors - 3-10-inch wg (750-2500 Pa)"; and in accordance with pressure class of the plenum or casing section in which access doors are to be installed.

1. Size: 20 by 54 (500 by 1370) inches (mm).
2. Vision Panel: Double-glazed, wire-reinforced safety glass with an airspace between panes and sealed with interior and exterior rubber seals.
3. Hinges: Piano or butt hinges and latches; number and size in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
4. Latches: Minimum of two wedge-lever-type latches; operable from inside and outside.
5. Neoprene gaskets around entire perimeters of door frames.
6. Install doors to open against air pressure.

H. Condensate Drain Pans: Formed sections of G90 (Z275) coated, galvanized sheet steel complying with requirements in ASHRAE 62.1. Extend pans a minimum of 12 inches (300 mm) past coil.

1. Construct pans with a double-wall having space between walls filled with foam insulation and sealed moisture tight.
2. Insulation: Polystyrene or polyurethane.
3. For units with stacked coils or stacked eliminators, provide intermediate drain pan or drain trough to collect condensate from each coil row. Provide downcomer to conduct condensate from intermediate pan or trough into lower drain pan. Intermediate drain pan, trough, and downcomer to be constructed of 20-gauge (1.05-mm), Type 304, stainless steel.
4. Slope drain pan floor in a minimum of two planes to collect condensate from cooling coils (including coil piping connections and return bends), eliminators, and humidifiers when units are operating at maximum catalogued face velocity across cooling coil. All condensate to drain from pan without any standing water.
5. Provide trap for each drain pan connection. Dimension trap as detailed on Drawings.

2.3 SHOP-FABRICATED CASINGS

A. Single- and Double-Wall Casings: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for sheet metal thickness based on indicated static-pressure class unless otherwise indicated.

1. Outer Panel: Galvanized sheet steel.

B. Fabricate casings with standing seams and angle-iron reinforcements unless otherwise indicated.

C. Fabricate close-off sheets from casing to dampers, filter frames, and coils and between stacked coils. Use G90 (Z275) galvanized sheet steel of same thickness as outer casing.

D. Bolt close-off sheets to frame flanges and housings. Support coils on stands fabricated from galvanized-steel angles or channels.

E. Reinforce casings with galvanized-steel angles.

F. Double-Wall Casing Inner Panel, Perforated: Galvanized sheet steel having 3/32-inch- (2.4-mm-) diameter perforations, with overall open area of 23 percent. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for sheet metal thickness based on indicated static-pressure class unless otherwise indicated.

G. Double-Wall Casing Inner Panel, Solid: Sheet steel. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for sheet metal thickness based on indicated static-pressure class unless otherwise indicated.

2.4 CASING INTERSTITIAL INSULATION

A. Casing insulation is used to fill the interstitial void between inner and outer panel wall in double-wall casing construction and provides thermal and acoustic insulation.

B. Interstitial Insulation, Polyurethane Foam: Polyurethane foam complying with requirements of NFPA 90A or NFPA 90B when tested in accordance with ASTM E84.

1. Casing Wall Thickness: 2 (50) or 4 (100) inches (mm) as directed.
2. Maximum Thermal Conductivity: 0.27 (0.039) Btu x in./h x sq. ft. x deg F (W/m x K) at 75 deg F (24 deg C) mean temperature.

C. Interstitial Insulation, Fibrous Glass: Fibrous-glass insulation complying with ASTM E84, NFPA 90A, or NFPA 90B; and with NAIMA AH124.

1. Casing Wall Thickness: 2 (50) or 4 (100) inches (mm) as directed.
2. Maximum Thermal Conductivity of Composite Panel: 0.27 (0.039) Btu x in./h x sq. ft. x deg F (W/m x K) at 75 deg F (24 deg C) mean temperature.
3. Coat insulation with antimicrobial coating.
4. Cover insulation with polyester film complying with NFPA 701.

D. Interstitial Insulation: Flexible-elastomeric duct insulation complying with ASTM C534/C534M, Type II for sheet materials and with ASTM E84 and NFPA 90A or NFPA 90B.

1. Casing wall thickness to be 1 inch (25 mm) or 2 inches (50 mm) as directed.
2. Maximum Thermal Conductivity: 0.25 (0.036) Btu x in./h x sq. ft. x deg F (W/m x K) at 75 deg F (24 deg C) mean temperature.

2.5 CASING LINER

A. Casing liner is applied to the inner side of the panel in single-wall casing construction and provides thermal and acoustic insulation. The inner surface is exposed to the airstream.

B. Fibrous-Glass Casing Liner: Comply with ASTM C1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124.
1. Maximum Thermal Conductivity:

a. Type I, Flexible: 0.27 (0.039) Btu x in./h x sq. ft. x deg F (W/m x K) at 75 deg F (24 deg C) mean temperature.
b. Type II, Rigid: 0.23 (0.033) Btu x in./h x sq. ft. x deg F (W/m x K) at 75 deg F (24 deg C) mean temperature.

2. Antimicrobial Erosion-Resistant Coating: Apply to surface of the liner that will form the interior surface of casing to act as a moisture repellent and an erosion-resistant coating. Use only antimicrobial compound tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
3. Solvent or Water-Based Liner Adhesive as directed: Comply with NFPA 90A or NFPA 90B and with ASTM C916.

C. Flexible-Elastomeric Casing Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C534/C534M, Type II, Grade 1, and with NFPA 90A or NFPA 90B.
1. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
2. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

D. Natural-Fiber Casing Liner: Cotton fiber with polybinding fibers, treated with fire retardant and microbial growth inhibitor. Complying with ASTM E84 and NFPA 90A or NFPA 90B.
   1. Maximum Thermal Conductivity: 0.24 (0.034) Btu x in./h x sq. ft. x deg F (W/m x K) at 75 deg F (24 deg C) mean temperature when tested in accordance with ASTM C518.
   2. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
   3. Liner Adhesive: As recommended by insulation manufacturer and complying with ASTM E84 and NFPA 90A or NFPA 90B.

E. Insulation Pins and Washers:

   1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) or 0.135-inch- (3.5-mm-) diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.
   2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick, galvanized or stainless steel, with beveled edge sized as required to hold insulation securely in place, but not less than 1-1/2 inches (38 mm) in diameter.

F. Shop or Factory Application of Casing Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."

   1. Adhere a single layer of indicated thickness of casing liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of casing liner is prohibited.
   2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
   3. Butt transverse joints without gaps, and coat joint with adhesive.
   4. Fold and compress liner in corners of casings or cut and fit to ensure butted-edge overlapping.
   5. Apply adhesive coating on longitudinal seams in casings with air velocity of 2500 fpm (12.7 m/s).
   6. Secure liner with mechanical fasteners 4 inches (100 mm) from corners and at intervals not exceeding 12 inches (300 mm) transversely; at 3 inches (75 mm) from transverse joints and at intervals not exceeding 18 inches (450 mm) longitudinally.
   7. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from casing wall. Fabricate edge facings at the following locations:

      a. Fan discharges.
      b. Intervals of lined casing preceding unlined duct.
      c. Upstream edges of transverse joints in casings where air velocities are higher than 2500 fpm (12.7 m/s) or where indicated.

   8. Secure insulation between perforated sheet metal inner wall of same thickness as specified for outer wall. Use mechanical fasteners that maintain inner wall at uniform distance from outer wall without compressing insulation.

2.6 SEALANT MATERIALS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets to have a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.

B. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. Maximum Static-Pressure Class: 10 inch wg (2500 Pa), positive or negative.
7. Service: Indoor or outdoor.
8. Substrate: Compatible with galvanized sheet steel or stainless steel.

C. Flanged Joint Sealant: Comply with ASTM C920.

1. General: Single component, acid curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.

D. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Examine concrete bases, roof curbs and, steel supports for compliance with requirements for conditions affecting installation and performance of HVAC casings. Verify that there is sufficient clearance for access and to install all piping, condensate traps, ductwork, and other fittings.

B. Install casings in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Equipment Mounting:

1. Where indicated on Drawings, install HVAC casings on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

D. Apply sealant to joints, connections, and mountings.

E. Field-cut openings for pipe and conduit penetrations through casing walls; insulate and seal in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

F. Seal all penetrations airtight. Cover with escutcheons and gaskets, or fill with suitable compound so there is no exposed insulation. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping." Provide shaft seals where fan shafts penetrate casing.

G. Support casings on base or foundation system. Secure and seal to base.

H. Support components rigidly with ties, braces, brackets, seismic restraints, and anchors of types that will maintain housing shape and prevent buckling.

I. Align casings accurately at connections, with 1/8-inch (3-mm) misalignment tolerance and with smooth interior surfaces.

3.2 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform tests and inspections with the assistance of a shop-authorized service representative.

D. Tests and Inspections:

1. Perform field tests of all fire dampers and control dampers, demonstrating that they open and close fully and without binding or excessive friction.
2. Inspect all duct and casing access doors and other openings having movable covers, demonstrating that they are reasonably accessible, open and close fully without binding or excessive fiction, and when fully closed, they seal properly.
3. Perform field tests and inspections including air-duct leakage testing of supply-, return-, and exhaust-air ducts in accordance with SMACNA's "HVAC Air Duct Leakage Test Manual."
4. Test the following systems:

    a. Systems required by ASHRAE/IES 90.1.
    b. Supply Air: 100 or 50 percent of total installed duct area with a pressure class of 3 (750) or 4 (1000) inch wg (Pa) or higher as directed.

5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.
6. Determine leakage from entire system or section of system by relating leakage to surface area of test section. Comply with requirements for leakage classification of ducts connected to casings.

7. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.

E. HVAC casings will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.3 CLEANING

A. Comply with requirements for cleaning in Section 233113 "Metal Ducts."

END OF SECTION 233119.13

SECTION 233119.16 - MANUFACTURED HVAC CASINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Manufactured casings.
2. Interstitial insulation.
3. Sealant materials.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

C. Shop Drawings: For HVAC casings.

1. Include plans, elevations, sections, and attachment details.
2. Include details of HVAC casing assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

    a. Sheet metal thickness(es).
    b. Insulation.
    c. Reinforcement and spacing.
    d. Seam and joint construction.
    e. Access doors including frames, hinges, and latches.
    f. Fan, filter, coil, humidifier, and other apparatus being installed in and mounted on casing.
    g. Locations for access to internal components.
    h. Hangers and supports including methods for building attachment, vibration isolation, seismic restraints, and casing attachment.
    i. Interior lighting, including switches.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for manufactured HVAC casings, accessories, and components, from manufacturer.

B. Product Certificates: For each type of casing.

1. For insulation properties, for both insulation material and complete panel assembly, from manufacturer.
2. For static-pressure ratings of complete panel assembly, from manufacturer.

3. Product Certificates: For acoustical performance of each casing, from manufacturer.

    a. Show sound-absorption coefficients in each octave band lower than those scheduled when tested in accordance with ASTM C423.
    b. Show airborne sound transmission losses lower than those scheduled when tested in accordance with ASTM E90.

4. Casing Performance: Submit calculations indicating that the proposed casing construction will achieve the required static-pressure classifications, acoustical performance, and structural performance.

C. Field quality-control reports.

1.4 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed

1. Verify that base height is sufficient to accommodate required drain trap depth.

B. Coordinate sizes and locations of steel supports. Supports are specified in Section 055000 "Metal Fabrications."

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."

1. Verify that roof curb height is sufficient to accommodate required drain trap depth.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Static-Pressure Classes:

1. Upstream from Fan(s): 2 (500) inch wg (Pa).
2. Downstream from Fan(s): As directed

B. Thermal Performance:

1. 2-Inch (50-mm) Panel: 0.12 (0.68) Btu/h x sq. ft. x deg F (W/sq. m x K).
2. 4-Inch (100-mm) Panel: 0.06 (0.34) Btu/h x sq. ft. x deg F (W/sq. m x K).

C. Acoustical Performance:

1. NRC: 1.09 or 0.94 in accordance with ASTM C423 as directed.
2. STC: 40 or 34 in accordance with ASTM E90 as directed

D. Structural Performance:

1. Fabricate casings to withstand 133 percent of the indicated static pressure without structural failure. Wall and roof deflection at the indicated static pressure shall not exceed 1/8 (0.97) inch/foot (mm/m) of width.

a. Fabricate outdoor casings to withstand wind load of 15 (720) lbf/sq. ft. (N/sq. m).
b. Fabricate outdoor casings to withstand snow load of 30 (1440) lbf/sq. ft. (N/sq. m).

E. Flammability and Smoke:

1. Insulation and Other Materials Exposed to the Airstream:

a. All materials exposed to the airstream to comply with requirements of NFPA 90A or NFPA 90B when tested in accordance with ASTM E84.

F. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

G. Seismic Performance: HVAC casings shall withstand the effects of earthquake motions determined in accordance with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems" and ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 or 1.0 as directed.
3. Insert requirements for Component Amplification Factor and Component Response Modification Factor.

2.2 GENERAL CASING FABRICATION REQUIREMENTS

A. Galvanized Sheet Steel: Comply with ASTM A653/A653M.

1. Exterior-Surface Galvanized Coating Designation: G60 (Z180) or G90 (Z275) as directed.
2. Interior-Surface Galvanized Coating Designation: G60 (Z180) or G90 (Z275) as directed.

a. Sections Not Exposed to Moisture: G60 (Z180) or G90 (Z275) as directed.
b. Sections Housing and Downstream from Cooling Coil and Humidifiers: G90 (Z275).

B. Factory-Applied Antimicrobial Coating:

1. Apply to the interior sheet metal surfaces of casing in contact with the airstream. Apply untreated clear coating to the exterior surface.
2. Use only antimicrobial compound tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
3. Coating Hardness: 2H minimum when tested in accordance with ASTM D3363.

4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 in accordance with UL 723; certified by an NRTL.
5. Applied Coating Color: as directed.

C. Reinforcement Shapes and Plates: ASTM A36/A36M, steel plates, shapes, and bars; black and galvanized.

D. Sealing Requirement: SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Seal Class A. Seal all seams, joints, connections, and abutments to building.

E. Access Doors: Fabricate access doors in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 9-15, "Casing Access Doors - 2-inch wg (500 Pa)," and Figure 9-16, "Casing Access Doors - 3-10-inch wg (750-2500 Pa)"; and in accordance with pressure class of the plenum or casing section in which access doors are to be installed.

1. Size: 20 by 54 (500 by 1370) inches (mm).
2. Vision Panel: Double-glazed, wire-reinforced safety glass with an airspace between panes and sealed with interior and exterior rubber seals.
3. Hinges: Piano or butt hinges and latches; number and size in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
4. Latches: Minimum of two wedge-lever-type latches; operable from inside and outside.
5. Neoprene gaskets around entire perimeters of door frames.
6. Doors to open against air pressure.

F. Condensate Drain Pans: Formed sections of G90 (Z275) coated, galvanized sheet steel complying with requirements in ASHRAE 62.1. Extend pans a minimum of 12 inches (300 mm) past coil.

1. Construct pans with a double-wall having space between walls filled with foam insulation and sealed moisture tight.
2. Insulation: Polystyrene or polyurethane.
3. For units with stacked coils or stacked eliminators, provide intermediate drain pan or drain trough to collect condensate from each coil row. Provide downcomer to conduct condensate from intermediate pan or trough into lower drain pan. Intermediate drain pan, trough, and downcomer to be constructed of 20-gauge (1.05-mm), Type 304 stainless or 18-gauge (1.31-mm) galvanized steel as directed.
4. Slope drain pan floor in a minimum of two planes to collect condensate from cooling coils (including coil piping connections and return bends), eliminators, and humidifiers when units are operating at maximum catalogued face velocity across cooling coil. All condensate to drain from pan without any standing water.
5. Provide trap for each drain pan connection. Dimension trap as detailed on Drawings.

2.3 MANUFACTURED CASINGS

A. Description: Double-wall, insulated, pressurized equipment casing.

B. Double-Wall Panel Fabrication: Exterior and interior sheet metal walls; with interstitial space filled with insulation.

1. Panel Thickness: 2 (50) or 4 (100) inches (mm) as directed.
2. Fabricate with a minimum number of joints.
3. Weld, crimp, or otherwise secure exterior and interior walls to perimeter; to interior, longitudinal channels; and to box-end internal closures. Longitudinal channels to be same metal as exterior wall. Paint welds.
4. Sheet metal thickness is to comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for static-pressure class indicated for casing.
5. Sheet Metal Thicknesses:

    a. Exterior Wall Thickness: 18 (1.3) gauge (mm) minimum.
    b. Interior Wall Thickness: 22 (0.85) gauge (mm) minimum.

6. Neoprene gasket applied around entire perimeters of panel frames.
7. Outer Wall Material: Solid galvanized sheet steel or sheet aluminum as directed.
8. Inner Wall Material, Solid: Solid galvanized sheet steel or sheet aluminum as directed.
9. Inner Wall Material, Perforated: Perforated galvanized sheet steel or sheet aluminum having 3/32-inch- (2.4-mm-) diameter perforations, with overall open area of 23 percent.
10. Inner Wall Material, Solid and Perforated: Perforated galvanized sheet steel or sheet aluminum having 3/32-inch- (2.4-mm- diameter perforations, with overall open area of 23 percent except for a distance of 42 inches (1070 mm) downstream of cooling coil and humidifier, use solid Type 304, stainless steel sheet.
11. Fill each panel assembly as directed insulating material that is noncombustible, inert, mildew resistant, and vermin proof and that complies with NFPA 90A.
12. Fabricate panels with continuous tongue-and-groove or self-locking joints effective inside and outside each panel.

C. Trim Items: Fabricate from a minimum of 18-gauge (1.3-mm) galvanized sheet steel, furnished in standard lengths for field cutting.

2.4 INTERSTITIAL INSULATION

A. Fibrous-Glass Insulation: Comply with maximum 25 flame-spread index and maximum 50 smoke-developed index when tested in accordance with ASTM E84.

1. Media to be incombustible, acoustical quality, fibrous-glass insulation with long, resilient fibers bonded with a thermosetting resin.
2. Maximum Thermal Conductivity:

    a. Type I, Flexible: 0.27 (0.039) Btu x in./h x sq. ft. x deg F (W/m x K) at 75 deg F (24 deg C) mean temperature.
    b. Type II, Rigid: 0.23 (0.033) Btu x in./h x sq. ft. x deg F (W/m x K) at 75 deg F (24 deg C) mean temperature.

3. Solvent or Water-Based Insulation Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C916 as directed.

B. Polyurethane-Foam Interstitial Insulation: Polyurethane foam complying with requirements of NFPA 90A or NFPA 90B when tested in accordance with ASTM E84 or UL 723.

1. Foam interstitial insulation to have maximum thermal conductivity of 0.27 Btu x in./h x sq. ft. deg F (0.039 N/m x K).

2.5 SEALANT MATERIALS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets to be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested in accordance with ASTM E84 or UL 723; certified by an NRTL.

B. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. Maximum Static-Pressure Class: 10 inch wg (2500 Pa), positive or negative.
7. Service: Indoor or outdoor.
8. Substrate: Compatible with galvanized sheet steel, aluminum, or stainless steel.

C. Flanged Joint Sealant: Comply with ASTM C920.

1. General: Single component, acid curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.

D. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Examine for compliance with requirements for conditions affecting installation and performance of HVAC casings as directed. Verify that there is sufficient clearance for access and to install all piping, condensate traps, ductwork, and other fittings.

B. Install casings in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and manufacturer's written installation instructions.

C. Equipment Mounting:

1. Where indicated on Drawings, install HVAC casings on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed
2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

D. Apply sealant to joints, connections, and mountings.

E. Field-cut openings for pipe, conduit, and duct penetrations; insulate and seal in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

F. Seal all penetrations airtight. Cover with escutcheons and gaskets or fill with suitable compound so there is no exposed insulation. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping." Provide shaft seals where fan shafts penetrate casing.

G. Support casings on base or foundation system. Secure and seal to base.

H. Support components rigidly with ties, braces, brackets, seismic restraints, and anchors of types that will maintain housing shape and prevent buckling.

I. Align casings accurately at connections, with 1/8-inch (3-mm) misalignment tolerance and with smooth interior surfaces.

3.2 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Tests and Inspections:

1. Perform field tests of all fire dampers and control dampers, demonstrating that they open and close fully and without binding or excessive friction.
2. Inspect all duct and casing access doors and other openings having movable covers, demonstrating that they are reasonably accessible, open and close fully without binding or excessive friction. and when fully closed, they seal properly.
3. Perform field tests and inspections including air-duct leakage testing of supply-, return-, and exhaust-air duct connections to casing in accordance with SMACNA's "HVAC Air Duct Leakage Test Manual."
4. Test the following systems:

    a. Systems required by ASHRAE/IES 90.1.
    b. Supply Air: 100 or 50 percent of total installed duct area with a pressure class of 3 (750) or 4 (1000) inch wg (Pa) or higher as directed.

5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.

6. Determine leakage from entire system or section of system by relating leakage to surface area of test section. Comply with requirements for leakage classification of ducts connected to casings.
7. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.

E. HVAC casings will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.3 CLEANING

A. Comply with requirements for cleaning in Section 233113 "Metal Ducts."

END OF SECTION 233119.16

SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Backdraft and pressure relief dampers.
2. Manual volume dampers.
3. Control dampers.
4. Fire dampers.
5. Smoke dampers.
6. Flange connectors.
7. Turning vanes.
8. Duct-mounted access doors.
9. Flexible connectors.
10. Duct accessory hardware.

B. Related Requirements:

1. Section 233723 "HVAC Gravity Ventilators" for roof-mounted ventilator caps.
2. Section 284621.11 "Addressable Fire-Alarm Systems" for duct-mounted fire and smoke detectors.
3. Section 284621.13 "Conventional Fire-Alarm Systems" for duct-mounted fire and smoke detectors.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:

a. Special fittings.
b. Manual volume damper installations.
c. Control-damper installations.
d. Fire-damper and smoke-damper installations, including sleeves; and duct-mounted access doors.
e. Wiring Diagrams: For power, signal, and control wiring.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A653/A653M.

1. Galvanized Coating Designation: G60 (Z180) or G90 (Z275) as directed.
2. Exposed-Surface Finish: Mill phosphatized.

B. Stainless-Steel Sheets: Comply with ASTM A480/A480M, Type 304, and having a No. 2 finish for concealed ducts and finish for exposed ducts.

C. Aluminum Sheets: Comply with ASTM B209 (ASTM B209M), Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

D. Extruded Aluminum: Comply with ASTM B221 (ASTM B221M), Alloy 6063, Temper T6.

E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

F. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.3 BACKDRAFT AND PRESSURE RELIEF DAMPERS

A. Description: Gravity balanced.

B. Maximum Air Velocity: As directed.

C. Maximum System Pressure: As directed.

D. Frame: Hat-shaped, as directed.

E. Blades: As directed.

F. Blade Action: Parallel.

G. Blade Seals: As directed.

H. Blade Axles:

1. Material: As directed.
2. Diameter: 0.20 inch (5 mm).

I. Tie Bars and Brackets: Aluminum or Galvanized steel.

J. Return Spring: Adjustable tension.

K. Bearings: Steel ball or synthetic pivot bushings.

L. Accessories:

1. Adjustment device to permit setting for varying differential static pressure.
2. Counterweights and spring-assist kits for vertical airflow installations.
3. Electric actuators.
4. Chain pulls.
5. Screen Mounting: Front mounted in sleeve.
    a. Sleeve Thickness: 20 gage (1.0 mm) minimum.
    b. Sleeve Length: 6 inches (152 mm) minimum.
6. Screen Mounting: Rear mounted.
7. Screen Material: Galvanized steel or Aluminum as directed.
8. Screen Type: Bird or Insect as directed.
9. 90-degree stops.

2.4 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:
1. Standard leakage rating, with linkage outside airstream.
2. Suitable for horizontal or vertical applications.
3. Frames:
    a. Frame: Hat-shaped, 0.094-inch- (2.4-mm-) thick, galvanized sheet steel or 0.05-inch- (1.3-mm-) thick stainless steel as directed.
    b. Mitered and welded corners.
    c. Flanges for attaching to walls and flangeless frames for installing in ducts.
4. Blades:
    a. Multiple or single blade.
    b. Parallel- or opposed-blade design.
    c. Stiffen damper blades for stability.
    d. Galvanized or Stainless-steel, 0.064 inch (1.62 mm) thick as directed.
5. Blade Axles: As directed.
6. Bearings:
    a. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

7. Tie Bars and Brackets: Galvanized steel.

B. Standard, Aluminum, Manual Volume Dampers:
1. Standard leakage rating, with linkage outside airstream.
2. Suitable for horizontal or vertical applications.
3. Frames: Hat-shaped, 0.10-inch- (2.5-mm-) thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
4. Blades:

   a. Multiple or single blade.
   b. Parallel- or opposed-blade design.
   c. Stiffen damper blades for stability.
   d. Roll-Formed Aluminum Blades: 0.10-inch- (2.5-mm-) thick aluminum sheet.
   e. Extruded-Aluminum Blades: 0.050-inch- (1.2-mm-) thick extruded aluminum.

5. Blade Axles: As directed.
6. Bearings:
   a. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

7. Tie Bars and Brackets: Aluminum.

C. Jackshaft:

1. Size: As directed.
2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

D. Damper Hardware:

1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch- (2.4-mm-) thick zinc-plated steel, and a 3/4-inch (19-mm) hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.5 CONTROL DAMPERS

A. Frames:

1. Shaped; As directed.
2. 0.094-inch- (2.4-mm-) thick, galvanized sheet steel or 0.05-inch- (1.3-mm-) thick stainless steel as directed.
3. Mitered and welded or Interlocking, gusseted corners as directed.

B. Blades:

1. Multiple blade with maximum blade width of 6 inches (152 mm) or 8 inches (200 mm) as directed.

2. Blade design; as directed.
3. 0.064 inch (1.62 mm) thick single skin or 0.0747-inch- (1.9-mm-) thick dual skin as directed.
4. Blade Edging: Closed-cell neoprene or PVC as directed.
5. Blade Edging: Inflatable seal blade edging, or replaceable rubber seals.

C. Blade Axles: 1/2-inch- (13-mm-) diameter; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings as directed.

1. Operating Temperature Range: From minus 40 to plus 200 deg F (minus 40 to plus 93 deg C).

D. Bearings:
1. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
2. Thrust bearings at each end of every blade.

2.6 FIRE DAMPERS

A. Type: Rated and labeled according to UL 555 by an NRTL as directed.

B. Closing rating in ducts up to 4-inch wg (1-kPa) static pressure class and minimum 2000-fpm (10-m/s) velocity.

C. Fire Rating: 1-1/2 and 3 hours.

D. Frame: As directed

E. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.

1. Minimum Thickness: 0.05 (1.3 mm), 0.138 inch (3.5 mm) or 0.39 inch (9.9 mm) thick, as indicated, and of length to suit application.
2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.

F. Mounting Orientation: Vertical or horizontal as indicated.

G. Blades: Roll-formed, interlocking, 0.024-inch- (0.61-mm) or 0.034-inch- (0.85-mm-) thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- (0.85-mm-) thick, galvanized-steel blade connectors.

H. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

I. Heat-Responsive Device: Replaceable, 165 deg F (74 deg C) or 212 deg F (100 deg C) rated, fusible links.

J. Heat-Responsive Device: link and switch package, factory installed, 165 deg F (74 deg C) and 212 deg F (100 deg C) rated.

2.7 SMOKE DAMPERS

A. General Requirements: Label according to UL 555S by an NRTL.

B. Smoke Detector: Integral, factory wired for single-point connection.

C. Frame: Hat-shaped, 0.094-inch- (2.4-mm-) thick, galvanized sheet steel, with welded, interlocking, gusseted or mechanically attached corners and mounting flange.

D. Blades: Roll-formed, horizontal, interlocking overlapping, 0.034-inch- (0.85-mm-) 0.063-inch- (1.6-mm) thick, galvanized sheet steel.

E. Leakage: Class I or Class II as directed.

F. Rated pressure and velocity to exceed design airflow conditions.

G. Mounting Sleeve: Factory-installed, 0.039-inch- (1.0-mm-) or 0.05-inch- (1.3-mm-) thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking as directed.

H. Damper Motors: Modulating or two-position action.

I. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC"
3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 150 in. x lbf (17 N x m).
5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F (minus 40 deg C).
6. Nonspring-Return Motors: For dampers larger than 25 sq. ft. (2.3 sq. m), size motor for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 300 in. x lbf (34 N x m).
7. Electrical Connection: 115 V, single phase, 60 Hz.

J. Accessories:

1. Auxiliary switches for signaling, fan control or position indication.
2. Momentary test switch, Test and reset switches, damper or remote mounted.

2.8 FLANGE CONNECTORS

A. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

B. Material: Galvanized steel.

C. Gage and Shape: Match connecting ductwork.

2.9 TURNING VANES

A. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

B. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."

D. Vane Construction: Single or Double wall as directed.

2.10 DUCT-MOUNTED ACCESS DOORS

A. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2 (7-2M), "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."

1. Door:

a. Double wall, rectangular.
b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
c. Vision panel.
d. Hinges and Latches: 1-by-1-inch (25-by-25-mm)butt or piano hinge and cam latches.
e. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
3. Number of Hinges and Locks:

a. Access Doors Less Than 12 Inches (300 mm) Square: No hinges and two sash locks.
b. Access Doors up to 18 Inches (460 mm) Square: Two hinges or Continuous and two sash locks as directed.

c. Access Doors up to 24 by 48 Inches (600 by 1200 mm): Three hinges Continuous and two compression latches with outside and inside handles.
d. Access Doors Larger Than 24 by 48 Inches (600 by 1200 mm): Four hinges or Continuous and two compression latches with outside and inside handles.

B. Pressure Relief Access Door:

1. Door and Frame Material: Galvanized sheet steel.
2. Door: Single wall or Double wall with insulation fill with metal thickness applicable for duct pressure class as directed
3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
4. Factory set at 3.0- to 8.0-inch wg (800 to 2000 Pa) or 10-inch wg (2500 Pa) as directed.
5. Doors close when pressures are within set-point range.
6. Hinge: Continuous piano.
7. Latches: Cam.
8. Seal: Neoprene or foam rubber.
9. Insulation Fill: 1-inch- (25-mm-) thick, fibrous-glass or polystyrene-foam board.

2.11 DUCT ACCESS PANEL ASSEMBLIES

A. Labeled according to UL 1978 by an NRTL.

B. Panel and Frame: Minimum thickness 0.0528-inch (1.3-mm) carbon or 0.0428-inch (1.1-mm) stainless steel as directed.

C. Fasteners: Carbon or Stainless steel as directed. Panel fasteners shall not penetrate duct wall.

D. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F (1093 deg C).

E. Minimum Pressure Rating: 10-inch wg (2500 Pa), positive or negative.

2.12 FLEXIBLE CONNECTORS

A. Materials: Flame-retardant or noncombustible fabrics.

B. Coatings and Adhesives: Comply with UL 181, Class 1.

C. Metal-Edged Connectors: As directed Factory fabricated with a fabric strip 3-1/2 inches (89 mm) or 5-3/4 inches (146 mm) wide attached to two strips of 2-3/4-inch- (70-mm-) wide, 0.028-inch- (0.7-mm-) thick, galvanized sheet steel or 0.032-inch- (0.8-mm-) thick aluminum sheets. Provide metal compatible with connected ducts.

D. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).
2. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.

3. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).

E. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

1. Minimum Weight: 24 oz./sq. yd. (810 g/sq. m).
2. Tensile Strength: 530 lbf/inch (93 N/mm) in the warp and 440 lbf/inch (77 N/mm) in the filling.
3. Service Temperature: Minus 50 to plus 250 deg F (Minus 45 to plus 121 deg C).

2.13 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install backdraft or control dampers as directed at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

1. Install steel volume dampers in steel ducts.
2. Install aluminum volume dampers in aluminum ducts.

E. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install test holes at fan inlets and outlets and elsewhere as indicated.

G. Install fire and smoke dampers according to UL listing.

H. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On both sides of duct coils.
2. Upstream and downstream from duct filters.
3. At outdoor-air intakes and mixed-air plenums.
4. At drain pans and seals.
5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
7. At each change in direction and at maximum 50-foot (15-m) spacing.
8. Upstream and downstream from turning vanes.
9. Upstream or downstream from duct silencers.
10. Control devices requiring inspection.
11. Elsewhere as indicated.

I. Install access doors with swing against duct static pressure.

J. Access Door Sizes:

1. One-Hand or Inspection Access: 8 by 5 inches (200 by 125 mm).
2. Two-Hand Access: 12 by 6 inches (300 by 150 mm).
3. Head and Hand Access: 18 by 10 inches (460 by 250 mm).
4. Head and Shoulders Access: 21 by 14 inches (530 by 355 mm).
5. Body Access: 25 by 14 inches (635 by 355 mm).
6. Body plus Ladder Access: 25 by 17 inches (635 by 430 mm).

K. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

L. Install flexible connectors to connect ducts to equipment.

M. Connect terminal units to supply ducts directly or with maximum 12-inch (300-mm) lengths of flexible duct. Do not use flexible ducts to change directions.

N. Connect diffusers or light troffer boots to ducts directly or with maximum 60-inch (1500-mm) lengths of flexible duct clamped or strapped in place.

O. Connect flexible ducts to metal ducts as directed.

P. Install duct test holes where required for testing and balancing purposes.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.

2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.

END OF SECTION 233300

SECTION 233346 - FLEXIBLE DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Non-insulated flexible ducts.
2. Insulated flexible ducts.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

1. Include plans showing locations and mounting and attachment details.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, and coordinated with each other, using input from installers of the items involved.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

C. Comply with the Air Diffusion Council's "ADC Flexible Air Duct Test Code FD 72-R1."

D. Comply with ASTM E96/E96M, "Test Methods for Water Vapor Transmission of Materials."

2.2 NON-INSULATED FLEXIBLE DUCTS

A. Non-Insulated, Flexible Duct: UL 181, Class 1, two-ply vinyl film supported by helically wound, spring-steel wire.

1. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
2. Maximum Air Velocity: 4000 fpm (20 m/s).
3. Temperature Range: Minus 10 to plus 160 deg F (Minus 23 to plus 71 deg C).

B. Non-Insulated, Flexible Duct: UL 181, Class 1, multiple layers of aluminum laminate supported by helically wound, spring-steel wire.

1. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
2. Maximum Air Velocity: 4000 fpm (20 m/s).
3. Temperature Range: Minus 20 to plus 210 deg F (Minus 29 to plus 99 deg C).

2.3 INSULATED FLEXIBLE DUCTS

A. Insulated, Flexible Duct: UL 181, Class 1, two-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene or aluminized vapor-barrier film as directed.

1. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
2. Maximum Air Velocity: 4000 fpm (20 m/s).
3. Temperature Range: Minus 10 to plus 160 deg F (Minus 23 to plus 71 deg C).
4. Insulation R-Value: As directed

B. Insulated, Flexible Duct: UL 181, Class 1, multiple layers of aluminum laminate supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene or aluminized vapor-barrier film as directed.

1. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
2. Maximum Air Velocity: 4000 fpm (20 m/s).
3. Temperature Range: Minus 20 to plus 210 deg F (Minus 29 to plus 99 deg C).
4. Insulation R-Value: As directed

2.4 FLEXIBLE DUCT CONNECTORS

A. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action or Nylon strap as directed in sizes 3 through 18 inches (75 through 460 mm), to suit duct size.

B. Non-Clamp Connectors: As directed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install flexible ducts according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install in indoor applications only. Flexible ductwork should not be exposed to UV lighting.

C. Connect terminal units to supply ducts directly or with maximum 12-inch (300-mm lengths of flexible duct. Do not use flexible ducts to change directions.

D. Connect diffusers or light troffer boots to ducts directly or with maximum 60-inch (1500-mm) lengths of flexible duct clamped or strapped in place.

E. Connect flexible ducts to metal ducts as directed.

F. Install duct test holes where required for testing and balancing purposes.

G. Installation:

1. Install ducts fully extended.
2. Do not bend ducts across sharp corners.
3. Bends of flexible ducting shall not exceed a minimum of one duct diameter.
4. Avoid contact with metal fixtures, water lines, pipes, or conduits.
5. Install flexible ducts in a direct line, without sags, twists, or turns.

H. Supporting Flexible Ducts:

1. Suspend flexible ducts with bands 1-1/2 inches (38 mm) wide or wider and spaced a maximum of 48 inches (1200 mm) apart. Maximum centerline sag between supports shall not exceed 1/2 inch (13 mm) per 12 inches (300 mm).
2. Install extra supports at bends placed approximately one duct diameter from center line of the bend.
3. Ducts may rest on ceiling joists or truss supports. Spacing between supports shall not exceed the maximum spacing per manufacturer's written installation instructions.
4. Vertically installed ducts shall be stabilized by support straps at a maximum of 72 inches (1800 mm) o.c.

END OF SECTION 233346

SECTION 233413 - AXIAL HVAC FANS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Tubeaxial fans.
2. Vaneaxial fans.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show fan room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.

B. Seismic Qualification Data: Certificates, for fans, accessories, and components, from manufacturer.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of unit components.

C. ASHRAE Compliance:

1. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation and seismic restraints, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

F. Seismic Performance: Axial HVAC fans shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event,
2. Component Importance Factor: 1.5 or 1.0.

2.2 CAPACITIES AND CHARACTERISTICS

A. Airflow: As directed.

B. External Static Pressure: As directed.

C. Fan Diameter: As directed.

D. Brake Horsepower: As directed.

E. Drive Type: Direct or Belt as directed.

F. Fan Rpm: As directed.

G. Motor:

1. Motor Enclosure: As directed.
2. Enclosure Materials: As directed.
3. Motor Bearings: As directed.

4. Efficiency: Premium efficiency.
5. NEMA Design: As directed.
6. Service Factor: As directed.
7. Electrical Characteristics:

    a. Motor Size: As directed.
    b. Motor Rpm: As directed.
    c. Volts: As directed.
    d. Phase: Single or Three As directed.
    e. Hertz: 60 Hz.
    f. Full-Load Amperes: As directed.
    g. Minimum Circuit Ampacity: As directed.
    h. Maximum Overcurrent Protection: As directed.

H. Sound Power:

1. 1st Octave: As directed.
2. 2nd Octave: As directed.
3. 3rd Octave: As directed.
4. 4th Octave: As directed.
5. 5th Octave: As directed.
6. 6th Octave: As directed.
7. 7th Octave: As directed.
8. 8th Octave: As directed.

I. Vibration Isolators: Spring or Restrained spring As directed isolators with a static deflection of 1 (25) inch(es) (mm).

J. Spark Resistance:

K. Service Conditions:

1. Ambient Temperature: As directed deg F (deg C).
2. Altitude: As directed feet (m) above sea level.
3. Humidity: As directed deg F (deg C) wet bulb.

2.3 TUBEAXIAL FANS

A. Description: Fan wheel and housing, factory-mounted motor with belt or direct drive, an inlet cone section, and accessories.

B. Housings: As directed with flanged inlet and outlet connections.

C. Wheel Assemblies: Cast or extruded aluminum with airfoil-shaped blades mounted on cast-iron wheel plate keyed to shaft with solid-steel key.

D. Wheel Assemblies: Fiberglass-reinforced plastic cured under pressure with airfoil-shaped blades keyed to stainless-steel shaft.

E. Wheel Assemblies: Cast aluminum; machined and fitted to shaft.

F. Belt Drives:

1. Factory mounted, with adjustable alignment and belt tensioning.
2. Service Factor Based on Fan Motor Size: As directed.
3. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
4. Fan Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
5. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
6. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
7. Belt Guards: Fabricate of prime-coated steel to comply with OSHA and SMACNA requirements for motors with exposed drive belt. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
8. Motor Base: Adjustable rail mount motor base with adjustment screw to set belt tension.
9. Shaft Bearings: Radial, self-aligning bearings.

    a. Ball-Bearing Rating Life: ABMA 9, L10 of 50,000 hours.
    b. Roller-Bearing Rating Life: ABMA 11, L10 of 50,000 hours.
    c. Extend lubrication lines to outside of casing and terminate with grease fittings.

G. Accessories:

1. Companion Flanges: Rolled flanges of same material as housing.
2. Inspection Door: Bolted door allowing limited access to internal parts of fan, of same material as housing.
3. Propeller Access Section Door: Short duct section bolted to fan inlet and outlet allowing access to internal parts of fan for inspection and cleaning, of same material as housing.
4. Swingout Construction: Assembly allowing entire fan section to swing out from duct for cleaning and servicing, of same material as housing.
5. Mounting Clips: Horizontal ceiling or Vertical mounting clips welded to fan housing, of same material as housing as directed.
6. Horizontal Support: Pair of supports bolted to fan housing, of same material as housing.
7. Vertical Support: Short duct section with welded brackets bolted to fan housing, of same material as housing.
8. Inlet Screen: On unducted fan inlet - wire-mesh screen, of same material as housing.
9. Outlet Screen: On unducted fan outlet - wire-mesh screen, of same material as housing.
10. Backdraft Dampers: Butterfly style, for bolting to fan discharge or outlet cone, of same material as housing.
11. Shaft Seal: Elastomeric seal and PTFE wear plate, suitable for up to 300 deg F (149 deg C).
12. Motor Cover: Cover with side vents to dissipate motor heat, of same material as housing.
13. Inlet Vanes: Adjustable; with peripheral control linkage operated from outside of airstream, bronze sleeve bearings on each end of vane support, and provision for manual or automatic operation, of same material as housing.
14. Inlet Bell: Curved inlet for when fan is not attached to duct, of same material as housing; aluminum.
15. Inlet Cone: Round-to-round transition, of same material as housing.
16. Outlet Cone: Round-to-round transition, of same material as housing.
17. Stack Cap: Vertical discharge assembly with backdraft dampers, of same material as housing.

18. Direct-Driven Units: Encase motor in housing outside of airstream. Extend lubrication lines to outside of casing and terminate with grease fittings.
19. Factory-wired motor disconnect switch located on outside of fan housing.

H. Factory Finishes:

1. Sheet Metal Parts: Prime coat before final assembly.
2. Exterior Surfaces: Baked-enamel finish coat after assembly.
3. Coatings: As directed.

a. Apply to finished housings.
b. Apply to fan wheels.

2.4 VANEAXIAL FANS

A. Description: Fan wheel and housing, straightening vane section, factory-mounted motor with belt or direct drive, an inlet cone section, and accessories.

1. Variable-Pitch Fans: Internally mounted electric or electronic actuator, externally mounted positive positioner, and mechanical-blade-pitch indicator As directed.

B. Housings: As directed.

1. Inlet and Outlet Connections: Flanges.
2. Guide Vane Section: Integral guide vanes downstream from fan wheel designed to straighten airflow.

C. Wheel Assemblies: Cast aluminum with airfoil-shaped blades mounted on cast-iron wheel plate keyed to shaft with solid-steel key.

D. Wheel Assemblies: Fiberglass-reinforced plastic cured under pressure with airfoil-shaped blades keyed to stainless-steel shaft.

E. Wheel Assemblies: Cast-aluminum hub assembly, machined and fitted with threaded bearing wells to receive blade-bearing assemblies with replaceable, cast-aluminum blades; factory mounted and balanced.

F. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.

1. Service Factor Based on Fan Motor Size: As directed.
2. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
3. Fan Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
4. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
6. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.
7. Motor Base: Adjustable rail mount motor base with adjustment screw to set belt tension.

8. Shaft Bearings: Radial, self-aligning bearings.

    a. Ball-Bearing Rating Life: ABMA 9, L10 of 100,000 hours.
    b. Roller-Bearing Rating Life: ABMA 11, L10 of 100,000 hours.
    c. Extend lubrication lines to outside of casing and terminate with grease fittings.

G. Accessories:

1. Companion Flanges: Rolled flanges of same material as housing.
2. Inspection Door: Bolted door allowing limited access to internal parts of fan, of same material as housing.
3. Propeller Access Section Door: Short duct section bolted to fan inlet and outlet allowing access to internal parts of fan for inspection and cleaning, of same material as housing.
4. Swingout Construction: Assembly allowing entire fan section to swing out from duct for cleaning and servicing, of same material as housing.
5. Mounting Clips: Horizontal ceiling or Vertical mounting clips welded to fan housing, of same material as housing As directed.
6. Horizontal Support: Pair of supports bolted to fan housing, of same material as housing.
7. Vertical Support: Short duct section with welded brackets bolted to fan housing, of same material as housing.
8. Inlet Screen: On unducted fan inlet - wire-mesh screen, of same material as housing.
9. Outlet Screen: On unducted fan outlet - wire-mesh screen, of same material as housing.
10. Backdraft Dampers: Butterfly style, for mounting with flexible connection to fan discharge or direct mounted to discharge diffuser section, of same material as housing.
11. Stall Alarm Probe: Sensing probe capable of detecting fan operation in stall and signaling control devices. Control devices and sequence of operation are specified in Section 230923.23 "Pressure Instruments" and Section 230993.11 "Sequence of Operations for HVAC DDC."
12. Flow Measurement Port: Pressure measurement taps installed in fan inlet to detect and signal airflow readings to temperature-control systems. Control devices and sequence of operation are specified in Section 230923.14 "Flow Instruments" and Section 230993.11 "Sequence of Operations for HVAC DDC."
13. Shaft Seal: Elastomeric seal and PTFE wear plate, suitable for up to 300 deg F (148 deg C).
14. Motor Cover: Cover with side vents to dissipate motor heat, of same material as housing.
15. Inlet Bell: Curved inlet for when fan is not attached to duct, of same material as housing.
16. Inlet Cone: Round-to-round transition, of same material as housing.
17. Outlet Cone: Round-to-round transition, of same material as housing.
18. Stack Cap: Vertical discharge assembly with backdraft dampers, of same material as housing.
19. Direct-Driven Units: Encase motor in housing outside of airstream. Extend lubrication lines to outside of casing and terminate with grease fittings.
20. Factory-wired motor disconnect switch located on outside of fan housing.

H. Factory Finishes:

1. Sheet Metal Parts: Prime coat before final assembly.
2. Exterior Surfaces: Baked-enamel finish coat after assembly.
3. Coatings: As directed..

    a. Apply to finished housings.

b. Apply to fan wheels.

2.5 SOURCE QUALITY CONTROL

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. AMCA Compliance:

1. Comply with AMCA performance requirements and bear the AMCA-Certified Ratings Seal.

C. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans in accordance with AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

D. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings in accordance with AMCA 210/ASHRAE 51, "Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install axial fans level and plumb.

B. Disassemble and reassemble units, as required for moving to the final location, in accordance with manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

D. Equipment Mounting:

1. Install fans on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." Or Section 033053 "Miscellaneous Cast-in-Place Concrete" As directed.
2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

E. Install units with adequate clearances for service and maintenance.

F. Label fans in accordance with requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

G. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

3.2 ELECTRICAL CONNECTIONS

A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.3 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

1. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Fans and components will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.5 CLEANING

A. After completing system installation and testing, adjusting, and balancing and after completing startup service, clean fans internally to remove foreign material and construction dirt and dust.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain axial HVAC fans As directed.

END OF SECTION 233413

SECTION 233416 - CENTRIFUGAL HVAC FANS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Backward-inclined centrifugal fans, including airfoil and curved blade fans.
2. Forward-curved centrifugal fans.
3. Square in-line centrifugal fans.
4. Tubular in-line centrifugal fans.
5. Plenum fans.
6. Utility set fans.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Sustainable Design Submittals:

D. Delegated-Design Submittal: For unit hangars and supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Fan room layout and relationships between components and adjacent structural and mechanical elements, drawn to scale, and coordinated with each other, using input from installers of the items involved.

B. Seismic Qualification Data: For fans, accessories, and components, from manufacturer.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Unusual Service Conditions

1. Base fan-performance ratings on the following:

a. Ambient Temperature: As directed.
b. Altitude: As directed above sea level.
c. Humidity: As directed.

B. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolators and supports.

C. Seismic Performance: Centrifugal fans shall withstand the effects of earthquake motions determined according to ASCE/SEI 7

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 or 1.0 As directed.

D. Capacities and Characteristics:

1. Fan Type: As directed.
2. Blade Type: As directed.
3. Airflow: As directed.
4. External Static Pressure: As directed.
5. Class: AMCA 99, As directed.
6. Drive Arrangement: As directed.
7. Drive Type: Belt or Direct As directed.
8. Discharge Arrangement: As directed.
9. Housing Material: As directed.
10. Housing Coating: As directed.
11. Wheel Size (Diameter): As directed.
12. Wheel Material: As directed.
13. Wheel Coating: As directed.
14. Brake Horsepower: As directed.
15. Fan rpm: As directed.

16. Outlet Velocity: As directed.
17. Motor:

    a. Motor Enclosure Type: As directed.
    b. Efficiency: As directed.
    c. Service Factor: 100 percent.
    d. Suitable for Use with Variable-Frequency Drive: Yes or No.
    e. Electrical Characteristics:

        1) Horsepower: As directed.
        2) RPM: As directed.
        3) Volts: As directed.
        4) Phase: Single or Poly As directed.
        5) Hertz: 60.
        6) Full-Load Amperes: As directed.
        7) Minimum Circuit Ampacity: As directed.
        8) Maximum Overcurrent Protection: As directed.

18. Discharge Sound Power:

    a. 1st Octave: As directed.
    b. 2nd Octave: As directed.
    c. 3rd Octave: As directed.
    d. 4th Octave: As directed.
    e. 5th Octave: As directed.
    f. 6th Octave: As directed.
    g. 7th Octave: As directed.
    h. 8th Octave: As directed.

19. Inlet Sound Power:

    a. 1st Octave: As directed.
    b. 2nd Octave: As directed.
    c. 3rd Octave: As directed.
    d. 4th Octave: As directed.
    e. 5th Octave: As directed.
    f. 6th Octave: As directed.
    g. 7th Octave: As directed.
    h. 8th Octave: As directed.

20. Vibration Isolators:

    a. Type: Spring or Restrained spring as directed.
    b. Static Deflection: 1 inch (25 mm).

21. Spark-Resistance Class: Classified according to AMCA 99, As directed.

2.2 BACKWARD-INCLINED CENTRIFUGAL FANS

A. Description:

1. As directed Factory-fabricated, -assembled, -tested, and -finished, belt- or direct-driven centrifugal fans, consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.
2. Factory-installed and -wired disconnect switch.

B. Housings:

1. Housing Material: As directed.
2. Housing Coating: As directed.
3. Housing Assembly: Sideplates continuously welded or spot welded or attached by continuous Pittsburgh lock seal or similar seal.
4. Formed panels to make curved-scroll housings with shaped cutoff.
5. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
6. Horizontally split, bolted-flange housing.
7. Spun inlet cone with flange.
8. Outlet flange.
9. Discharge Arrangement: Fan scroll housing is field rotatable to any of seven or eight discharge positions as directed. Provide fan with discharge positioned in proper direction to minimize connected duct turns.

C. Wheels:

1. Wheel Configuration: SWSI or DWDI construction with a precision-spun curved inlet flange and a backplate fastened to shaft with setscrews. Wheels shall be statically and dynamically balanced, and nonoverloading as directed.
2. Wheel and Blade Material: As directed.

    a. Spark-Resistant Construction: Classified according to AMCA 99, As directed.

3. Wheel and Blade Coating: As directed.
4. Cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.
5. Backward-Inclined Airfoil Blades:

    a. Aerodynamic design.
    b. Heavy backplate.
    c. Hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate.

6. Backward-Inclined Curved Blades:

    a. Curved design.
    b. Heavy backplate.
    c. Single-thickness blades continuously welded at tip flange and backplate.

D. Shafts:

1. Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with adjustable alignment and belt tensioning.

2. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
3. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

E. Bearings:

1. Prelubricated and Sealed Shaft Bearings:

   a. Self-aligning, pillow-block-type ball bearings.

2. Grease-Lubricated Shaft Bearings, Tapered Roller:

   a. Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.
   b. Extended Lubrication Lines: Extend lines to accessible location.

3. Grease-Lubricated Shaft Bearings, Ball or Roller:

   a. Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
   b. Extended Lubrication Lines: Extend lines to accessible location.

F. Belt Drives:

1. Factory mounted, with adjustable alignment and belt tensioning.
2. Service Factor Based on Fan Motor Size: As directed.
3. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
4. Motor Pulleys: Adjustable pitch for use with motors through 5 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions. Provide fixed pitch pulleys for use with motors larger than 5 hp.
5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
6. Belt Guards: Comply with OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards"; 0.146 inch- (2.7 mm-) thick, 3/4-inch (20-mm) diamond-mesh wire screen, welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short-circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
7. Motor Mount: Adjustable for belt tensioning.

G. Motor Enclosure: As directed.

H. Accessories:

1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.
2. Scroll Drain Connection: NPS 1 (DN 25) steel pipe coupling welded to low point of fan scroll.
3. Companion Flanges: Rolled flanges for duct connections of same material as housing.

4. Discharge Dampers: Assembly with parallel or opposed blades constructed of two plates formed around, and to, shaft, channel frame, and sealed ball bearings; with blades linked outside of airstream to single control lever of same material as housing As directed.
5. Inlet Screens: Grid screen of same material as housing.
6. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
7. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
8. Weather Cover: Enameled-steel sheet with ventilation slots, bolted to housing.
9. Piezometer Ring: Piezometer ring mounted at fan inlet cone for airflow measurement.

2.3 FORWARD-CURVED CENTRIFUGAL FANS

A. Description:

1. Factory-fabricated, -assembled, -tested, and -finished, belt- or direct-driven centrifugal fans, consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure.
2. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.
3. Factory-installed and -wired disconnect switch.

B. Housings:

1. Housing Material: As directed.
2. Housing Coating: As directed.
3. Housing Assembly: Sideplates continuously welded or spot welded or attached by continuous Pittsburgh lock seal or similar seal.
4. Formed panels to make curved-scroll housings with shaped cutoff.
5. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
6. Horizontally split, bolted-flange housing.
7. Spun inlet cone with flange.
8. Outlet flange.
9. Discharge Arrangement: Fan scroll housing field rotatable to any of seven or eight discharge positions. Provide fan with discharge positioned in proper direction to minimize connected duct turns as sirected.

C. Wheels:

1. Wheel Configuration: SWSI or DWDI construction with a curved inlet flange, and a backplate fastened to shaft with setscrews.
2. Wheel and Blade Material: As directed.

    a. Spark-Resistant Construction: Classified according to AMCA 99, As directed.

3. Wheel and Blade Coating: As directed.
4. Cast-iron or cast-steel hub riveted to backplate and fastened to shaft with setscrews.
5. Forward-Curved Wheels:

a. Black-enameled or galvanized-steel construction with inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow.
b. Mechanically secured to flange and backplate; cast-steel hub swaged to backplate and fastened to shaft with setscrews.

D. Shafts:

1. Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with adjustable alignment and belt tensioning.
2. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
3. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

E. Bearings:

1. Prelubricated and Sealed Shaft Bearings:

a. Self-aligning, pillow-block-type ball or roller bearings.

2. Grease-Lubricated Shaft Bearings, Tapered Roller:

a. Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.
b. Extended Lubrication Lines: Extend lines to accessible location.

3. Grease-Lubricated Shaft Bearings, Ball or Roller:

a. Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
b. Extended Lubrication Lines: Extend lines to accessible location.

F. Belt Drives:

1. Factory mounted, with adjustable alignment and belt tensioning.
2. Service Factor Based on Fan Motor Size: As directed.
3. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
4. Motor Pulleys: Adjustable pitch for use with motors through 5 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions. Provide fixed pitch for use with motors larger than 5 hp.
5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
6. Belt Guards: Comply with OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards"; 0.146 inch- (2.7 mm-) thick, 3/4-inch (20-mm) diamond-mesh wire screen, welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short-circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
7. Motor Mount: Adjustable for belt tensioning.

G. Motor Enclosure:

H. Accessories:

1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.
2. Scroll Drain Connection: NPS 1 (DN 25) steel pipe coupling welded to low point of fan scroll.
3. Companion Flanges: Rolled flanges for duct connections of same material as housing.
4. Discharge Dampers: Assembly with parallel or opposed blades constructed of two plates formed around, and to, shaft, channel frame, and sealed ball bearings; with blades linked outside of airstream to single control lever of same material as housing As directed.
5. Inlet Screens: Grid screen of same material as housing.
6. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
7. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
8. Weather Cover: Enameled-steel sheet with ventilation slots, bolted to housing.
9. Piezometer Ring: Piezometer ring mounted at fan inlet cone for airflow measurement.

2.4 SQUARE IN-LINE CENTRIFUGAL FANS

A. Description: Square in-line centrifugal fans.

B. Housing:

1. Housing Material: As directed.
2. Housing Coating: As directed.
3. Housing Construction: Side panels shall be easily removable for service. Include inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

C. Direct-Drive Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing; with wheel, inlet cone, and motor on swing-out service door.

D. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosures around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.

E. Fan Wheels: Aluminum airfoil blades welded to aluminum hub.

F. Motor Enclosure: As directed.

G. Accessories:

1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.
2. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
3. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
4. Companion Flanges: For inlet and outlet duct connections.
5. Fan Guards: 1/2- by 1-inch (13- by 25-mm) mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
6. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.

7. Side Discharge: Flange connector and attachment hardware to provide right-angle discharge on side of unit.

2.5 TUBULAR IN-LINE CENTRIFUGAL FANS

A. Description: Tubular in-line centrifugal fans.

B. Housing:

1. Housing Material: As directed.
2. Housing Coating: As directed.
3. Housing Construction: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

C. Direct-Drive Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing; with wheel, inlet cone, and motor on swing-out service door.

D. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.

E. Fan Wheels: Steel or Aluminum As directed, airfoil blades welded to aluminum hub.

F. Motor Enclosure: As directed.

G. Accessories:

1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.
2. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
3. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
4. Companion Flanges: For inlet and outlet duct connections.
5. Fan Guards: 1/2- by 1-inch (13- by 25-mm) mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
6. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.

2.6 PLENUM FANS

A. Description:

1. Factory-fabricated, -assembled, -tested, and -finished, belt- or direct- driven centrifugal fans, consisting of wheel, fan shaft, bearings, motor, drive assembly, and support structure As directed.
2. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.
3. Factory-installed and -wired disconnect switch.

B. Wheels:

1. Wheel Configuration: SWSI construction with curved inlet flange and heavy backplate; fastened to shaft with setscrews.
2. Wheel and Blade Material: As directed.

    a. Spark-Resistant Construction: Classified according to AMCA 99, As directed.

3. Wheel and Blade Coating: As directed.
4. Backward-Inclined Airfoil Blades: Hollow, die-formed, airfoil-shaped blades continuously welded at tip flange and backplate.

C. Shafts:

1. Statically and dynamically balanced and selected for continuous operation at maximum-rated fan speed and motor horsepower, with adjustable alignment and belt tensioning.
2. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
3. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

D. Bearings:

1. Prelubricated and Sealed Shaft Bearings:

    a. Self-aligning, pillow-block-type ball bearings.
    b. Ball-Bearing Rating Life: ABMA 9, L(10) at 50,000 or 120,000 hours As directed.
    c. Roller-Bearing Rating Life: ABMA 11, L(10) at 50,000 or 120,000 hours As directed..

2. Grease-Lubricated Shaft Bearings, Tapered Roller:

    a. Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.
    b. Roller-Bearing Rating Life: ABMA 11, L(10) at 50,000 or 120,000 hours as directed.
    c. Extended Lubrication Lines: Extend lines to accessible location.

3. Grease-Lubricated Shaft Bearings, Ball or Roller:

    a. Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
    b. Ball-Bearing Rating Life: ABMA 9, L (10) at 50,000 or 120,000 hours As directed.
    c. Roller-Bearing Rating Life: ABMA 11, L (10) at 50,000 or 120,000 hours As directed.
    d. Extended Lubrication Lines: Extend lines to accessible location.

E. Belt Drives:

1. Factory mounted, with adjustable alignment and belt tensioning.
2. Service Factor Based on Fan Motor Size: As directed.

3. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
4. Motor Pulleys: Adjustable pitch for use with motors through 5 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions. Provide fixed pitch for use with motors larger than 5 hp.
5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
6. Belt Guards: Comply with OSHA and fabricate to SMACNA's "HVAC Duct Construction Standards"; 0.146 inch- (2.7 mm-) thick, 3/4-inch (20-mm) diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short-circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
7. Motor Mount: Adjustable for belt tensioning.

F. Motor Enclosure: As directed.

G. Accessories:

1. Inlet Safety Screen: Comply with OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards." Diamond mesh wire screen is welded to steel angle frame or equivalent, prime coated.
2. Safety Enclosure: Comply with OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards." Diamond mesh wire screen is welded to steel angle frame or equivalent, prime coated.
3. Belt Guard: Comply with OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards." Diamond mesh wire screen is welded to steel angle frame or equivalent, prime coated.
4. Inlet Companion Flange: Rolled flanges for duct connections of same material as housing.
5. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
6. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
7. Piezometer Ring: Piezometer ring mounted at fan inlet cone for airflow measurement.

2.7 UTILITY SET FANS

A. Description:

1. Factory-fabricated, -assembled, -tested, and -finished, belt- or direct-driven centrifugal fan utility vent sets, consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure as directed.

B. Housings:

1. Housing Material: As directed.
2. Housing Coating: As directed.
3. Formed panels to make curved-scroll housings with shaped cutoff.
4. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.

5. Discharge Arrangement: Fan scroll housing field rotatable to any of seven or eight discharge positions As directed. Provide fan with discharge positioned in proper direction to minimize connected duct turns.

C. Wheels:

1. Wheel Configuration: SWSI, with hub keyed to shaft.
2. Wheel and Blade Materials: As directed.

    a. Spark-Resistant Construction: Classified according to AMCA 99, As directed.

3. Wheel and Blade Coating: As directed.
4. Backward-Inclined Airfoil Blades:

    a. Aerodynamic design.
    b. Heavy backplate.
    c. Hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate.

5. Backward-Inclined Curved Blades:

    a. Curved design.
    b. Heavy backplate.
    c. Single-thickness blades continuously welded at tip flange and backplate.

6. Backward-Inclined Flat Blades:

    a. Flat design.
    b. Heavy backplate.
    c. Single-thickness blades continuously welded at tip flange and backplate.

7. Forward-Curved Blades:

    a. Curved design.
    b. Heavy backplate.
    c. Single-thickness blades continuously welded or riveted at tip flange and backplate.

D. Shafts:

1. Turned, ground, and polished steel; keyed to wheel hub. First critical speed at least 1.4 times maximum class speed.

E. Bearings:

1. Heavy-duty regreasable ball or roller type in a cast iron pillowblock housing.
2. Ball-Bearing Rating Life: ABMA 9, L (50) of 200,000 hours or L(10) of 80,000 hours As directed.
3. Roller-Bearing Rating Life: ABMA 11, L (50) of 200,000 hours or L(10) of 80,000 hours As directed.
4. Extend grease fitting to accessible location outside of unit.

F. Belt Drive:

1. Factory mounted, with final alignment and belt adjustment made after installation.
2. Service Factor Based on Fan Motor Size: As directed.
3. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
4. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with motors larger than 5 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
6. Belt Guards: Comply with OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards," 0.146 inch- (2.7 mm-) thick, 3/4-inch (20-mm) diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short-circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

G. Motor Enclosure: As directed.

H. Accessories:

1. Inlet and Outlet: Flanged.
2. Companion Flanges: Rolled flanges for duct connections of same material as housing.
3. Backdraft Dampers: Gravity actuated with counterweight and interlocking aluminum blades, with felt edges in steel frame installed on fan discharge.
4. Access Door: Gasketed door in scroll with latch-type handles.
5. Scroll Dampers: Single-blade damper installed at fan scroll top with adjustable linkage.
6. Inlet Screens: Removable wire mesh.
7. Outlet Screens: Removable wire mesh.
8. Belt Guard: OSHA-compliant, completely enclosed shaft and drive components.
9. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
10. Drain Connections: NPS 3/4 (DN 20) threaded coupling drain connection installed at lowest point of housing.
11. Weather Hoods: Weather resistant with stamped vents over motor and drive compartment.
12. Discharge Dampers: Assembly with parallel or opposed blades constructed of two plates formed around, and to, shaft, channel frame, and sealed ball bearings, with blades linked outside of airstream to single control lever of same material as housing.
13. Grease Collection Trough and Receiver: For restaurant exhaust application.
14. Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.

2.8 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

B. Where variable-frequency drives are indicated or scheduled, provide fan motor compatible with variable-frequency drive.

2.9 SOURCE QUALITY CONTROL

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

B. AMCA Compliance: Fans shall comply with AMCA 11 and bear the AMCA-Certified Ratings Seal.

C. Fan Sound Ratings: Comply with AMCA 311 and label fans with the AMCA-Certified Ratings Seal. Sound ratings shall comply with AMCA 301. The fans shall be tested according to AMCA 300.

D. Fan Performance Ratings: Comply with AMCA 211 and label fans with AMCA-Certified Rating Seal. The fans shall be tested for air performance - flow rate, fan pressure, power, fan efficiency, air density, speed of rotation, and fan efficiency - according to AMCA 210/ASHRAE 51.

E. Operating Limits: Classify fans according to AMCA 99.

PART 3 - EXECUTION

3.1 INSTALLATION OF CENTRIFUGAL HVAC FANS

A. Install centrifugal fans level and plumb.

B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

D. Equipment Mounting:

1. Install floor- or roof-mounted centrifugal fans on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete or Section 033053 "Miscellaneous Cast-in-Place Concrete As directed.
2. Support duct-mounted and other hanging centrifugal fans directly from the building structure, using suitable hanging systems as specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
3. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
4. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

E. Curb Support, Field Built-Up: Install roof curb on roof structure, level and secure, according to "The NRCA Roofing and Waterproofing Manual," detail "Equipment Support Curb," number "SPF-9" (page 1409) and detail "Equipment Support Curb," number "SPF-9S" (page 1410). Install and secure centrifugal fans on curbs, and coordinate roof penetrations and flashing with roof construction. Secure units to curb support with anchor bolts.

F. Curb Support, Prefabricated: Rail-type wood support provided by fan manufacturer.

G. Unit Support: Install centrifugal fans level on structural curbs or pilings As directed. Coordinate wall penetrations and flashing with wall construction. Secure units to structural support with anchor bolts.

H. Isolation Curb Support: Install centrifugal fans on isolation curbs and install flexible duct connectors and vibration-isolationand seismic-control devices.

1. Comply with requirements in Section 233300 "Air Duct Accessories" for flexible duct connectors.
2. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" or Section 230548.13 "Vibration Controls for HVAC" for vibration-isolation and seismic-control devices As directed.

I. Install units with clearances for service and maintenance.

J. Label fans according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 DUCTWORK AND PIPING CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

B. Install ducts adjacent to fans to allow service and maintenance.

C. Install piping from scroll drain connection, with trap with seal equal to 1.5 times specified static pressure, to nearest floor drain with pipe sizes matching the drain connection.

D. Install heat tracing on all drain piping subject to freezing temperature and as indicated on Drawings. Furnish and install heat tracing according to Section 230533 "Heat Tracing for HVAC Piping."

3.3 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."

2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Tests and Inspections:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that there is adequate maintenance and access space.
4. Verify that cleaning and adjusting are complete.
5. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
6. Adjust belt tension.
7. Adjust damper linkages for proper damper operation.
8. Verify lubrication for bearings and other moving parts.
9. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
10. See Section 230593 "Testing, Adjusting, and Balancing For HVAC" for testing, adjusting, and balancing procedures.
11. Remove and replace malfunctioning units and retest as specified above.

E. Test and adjust controls and safeties. Controls and equipment will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys as required to achieve design airflow.

E. Lubricate bearings.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans As directed..

END OF SECTION 233416

SECTION 233423 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Ceiling-mounted ventilators.
2. Centrifugal ventilators - roof downblast.
3. Centrifugal ventilators - roof upblast and sidewall.
4. Sidewall propeller fans.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints.

C. Delegated-Design Submittal: For unit hangars and supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, or BIM model, drawn to scale and coordinated with all building trades.

B. Seismic Qualification Data: For fans, accessories, and components, from manufacturer.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Unusual Service Conditions

1. Base fan-performance ratings on the following:

a. Ambient Temperature: As directed.
b. Altitude: As directed.
c. Humidity: As directed.

B. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation and seismic restraints, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

C. Seismic Performance: HVAC power ventilators shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 or 1.0 As directed.

D. Capacities and Characteristics:

1. Airflow: As directed.
2. External Static Pressure: As directed.
3. Fan Diameter: As directed.
4. Drive Type: Direct or Belt As directed.
5. Fan rpm: As directed.
6. Tip Speed: As directed.
7. Sound: As directed.
8. Curb Height: As directed.
9. Damper: As directed.
10. Brake Horsepower: As directed.
11. Motor Size: As directed.
12. Motor rpm: As directed.
13. Motor Enclosure: As directed.
14. Electrical Characteristics:

a. Volts: As directed.

b. Phase: Single or Poly As directed.
c. Hertz: 60

15. Accessories:

2.2 CEILING-MOUNTED VENTILATORS

A. Housing: Steel, lined with acoustical insulation.

B. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel removable for service.

C. Back-draft damper: Integral.

D. Grille: Louvered grille with flange on intake and thumbscrew or spring retainer attachment to fan housing as directed.

E. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.

F. Accessories:

1. Variable-Frequency Motor Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Manual Starter Switch: Single-pole rocker switch assembly with cover and pilot light.
3. Time-Delay Switch: Assembly with single-pole rocker switch, timer, and cover plate.
4. Motion Sensor: Motion detector with adjustable shutoff timer.
5. Ceiling Radiation Damper: Fire-rated assembly with ceramic blanket, stainless steel springs, and fusible link.
6. Filter: Washable aluminum to fit between fan and grille.
7. Isolation: Rubber-in-shear vibration isolators.
8. Manufacturer's standard roof jack or wall cap, and transition fittings.

2.3 CENTRIFUGAL VENTILATORS - ROOF DOWNBLAST

A. Housing: Downblast; removable square, one-piece aluminum base with venturi inlet cone As directed.

B. Fan Wheels: Aluminum hub and wheel with backward-inclined blades; sparkproof construction.

C. Belt Drives:

1. Resiliently mounted to housing.
2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
4. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
5. Motor Pulleys: Adjustable pitch for use with motors through 5 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions. Provide fixed pitch for use with motors larger than 5 hp.

6. Fan and motor isolated from exhaust airstream.

D. Accessories:

1. Variable-Frequency Motor Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside or outside fan housing, factory wired through an internal aluminum conduit.
3. Bird Screens: Removable, 1/2-inch (13-mm) mesh, aluminum or brass wire.
4. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
5. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
6. Spark-resistant, all-aluminum wheel construction.
7. Mounting Pedestal: Galvanized steel with removable access panel.

E. Prefabricated Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: As directed.
2. Overall Height: As directed.
3. Sound Curb: Curb with sound-absorbing insulation.
4. Hinged sub-base to provide access to damper or as cleanout for grease applications.
5. Burglar Bars: Thick steel bars welded in place to form 6-inch (150-mm) squares As directed.
6. Pitch Mounting: Manufacture curb for roof slope.
7. Metal Liner: Galvanized steel.
8. Mounting Pedestal: Galvanized steel with removable access panel.

2.4 CENTRIFUGAL VENTILATORS - ROOF UPBLAST OR SIDEWALL

A. Configuration: Centrifugal ventilator As directed.

B. Housing: Removable Square, one-piece aluminum base with venturi inlet cone As directed.

1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains.
2. Provide grease collector.

C. Fan Wheels: Aluminum hub and wheel with backward-inclined blades; sparkproof construction.

D. Belt Drives:

1. Resiliently mounted to housing.
2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings; minimum ABMA9, L(10) of 100,000 hours
4. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.

5. Motor Pulleys: Adjustable pitch for use with motors through 5 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions. Provide fixed pitch for use with motors larger than 5 hp.
6. Fan and motor isolated from exhaust airstream.

E. Accessories:

1. Variable-Frequency Motor Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside or outside fan housing, factory wired through an internal aluminum conduit.
3. Bird Screens: Removable, 1/2-inch (13-mm) mesh, aluminum or brass wire.
4. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
5. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
6. Spark-resistant, all-aluminum wheel construction.
7. Mounting Pedestal: Galvanized steel with removable access panel.
8. Wall Mount Adapter: Attach wall-mounted fan to wall.
9. Grease Hood Kitchen Exhaust: UL 762 listed for grease-laden air exhaust.

F. Prefabricated Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: As directed.

G. Prefabricated Kitchen Exhaust Roof Curbs: Galvanized steel; mitered and welded corners; ventilation openings on all sides to ventilate curb interstitial space. Size as required to suit roof opening and fan base.

1. Configuration: As directed.
2. Overall Height: As directed.
3. Sound Curb: Curb with sound-absorbing insulation and galvanized metal liner.
4. Hinged sub-base to provide access to damper or as cleanout for grease applications.
5. Burglar Bars: Thick steel bars welded in place to form 6-inch (150-mm) squares.
6. Pitch Mounting: Manufacture curb for roof slope As directed.
7. Metal Liner: Galvanized steel.
8. Mounting Pedestal: Galvanized steel with removable access panel.
9. Vented Curb: For kitchen exhaust; 12-inch- (300-mm-) high galvanized steel; unlined, with louvered vents in vertical sides.
10. NFPA 96 code requirements for commercial cooking operations.
11. Kitchen Hood Exhaust: UL 762 listed for grease-laden air.

2.5 SIDEWALL PROPELLER FANS

A. Housing: Galvanized-steel sheet with flanged edges and integral orifice ring, with baked-enamel finish coat applied after assembly.

B. Fan Wheels: Formed-steel blades riveted to heavy-gauge steel spider bolted to cast-iron hub.

C. Fan Wheel: Replaceable, cast or extruded-aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades as directed.

D. Fan Drive: Direct-drive motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.

E. Fan Drive:

1. Belt drive.
2. Resiliently mounted to housing.
3. Statically and dynamically balanced.
4. Selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
5. Extend grease fitting to accessible location outside of unit.
6. Service Factor Based on Fan Motor Size: 1.4.
7. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
8. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
    a. Ball-Bearing Rating Life: ABMA 9, L(10) of 100,000 hours.
9. Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
10. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
11. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
12. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.

F. Accessories:

1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
2. Dampers: Counterbalanced, parallel-blade, backdraft dampers factory set to close when fan stops.
3. Motorized Dampers: Parallel-blade dampers with electric actuator wired to close when fan stops.
4. Motor-Side Back Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
5. Wall Sleeve: Galvanized steel to match fan and accessory size.
6. Weathershield Hood: Galvanized steel to match fan and accessory size.
7. Weathershield Front Guard: Galvanized steel with expanded metal screen.

2.6 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2.7 SOURCE QUALITY CONTROL

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

B. AMCA Certification: Fans shall comply with AMCA 11 and bear the AMCA-Certified Ratings Seal.

C. Fan Sound Ratings: Comply with AMCA 311, and label fans with the AMCA-Certified Ratings Seal. Sound ratings shall comply with AMCA 301. The fans shall be tested according to AMCA 300.

D. Fan Performance Ratings: Comply with AMCA 211 and label fans with AMCA-Certified Rating Seal. The fans shall be tested for air performance - flow rate, fan pressure, power, fan efficiency, air density, speed of rotation, and fan efficiency - according to AMCA 210/ASHRAE 51.

E. Operating Limits: Classify according to AMCA 99.

F. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

PART 3 - EXECUTION

3.1 INSTALLATION OF HVAC POWER VENTILATORS

A. Install power ventilators level and plumb.

B. Equipment Mounting:

1. Install power ventilators on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete or Section 033053 "Miscellaneous Cast-in-Place Concrete" As directed.
2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

C. Secure roof-mounted fans to roof curbs with zinc-plated hardware. See Section 077200 "Roof Accessories" for installation of roof curbs.

D. Ceiling Units: Suspend units from structure; use steel wire or metal straps.

E. Support suspended units from structure using threaded steel rods As directed having a static deflection of 1 inch (25 mm). Vibration-control devices are specified in Section 230548 "Vibration and Seismic Controls for HVAC or Section 230548.13 "Vibration Controls for HVAC As directed.

F. Install units with clearances for service and maintenance.

G. Label units according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 DUCTWORK CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

3.3 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Tests and Inspections:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that there is adequate maintenance and access space.
4. Verify that cleaning and adjusting are complete.

5. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
6. Adjust belt tension.
7. Adjust damper linkages for proper damper operation.
8. Verify lubrication for bearings and other moving parts.
9. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
10. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
11. Shut unit down and reconnect automatic temperature-control operators.
12. Remove and replace malfunctioning units and retest as specified above.

E. Test and adjust controls and safeties. Controls and equipment will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys as required to achieve design airflow.

E. Lubricate bearings.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans as directed.

END OF SECTION 233423

SECTION 233433.13 - COMMERCIAL AIR CURTAINS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes commercial air-curtain unit.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For air curtains.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal: For air curtains indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by a qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of air-curtain mounting assemblies.
2. Include design calculations for selecting vibration isolators and seismic restraints.

1.3 INFORMATIONAL SUBMITTALS

A. Sample warranties.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of air curtains that fail in materials or workmanship within specified warranty period.

1. Warranty Period (Nonheating Units): 60 or 24 As directed months.
2. Warranty Period (Electric Heating Units): 18 or 24 As directed months.
3. Warranty Period (Hot-Water Heating Units): 18 or 24 As directed months.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Unusual Service Conditions:

1. Base fan-performance ratings on the following:

a. Ambient Temperature: As directed.
b. Altitude: As directed.
c. Humidity: As directed.

B. Capacities and Characteristics:

1. Application: As directed.
2. Mounting Type: As directed.
3. Discharge Direction: Vertical.
4. Door Type: Exterior or Interior As directed.
5. Door Height: As directed.
6. Door Width: As directed.
7. Unit Length: As directed.
8. Net Weight: As directed.
9. Nozzle Velocity: As directed.
10. Airflow: As directed.
11. Intake: Internal.
12. Number of Fan(s): As directed.
13. Fan Motor:

a. Electrical Characteristics:

1) Horsepower: 0.2 or 0.5 hp. As directed.
2) Volts: As directed.
3) Phase: Single or Three As directed.
4) Hertz: 60 Hz.
5) Speed: 1750 rpm.
6) Full-Load Amperes: As directed.
7) Minimum Circuit Ampacity: As directed.
8) Maximum Overcurrent Protection: As directed.

14. Sound Level Measured 10 Feet (3 m) from Nozzle: As directed.
15. Hot-Water Coil:

a. Entering-Water Temperature: As directed.
b. Leaving-Water Temperature: As directed.
c. Water Flow: As directed.
d. Water Pressure Drop: As directed.
e. Air-Temperature Rise: As directed.
f. Number of Coil Row(s): One or Two As directed.

16. Electric Heater:

a. Capacity: As directed.
b. Air-Temperature Rise: As directed.
c. Volts: As directed.
d. Phase: Single or Three As directed.
e. Hertz: 60 Hz.
f. Minimum Circuit Ampacity: As directed.
g. Maximum Overcurrent Protection: As directed.
h. Control Step(s): One or Two As directed.

2.2 COMMERCIAL AIR-CURTAIN UNIT

A. Housing:

1. Galvanized Steel: Galvanized steel with electrostatically applied, epoxy-enamel, powder-coat finish.
2. Discharge Nozzle: Integral to housing, containing adjustable air-directional vanes with 40-degree sweep front to back.

B. Mounting Brackets: Galvanized steel, for wall or ceiling mounting as directed.

C. Air-Intake Grilles:

1. Grilles: Integral to, and same material as, housing.

D. Fans:

1. Centrifugal, forward curved, double width, double inlet.
2. Galvanized steel or Painted steel or Aluminum As directed.
3. Statically and dynamically balanced.
4. Direct drive.

E. Motors: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Single speed or Two speed or Multispeed or Variable speed as directed.
3. Resiliently mounted.
4. Continuous duty.
5. Totally enclosed, air over.
6. Integral thermal-overload protection.
7. Bearings: Permanently sealed, lifetime, prelubricated, ball bearings.
8. Disconnect: Internal power cord with plug and receptacle or Lockable disconnect As directed.

F. Water Coils:

1. Type: As directed.
2. Piping Connections: Threaded on same end or opposite ends as directed.

3. Tube Material: Copper, complying with ASTM B75/B75M.

    a. Tube Diameter: 0.625 inch (15.9 mm).

4. Fins: Aluminum or Copper with fin spacing As directed.
5. Fin and Tube Joint: Mechanical bond.
6. Headers: Seamless copper tube with brazed joints, prime coated.
7. Frames: Galvanized-steel channel frame, As directed.
8. Ratings: In accordance with ASHRAE 33.
9. Working-Pressure Ratings: 200 psig (1380 kPa), 325 deg F (163 deg C).

G. Electric-Resistance Coils:

1. Coil Assembly: Comply with UL 1995.
2. Frame: Galvanized-steel frame.
3. Heating Elements: Open-coil resistance wire of 80 percent nickel and 20 percent chromium, supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
4. Overtemperature Protection: Disk-type, automatically reset, thermal-cutout, safety device; serviceable through terminal box without removing heater from duct or unit.

    a. Secondary Protection: Load-carrying, manually reset or manually replaceable, thermal cutouts; factory wired in series with each heater stage.

5. Control Panel: As directed Unit or Remote mounted with disconnecting means and overcurrent protection. Include the following controls:

    a. Magnetic contactor.
    b. Solid-state stepless pulse or Step controller as directed.
    c. Time-delay relay.
    d. Pilot lights; one per step.
    e. Airflow-proving switch.

H. Filters:

1. Disposable Panel Filters: Factory-fabricated, viscous-coated, flat-panel-type, disposable air filters with glass-fiber media sprayed with nonflammable adhesive in cardboard or galvanized-steel frame as directed.
2. Washable Panel Filters: Removable, aluminum or stainless steel baffle-type filters with spring-loaded fastening as directed; with minimum 0.0781-inch- (1.984-mm-) thick, stainless steel filter frame.
3. Mounting Frames: Welded, galvanized steel with gaskets and fasteners and suitable for bolting together into built-up filter banks.

I. Controls:

1. Built-in or Remote, Field-Installed Thermostat As directed: Line voltage or 24 V, factory installed and wired to junction box on air curtain or motor-control panel As directed.
2. Automatic Door Switch: Installed in door area to activate air curtain when door opens and to deactivate air curtain when door closes As directed.
3. Start-Stop, Push-Button Switch: Manually activates and deactivates air curtain.

4. Three-Speed Switch: Manually activates, deactivates, and controls air-curtain fan speed.
5. Time-Delay Relay: Factory installed and adjustable to allow air curtain to operate from 0.5 seconds to 10 hours.
6. Motor-Control Panel: Complete with motor starter, 115-V ac transformer with primary and secondary fuses, terminal strip, and NEMA 250, Type 1 or Type 12 enclosure with door-mounted, HAND-OFF-AUTO switch or with built-in, variable fan-speed control As directed.

J. Accessories:

1. Mounting Brackets: Adjustable mounting brackets for wall or top mounting As directed.
2. Discharge Extension Neck: For ceiling-recessed installation.

2.3 SOURCE QUALITY CONTROL

A. Source Quality Control: Test to 300 and 200 psig (2070 and 1380 kPa) underwater.

B. Comply with AMCA 220, "Laboratory Methods of Testing Air Curtains for Aerodynamic Performance Ratings," for airflow, outlet velocity, and power consumption.

C. Comply with AHRI 410, "Forced-Circulation Air-Cooling and Air-Heating Coils," for components, construction, and rating.

D. Comply with NSF 37, "Air Curtains for Entranceways in Food and Food Service Establishments."

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

F. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Install air curtains with clearance for equipment service and maintenance.

B. Equipment Installation: Install air curtains with seismic-restraint devices. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

C. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

3.2 PIPING CONNECTIONS

A. Comply with requirements for heating hot-water piping specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to equipment, allow space for service and maintenance.

3.3 ELECTRICAL CONNECTIONS

A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Tests and Inspections:

1. After installing air curtains completely, perform visual and mechanical check of individual components.
2. After electrical circuitry has been energized, start unit to confirm motor rotation and unit operation. Certify compliance with test parameters.
3. Inspect for water leaks.

4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Air-curtain unit will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust motor speed to achieve specified airflow.

B. Adjust discharge louver and dampers to regulate airflow.

C. Adjust air-directional vanes.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain commercial air curtains.

END OF SECTION 233433.13

SECTION 233433.16 - INDUSTRIAL AIR CURTAINS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes industrial air-curtain unit.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For air curtains.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal: For air curtains indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of air-curtain mounting assemblies.
2. Include design calculations for selecting vibration isolators and seismic restraints.

1.3 INFORMATIONAL SUBMITTALS

A. Sample warranties.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of air curtains that fail in materials or workmanship within specified warranty period.

1. Warranty Period (Nonheating Units): 24 months.
2. Warranty Period (Water Heating Units): 18 or 24 months as directed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Unusual Service Conditions:

1. Base fan-performance ratings on the following:

a. Ambient Temperature: As directed.
b. Altitude: As directed.
c. Humidity: As directed.

B. Capacities and Characteristics:

1. Application: As directed.
2. Mounting Type: As directed.
3. Discharge Direction: Horizontal or Vertical As directed.
4. Door Type: Exterior or Interior As directed.
5. Door Height: As directed.
6. Door Width: As directed.
7. Unit Length: As directed.
8. Net Weight: As directed.
9. Nozzle Velocity: 1000 (5) fpm (m/s).
10. Airflow: As directed.
11. Intake: Internal or External As directed.
12. Number of Fan(s): As directed.
13. Fan Motor:

a. Electrical Characteristics:

1) Horsepower: As directed.
2) Volts: As directed.
3) Phase: Single or Three As directed.
4) Hertz: 60 Hz.
5) Speed: 1750 rpm.
6) Full-Load Amperes: As directed.
7) Minimum Circuit Ampacity: As directed.
8) Maximum Overcurrent Protection: As directed.

14. Sound Level Measured 10 Feet (3 m) from Nozzle: As directed.
15. Hot-Water Coil:

a. Entering-Water Temperature: As directed.
b. Leaving-Water Temperature: As directed.
c. Water Flow: As directed.
d. Water Pressure Drop: As directed.
e. Air-Temperature Rise: As directed.
f. Number of Coil Row(s): One or two as directed.

16. Electric Heater:

a. Capacity: As directed.
b. Air-Temperature Rise: As directed.
c. Volts: As directed.
d. Phase: Single or Three As directed.
e. Hertz: 60 Hz.
f. Minimum Circuit Ampacity: As directed.
g. Maximum Overcurrent Protection: As directed.
h. Control Step(s): As directed.

2.2 INDUSTRIAL AIR-CURTAIN UNIT

A. Housing:

1. Galvanized Steel: Galvanized steel with electrostatically applied, epoxy-enamel, powder-coat finish.
2. Electroplated Steel: Heavy-gauge, electroplated-zinc steel with welded construction and polyester-coated finish.
3. Aluminum: Heavy-gauge, aluminum construction.

    a. Anodized Finish: Match finish and color of adjacent architectural metals. Comply with NAAMM/NOMMA 500 for recommendations for applying and designating finishes.
    b. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.

        1) Class II, Clear Anodic Finish: AA-M12C22A31 (Mechanical Finish: Nonspecular as fabricated; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class II, clear coating 0.010 mm or thicker) complying with AAMA 611.
        2) Class II, Color Anodic Finish: AA-M12C22A32/A34 (Mechanical Finish: Nonspecular as fabricated; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class II, integrally colored or electrolytically deposited color coating 0.010 mm or thicker).

4. Fixed Discharge Nozzle: Integral part of the housing, containing fixed air-directional vanes.
5. Adjustable Discharge Nozzle: Integral part of the housing, containing adjustable air-directional vanes with 40-degree sweep front to back.

B. Mounting Brackets: Steel, for wall or ceiling mounting As directed.

C. Air-Intake Louvers: Comply with requirements in Section 089000 "Louvers and Vents."

D. Air-Intake Louvers or Grilles As directed:

1. Louvers: Integral part of and same material as the housing, mechanically field adjustable and capable of reducing air-outlet velocity by 60 percent with louver in totally closed position.
2. Grille: Integral part of and same material as the housing.
3. Insect Screen: Aluminum or Stainless steel removable as directed.

E. Fans:

1. Centrifugal, forward curved, double width, double inlet or Vane axial As directed.
2. Galvanized steel or Painted steel or Aluminum As directed.
3. Statically and dynamically balanced.
4. Direct drive or Belt drive, equipped with belt guards, adjustable sheaves, and pulleys as directed.

F. Motors: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Single speed or Two speed or Multispeed As directed.
3. Resiliently mounted.
4. Continuous duty.
5. Totally enclosed, air over or Totally enclosed, fan cooled or Open, drip proof or Explosion proof As directed.
6. Integral thermal-overload protection.
7. Bearings: Permanently sealed, lifetime, prelubricated, ball bearings.
8. Disconnect: Internal power cord with plug and receptacle.

G. Water Coils:

1. Type: As directed.
2. Piping Connections: Threaded on same end or opposite ends As directed.
3. Tube Material: Copper, complying with ASTM B75/B75M.

    a. Tube Diameter: 0.625 inch (15.9 mm).

4. Fins: Aluminum or Copper with fin spacing as directed.
5. Fin and Tube Joint: Mechanical bond or Silver brazed as directed.
6. Headers: As directed.
7. Frames: Galvanized-steel channel frame, As directed.
8. Ratings: In accordance with ASHRAE 33.
9. Working-Pressure Ratings: 200 psig (1380 kPa), 325 deg F (163 deg C).

H. Electric-Resistance Coils:

1. Coil Assembly: Comply with UL 1995.
2. Frame: Galvanized-steel frame.
3. Heating Elements: Open-coil resistance wire of 80 percent nickel and 20 percent chromium, supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
4. Overtemperature Protection: Disk-type, automatically reset, thermal-cutout, safety device; serviceable through terminal box without removing heater from duct or unit.

    a. Secondary Protection: Load-carrying, manually reset or manually replaceable, thermal cutouts; factory wired in series with each heater stage.

5. Control Panel: As directed Unit or Remote mounted with disconnecting means and overcurrent protection. Include the following controls:

    a. Magnetic contactor.
    b. Solid-state stepless pulse or Step controller As directed.
    c. Toggle switches; one per step.
    d. Time-delay relay.
    e. Pilot lights; one per step.
    f. Airflow-proving switch.

I. Filters:

1. Disposable Panel Filters: Factory-fabricated, viscous-coated, flat-panel-type, disposable air filters with glass-fiber media sprayed with nonflammable adhesive in cardboard or galvanized-steel frame As directed.
2. Washable Panel Filters: Removable, stainless steel, baffle-type filters with spring-loaded fastening; with minimum 0.0781-inch- (1.984-mm-) thick, stainless steel filter frame.
3. Mounting Frames: Welded, galvanized steel with gaskets and fasteners and suitable for bolting together into built-up filter banks.

J. Controls:

1. Built-in or Remote, Field-Installed Thermostat As directed: Line voltage or 24 V, factory installed and wired to junction box on air curtain or motor-control panel As directed.
2. Automatic Door Switch: Installed in door area to activate air curtain when door opens and to deactivate air curtain when door closes as directed.
3. Start-Stop, Push-Button Switch: Manually activates and deactivates air curtain.
4. Three-Speed Switch: Manually activates, deactivates, and controls air-curtain fan speed.
5. Time-Delay Relay: Factory installed and adjustable to allow air curtain to operate from 0.5 seconds to 10 hours.
6. Motor-Control Panel: Complete with motor starter, 115-V ac transformer with primary and secondary fuses, terminal strip, and NEMA 250, Type 1 or Type 12 enclosure with door-mounted, HAND-OFF-AUTO switch or with built-in, variable fan-speed control As directed.

K. Accessories:

1. Mounting Brackets: Adjustable mounting brackets for drum-type roll-up doors.

2.3 SOURCE QUALITY CONTROL

A. Source Quality Control: Test to 300 and 200 psig (2070 and 1380 kPa) underwater.

B. Testing: Test and inspect steam coils in accordance with ASHRAE 33.

C. Comply with AMCA 220, "Laboratory Methods of Testing Air Curtains for Aerodynamic Performance Ratings," for airflow, outlet velocity, and power consumption.

D. Comply with AHRI 410, "Forced-Circulation Air-Cooling and Air-Heating Coils," for components, construction, and rating.

E. Comply with NSF 37, "Air Curtains for Entranceways in Food and Food Service Establishments."

F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

G. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install air curtains with clearance for equipment service and maintenance.

B. Equipment Installation: Install air curtains with seismic-restraint devices. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

C. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

3.2 PIPING CONNECTIONS

A. Comply with requirements for heating hot-water piping specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to equipment, allow space for service and maintenance.

C. Breeching: Comply with applicable requirements in Section 235116 "Fabricated Breechings and Accessories." Connect breeching to full size at flue outlet.

3.3 ELECTRICAL CONNECTIONS

A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."

2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Tests and Inspections:

1. After installing air curtains completely, perform visual and mechanical check of individual components.
2. After electrical circuitry has been energized, start unit to confirm motor rotation and unit operation. Certify compliance with test parameters.
3. Inspect for water leaks.
4. Test gas train and verify that there are no gas leaks.
5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Air-curtain unit will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust belt tension.

B. Adjust motor and fan speed to achieve specified airflow.

C. Adjust discharge louver and dampers to regulate airflow.

D. Adjust air-directional vanes.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain industrial air curtains As directed.

END OF SECTION 233433.16

SECTION 233439 - HIGH-VOLUME, LOW-SPEED FANS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes high-volume, low-speed fans.

1.2 DEFINITIONS

A. HVLS - High volume, low speed.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Show dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

D. Delegated-Design Submittal: For each HVLS fan.

1. Include design calculations and details for selecting product mounting components and seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Design Calculations: Calculate static and dynamic loading due to equipment weight, operation, and seismic forces required to select mounting components and seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and details, drawn to scale and coordinated with each other, using input from installers of the items involved.

B. Seismic-Restraint Details:

1. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.

2. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
3. Preapproval and Evaluation Documentation: By an evaluation service member of ICC-ES or Office of Statewide Health Planning and Development or an agency acceptable to authorities having jurisdiction as directed, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of fans that fail in materials or workmanship within specified warranty period.

1. Warranty Period:

a. For Motor, Including Controls: Five year(s) from date of Substantial Completion.
b. For Parts, Including Blades and Hub: Five year(s) from date of Substantial Completion.
c. For Labor: One year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. UL Compliance: Listed and labeled to UL 507.

C. CSA Compliance: Listed and labeled to CSA C22.2, No. 113.

D. Comply with NFPA 13 requirements for HVLS fans.

E. AMCA Compliance:

1. Test HVLS fans according to AMCA 230.
2. Certify HVLS fan performance according to AMCA 211.

F. Performance Data: Comply with ANSI 230 test procedure standard, based on five rating points: 20-, 40-, 60-, 80-, and 100-percent of maximum speed. Comply with AMCA 211 for publication of performance data.

G. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design HVLS ceiling fans.

H. Seismic Performance: HVLS ceiling fans shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the HVLS fans will remain in place without separation of any parts when subjected to the seismic forces specified and the units will be fully operational after the seismic event.
2. Component Importance Factor: 1.5 or 1.0 As directed.
3. Insert requirements for Component Amplification Factor and Component Response Modification Factor.

2.2 CAPACITIES AND CHARACTERISTICS

A. Fan:

1. Type: HVLS As directed.
2. Number of Fan Blades: As directed.
3. Fan Diameter: As directed.
4. Maximum Fan Speed: As directed.
5. Fan Airflow at AMCA Rating Points cfm (L/s):

    a. Airflow at 20 Percent: As directed.
    b. Airflow at 40 Percent: As directed.
    c. Airflow at 60 Percent: As directed.
    d. Airflow at 80 Percent: As directed.
    e. Airflow at 100 Percent: As directed.

6. Fan Discharge Sound Power at Maximum Speed, dB:

    a. 1st Octave: As directed.
    b. 2nd Octave: As directed.
    c. 3rd Octave: As directed.
    d. 4th Octave: As directed.
    e. 5th Octave: As directed.
    f. 6th Octave: As directed.
    g. 7th Octave: As directed.
    h. 8th Octave: As directed.

B. Motor:

1. Size: As directed.
2. Speed: As directed.
3. Volts: Phase: Single or Three As directed.
4. Hertz: 60 Hz.

5. Full-Load Amperes: As directed.
6. Minimum Circuit Ampacity: As directed.
7. Maximum Overcurrent Protection: As directed.

2.3 MANUFACTURERS

A. Source Limitations: Obtain HVLS fans from single source from single manufacturer.

2.4 HIGH-VOLUME, LOW-SPEED FANS

A. Description: Factory-assembled and -tested horizontal, non-ducted fan unit, consisting of large-diameter blade set, direct-drive electric motor, with speed-reducing gearbox or variable-speed motor controller as directed.

1. Provide fan designed to circulate large air volume, vertically, at low velocity.
2. Maximum Operating Temperature: 122 (50) or 140 (60) deg F (deg C) As directed.
3. Frame:
    a. Material: As directed.
        1) Finish: As directed.
4. Diameter: As directed.
5. Blades: Airfoil type.
    a. Quantity: 3
    b. Material: Aluminum
        1) Blade Finish: Anodized
6. Motor: As directed.
7. Wiring and Controls Enclosure:
    a. NEMA 250, As directed.
    b. Material: As directed.
        1) Enclosure Finish: As directed.
    c. Grounded.
8. Controls: Provide wall-mounted keypad.
    a. Provide speed control as directed.
9. Maximum Sound Power Level: As directed.
10. Standard Mounting Bracket: Steel beam/steel angle.
11. Mounting Bracket: As directed.
12. Accessories:
    a. Mounting extension tube.

PART 3 - EXECUTION

3.1 INSTALLATION OF HIGH-VOLUME LOW-SPEED FANS

A. Examine conditions for compliance with requirements for installation tolerances and other conditions affecting HVLS fan performance, maintenance, and operations.

B. Fan locations indicated on Drawings are approximate. Determine exact locations before roughing-in for mounting, control, and electrical connections.

C. Install fan according to manufacturer's published instructions.

D. Comply with NECA 1 and NFPA 70.

E. Comply with NFPA 13 for installation of HVLS fans and maximum allowable fan diameter. Center HVLS fans between four adjacent sprinklers. Minimum vertical clearance from HVLS fan to sprinkler deflector is 3 feet (0.9 m).

F. Comply with NFPA 72 and interlock HVLS fans to shut down upon receiving an alarm from fire alarm system.

G. Equipment Mounting:

1. Anchor fan to building structure with manufacturer's recommended mounting bracket or as shown in approved delegated design for installed condition As directed.
2. Consult a licensed professional structural engineer for mounting methods and approval for mounting to the structure. Structure must be able to withstand the torque and forces generated by the fan.
3. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
4. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
5. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

H. Install unit to permit access for maintenance.

I. Install parts and accessories shipped loose.

J. Engage a factory-authorized service representative to perform or Perform startup service As directed.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that fan is secure on mountings and supporting devices and that connections to electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
3. Verify proper motor rotation direction and free fan rotation.
4. Check bearing and gearbox lubrication.
5. Verify proper fan rotation. Set rotation selector to blow vertically downward during heating season and vertically upward during cooling season.

3.2 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

E. Install power wiring to field-mounted electrical devices, furnished by fan manufacturer, but not factory mounted.

3.3 CONTROL CONNECTIONS

A. Connect control wiring to field-mounted control devices.

B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

C. Connect control interlock wiring between HVLS fan and other equipment to provide a complete and functioning system.

D. Connect control wiring between fan unit control interface and control system to provide remote control and monitoring.

E. Install control devices furnished by manufacturer, but not factory mounted.

F. Install control wiring to field-mounted control devices, furnished by fan manufacturer, but not factory mounted.

G. Protect installed units from damage caused by other work.

3.4 FIELD QUALITY CONTROL

A. Testing Agency, Owner Engaged: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency, Contractor Engaged: Engage a qualified testing agency to perform tests and inspections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Fan or components will be considered defective if fan or components do not pass tests and inspections.

E. Prepare and submit test and inspection reports.

3.5 ADJUSTING

A. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

3.6 CLEANING

A. Clean equipment externally; remove coatings applied for protection during shipping and storage, foreign material, and oily residue according to manufacturer's written instructions. Following manufacturer's cleaning procedures, and clean with manufacturer-recommended cleaning products.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain HVLS fans as directed.

END OF SECTION 233439

SECTION 233533 - LISTED KITCHEN VENTILATION SYSTEM EXHAUST DUCTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Listed grease ducts.
2. Access doors.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For listed grease ducts.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of hangers and seismic restraints.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.4 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D9.1/D9.1M, "Sheet Metal Welding Code," for shop and field welding of joints and seams in listed grease ducts and field-fabricated grease ducts.

PART 2 - PRODUCTS

2.1 LISTED GREASE DUCTS

A. Description: Factory-fabricated, -listed, and -labeled, double-wall ducts tested according to UL 1978 and rated for 500 deg F (260 deg C) continuously, or 2000 deg F (1093 deg C) for 30 minutes; with positive or negative duct pressure and complying with NFPA 211.

B. Construction: Inner shell and outer jacket separated as directed by annular space filled with high-temperature, ceramic-fiber insulation.

1. Inner Shell: ASTM A666, Type 304 or Type 316 stainless steel as directed
2. Outer Jacket: Aluminized steel or Stainless steel where concealed as directed. Stainless steel where exposed.

C. Gaskets and Flanges: Ensure that gaskets and sealing materials are rated at 1500 deg F (816 deg C) minimum.

D. Hood Connectors: Constructed from same material as grease duct with internal or external continuously welded or brazed joints.

E. Accessories: Tees, elbows, increasers, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly. Include unique components required to comply with NFPA 96 including cleanouts, transitions, adapters, and drain fittings.

F. Grease Duct Supports: Construct duct bracing and supports from non-combustible material.

1. Design bracing and supports to carry static and seismic loads within stress limitations of the International Building Code.
2. Ensure that bolts, screws, rivets and other mechanical fasteners do not penetrate duct walls.

G. Comply with ASTM E2336.

H. Factory Tests: Test and inspect fire resistance of grease duct system according to ASTM E2336 in presence of Owner.

1. Allow consultant two days' minimum notification before test is performed.

2.2 ACCESS DOORS

A. Description: Factory-fabricated, -listed, and -labeled, double-wall personnel and maintenance access doors tested according to UL 1978 and rated for 500 deg F (260 deg C) continuously, or 2000 deg F (1093 deg C) for 30 minutes; with positive or negative duct pressure and complying with NFPA 211.

1. Construction: 0.0625 inch (1.6 mm) ASTM A666, Type 304 or Type 316 stainless-steel inner shell as directed and aluminized-steel or stainless-steel outer cover with two handles as directed
2. Fasteners: Stainless-steel bolts and wing nuts.

    a. Ensure that bolts do not penetrate interior of duct space.

3. Maintenance Access Door Dimensions: 7 x 7 inches (178 x 178 mm)
4. Personnel Access Door Dimensions: 22 x 20 inches (559 x 508 mm) or 24 x 24 inches (610 x 610 mm) as directed

5. Door Label: Mark door with uppercase lettering as follows: "ACCESS PANEL. DO NOT OBSTRUCT."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Coordinate installation of roof curbs, equipment supports, and roof penetrations. Comply with requirements in Section 077200 "Roof Accessories."

B. Coordinate connections to kitchen exhaust hoods with requirements in Section 233813 "Commercial-Kitchen Hoods."

C. Coordinate connections to exhaust fans with requirements in Section 233413 "Axial HVAC Fans or 233416 "Centrifugal HVAC Fans as directed

D. Coordinate firestopping where grease ducts penetrate fire separations with requirements in Section 078413 "Penetration Firestopping."

E. Comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211 and UL 2221, whichever is most stringent.

F. Install airtight personnel and maintenance access doors where indicated.

G. Seal between sections of grease exhaust ducts according to manufacturer's written installation instructions, using sealants recommended by manufacturer.

H. Connections: Make grease duct connections according to the International Mechanical Code.

1. Grease duct to exhaust fan connections: Connect grease ducts to inlet side of fan using flanges, gaskets, and bolts.
2. Grease duct to hood connections:

    a. Make grease duct to hood joints connections using internal or external continuously welded or brazed joints.
    b. Make watertight grease duct to hood joints connections using flanges, gaskets, and bolts.

I. Support ducts at intervals recommended by manufacturer to support weight of ducts and accessories, without applying loading on kitchen hoods.

1. Securely attach supports and bracing to structure.

J. Grease Duct Enclosures: Comply with requirements of the International Building Code and ASTM E2336.

K. Coordinate fire-rated enclosure construction with Section 092116.23 "Gypsum Board Shaft Wall Assemblies."

L. Repair damage to adjacent materials caused by listed kitchen ventilation system exhaust ducts installation.

3.2 FIELD QUALITY CONTROL

A. Perform air leakage test in presence of Owner before concealment of any portion of the grease duct system.

1. Notify Owner a minimum of two days before test is performed.

END OF SECTION 233533

SECTION 233600 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bypass, single-duct air terminal units.
2. Shutoff, single-duct air terminal units.
3. Parallel, fan-powered air terminal units.
4. Series, fan-powered air terminal units.
5. Casing liner.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of air terminal unit.

B. Sustainable Design Submittals:

C. Shop Drawings: For air terminal units.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

D. Delegated-Design Submittal:

1. Materials, fabrication, assembly, and spacing of hangers and supports.
2. Include design calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports and seismic restraints.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

C. ASHRAE Compliance: Applicable requirements in ASHRAE/IES 90.1, "Section 6 - Heating, Ventilating, and Air Conditioning."

2.2 BYPASS, SINGLE-DUCT AIR TERMINAL UNITS

A. Configuration: Diverting-damper assembly inside unit casing with control components inside a protective metal shroud.

B. Casing: 0.040-inch- (1.0-mm-) or 0.034-inch- (0.85-mm-) thick galvanized steel, single wall as directed

1. Casing Liner: Comply with requirements in "Casing Liner" Article for fibrous-glass or flexible elastomeric duct liner as directed

C. Diverter Assembly: Galvanized-steel gate, with polyethylene linear bearings or Aluminum blade, with nylon-fitted pivot points as directed.

D. Multioutlet Attenuator Section: With two or three or four 6-inch- (150-mm-) or 8-inch- (200-mm-) or 10-inch- (250-mm-) diameter collars, each with locking butterfly balancing damper as directed.

1. Attenuator Section Liner: Comply with requirements in "Casing Liner" Article for fibrous-glass or flexible elastomeri duct liner as directed.
2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

E. Hydronic Heating Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), and rated for a minimum working pressure of 200 psig (1380 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve.

F. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware.

1. Stage(s): as directed.
2. SCR controlled.
3. Access door interlocked disconnect switch.
4. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable).
5. Nickel chrome 80/20 heating elements.
6. Airflow switch for proof of airflow.
7. Fuses in terminal box for overcurrent protection (for coils more than 48 A).
8. Mercury contactors.
9. Pneumatic-electric switches and relays.
10. Magnetic contactor for each step of control (for three-phase coils).

G. Electric Controls: Damper actuator and thermostat.

1. Damper Actuator: 24 V, powered closed, powered open with microswitch to energize heating control circuit.
2. Thermostat: Wall-mounted electric type with temperature display in Fahrenheit and Celsius, and space temperature set point.
3. Changeover Thermostat: Duct-mounted, field-adjustable, electric type reverses action of zone thermostat when air temperature reaches 70 deg F (21 deg C).

H. Electronic Controls: Bidirectional damper operator and microprocessor-based thermostat. Control devices shall be compatible with temperature controls specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and shall have the following features:

1. Damper Actuator: 24 V, powered open, spring or capacitous return as directed.
2. Thermostat: Wall-mounted electronic type with the following features:

    a. Temperature set-point display in Fahrenheit and Celsius.
    b. Auxiliary switch to energize heating control circuit.
    c. Changeover thermistor to reverse action.

I. Direct Digital Controls: Single-package unitary controller and actuator specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

2.3 SHUTOFF, SINGLE-DUCT AIR TERMINAL UNITS

A. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.

B. Casing: 0.040-inch- (1.0-mm-) or 0.034-inch- (0.85-mm-) thick galvanized steel, single wall as directed.

1. Casing Liner: Comply with requirements in "Casing Liner" Article for fibrous-glass or flexible elastomeric duct liner as directed.
2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
3. Air Outlet: S-slip and drive connections, size matching inlet size.
4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.

5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Regulator Assembly: System-air-powered bellows section incorporating polypropylene bellows for volume regulation and thermostatic control. Bellows shall operate at temperatures from zero to 140 deg F (minus 18 to plus 60 deg C), shall be impervious to moisture and fungus, shall be suitable for 10-inch wg (2500-Pa) static pressure, and shall be factory tested for leaks.

D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: AHRI 880 rated, 2 or 3 percent of nominal airflow at 3-inch wg (750-Pa) or 6-inch wg (1500-Pa) inlet static pressure as directed.
2. Damper Position: Normally open or closed as directed.

E. Attenuator Section: 0.034-inch (0.85-mm) steel or 0.032-inch (0.8-mm) aluminum sheet as directed.

1. Attenuator Section Liner: Comply with requirements in "Casing Liner" Article for fibrous-glass or flexible elastomeric duct liner as directed.
2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

F. Multioutlet Attenuator Section: With two or three or four 6-inch- (150-mm-) or 8-inch- (200-mm-) or 10-inch- (250-mm-) diameter collars, each with locking butterfly balancing damper as directed.

G. Hydronic Heating Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), and rated for a minimum working pressure of 200 psig (1380 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve.

H. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware.

1. Stage(s): as directed.
2. SCR controlled.
3. Access door interlocked disconnect switch.
4. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable).
5. Nickel chrome 80/20 heating elements.
6. Airflow switch for proof of airflow.
7. Fan interlock contacts.
8. Fuses in terminal box for overcurrent protection (for coils more than 48 A).
9. Mercury contactors.
10. Pneumatic-electric switches and relays.
11. Magnetic contactor for each step of control (for three-phase coils).

I. Control devices shall be compatible with temperature controls system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

1. Electric Damper Actuator: 24 V, powered open, spring or capacitous return as directed.
2. Pneumatic Damper Operator: 0- to 13-psig (0- to 90-kPa) spring range.
3. Electronic Damper Actuator: 24 V, powered open, spring or capacitous return as directed.
4. Electric Thermostat: Wall-mounted electronic type with clock display, temperature display in Fahrenheit and Celsius, and space temperature set point.
5. Pneumatic Thermostat: Wall-mounted, pneumatic type, direct acting or and or reverse acting with appropriate mounting hardware as directed.
6. Electronic Thermostat: Wall-mounted electronic type with temperature set-point display in Fahrenheit and Celsius.
7. Pneumatic Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg (1000 Pa); and shall have a multipoint velocity sensor at air inlet.
8. Electronic Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg (1000 Pa); and shall have a multipoint velocity sensor at air inlet.
9. Terminal Unit Controller: Pressure-independent, variable-air-volume (VAV) controller with electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes, and having the following features:

    a. Occupied and unoccupied operating mode.
    b. Remote reset of airflow or temperature set points.
    c. Adjusting and monitoring with portable terminal.
    d. Communication with temperature-control system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

10. Room Sensor: Wall mounted with temperature set-point adjustment and access for connection of portable operator terminal.

J. Controls:

1. Suitable for operation with duct pressures between 0.25- and 3.0-inch wg (60- and 750-Pa) inlet static pressure.
2. System-powered, wall-mounted thermostat.

K. Control Sequences:

1. Occupied:

    a. In a call for cooling, airflow will increase as the damper opens towards maximum setting to satisfy set point.
    b. In a call for less cooling, airflow will decrease as the damper closes towards minimum setting to satisfy set point.

2. Unoccupied:

    a. Damper closes to minimum maximum setting.

2.4 PARALLEL FAN-POWERED AIR TERMINAL UNITS

A. Configuration: Volume-damper assembly and fan in parallel arrangement inside unit casing with control components inside a protective metal shroud. Designed for quiet operation. Or Low-profile design as directed.

B. Casing: 0.040-inch- (1.0-mm-) or 0.034-inch- (0.85-mm-) thick galvanized steel, single wall as directed.

1. Casing Liner: Comply with requirements in "Casing Liner" Article for fibrous-glass or flexible elastomeric duct liner as directed.
2. Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.
3. Air Outlet: S-slip and drive connections.
4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches.
5. Fan: Forward-curved centrifugal, located at plenum air inlet.
6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Volume Damper: Galvanized steel with flow-sensing ring and peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: AHRI 880 rated, 2 or 3 percent of nominal airflow at 3-inch wg (750-Pa) or 6-inch wg (1500-Pa) inlet static pressure.
2. Damper Position: Normally open or closed as directed.

D. Velocity Sensors: Multipoint array with velocity sensors.

E. Motor:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Type: Permanent-split capacitor with SCR for speed adjustment or Electronically commutated motor as directed.
3. Fan-Motor Assembly Isolation: Rubber isolators.
4. Enclosure: As directed.
5. Enclosure Materials: As directed.
6. Motor Bearings: As directed.
7. Unusual Service Conditions:

    a. Ambient Temperature: As directed.
    b. Altitude: As directed.
    c. High humidity.

8. Efficiency: Premium efficient.
9. NEMA Design: As directed.
10. Service Factor: As directed.
11. Motor Speed: Single speed or Multispeed As directed.

a. Speed Control: Infinitely adjustable with pneumatic-electric and electronic controls.

12. Electrical Characteristics:

a. Horsepower: As directed.
b. Volts: As directed.
c. Phase: Single or Poly As directed.
d. Hertz: 60.
e. Full-Load Amperes: As directed.
f. Minimum Circuit Ampacity: As directed.
g. Maximum Overcurrent Protection: As directed.

F. Filters:

1. Minimum Efficiency Reporting Value and Average Arrestance: According to ASHRAE 52.2.
2. Minimum Efficiency Reporting Value: According to ASHRAE 52.2.
3. Material: Polyurethane foam, MERV 3.
4. Material: Glass fiber treated with adhesive, MERV 5
5. Material: Pleated cotton-polyester media, MERV 7
6. Thickness: 2 inches (50 mm) or 1 inch (25 mm) As directed.

G. Attenuator Section: 0.034-inch (0.85-mm) galvanized steel or 0.032-inch (0.8-mm) aluminum sheet As directed.

1. Attenuator Section Liner: Comply with requirements in "Casing Liner" Article for fibrous-glass or flexible elastomeric duct liner as directed.
2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

H. Hydronic Heating Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of 200 psig (1380 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve.

1. Location: Plenum air inlet.

I. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware.

1. Location: Plenum air inlet.
2. Stage(s): As directed.
3. SCR controlled.
4. Access door interlocked disconnect switch.
5. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable).
6. Nickel chrome 80/20 heating elements.
7. Airflow switch for proof of airflow.

8. Fan interlock contacts.
9. Fuses in terminal box for overcurrent protection (for coils more than 48 A).
10. Mercury contactors.
11. Pneumatic-electric switches and relays.
12. Magnetic contactor for each step of control (for three-phase coils).

J. Factory-Mounted and -Wired Controls: Electrical components mounted in control box with removable cover. Incorporate single-point electrical connection to power source.

1. Control Transformer: Factory mounted for control voltage on electric and electronic control units with terminal strip in control box for field wiring of thermostat and power source.
2. Wiring Terminations: Fan and controls to terminal strip. Terminal lugs to match quantities, sizes, and materials of branch-circuit conductors. Enclose terminal lugs in terminal box that is sized according to NFPA 70.
3. Disconnect Switch: Factory-mounted, fuse type.

K. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.

L. Control devices shall be compatible with temperature controls system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

1. Electric Damper Actuator: 24 V, powered open, spring or capacitous return As directed.
2. Pneumatic Damper Operator: 0- to 13-psig (0- to 90-kPa) spring range.
3. Electronic Damper Actuator: 24 V, powered open, spring or capacitous return As directed.
4. Electric Thermostat: Wall-mounted electronic type with clock display, temperature display in Fahrenheit and Celsius, and space temperature set point.
5. Pneumatic Thermostat: Wall-mounted pneumatic type direct acting or reverse acting or direct or reverse acting as indicated on Drawings with appropriate mounting hardware As directed.
6. Electronic Thermostat: Wall-mounted electronic type with temperature set-point display in Fahrenheit and Celsius.
7. Pneumatic Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg (1000 Pa); and shall have a multipoint velocity sensor at air inlet.
8. Electronic Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg (1000 Pa); and shall have a multipoint velocity sensor at air inlet.
9. Terminal Unit Controller: Pressure-independent, VAV controller with electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes, and having the following features:

M. Control Sequence:

1. Occupied (Primary Airflow On):

a. Operate as throttling control for cooling.
b. As cooling requirement decreases, control valve throttles toward minimum airflow.
c. As heating requirement increases, fan energizes to draw in warm plenum air and electric heat is energized in steps or and electric heat modulates under SCR control and the hot-water coil valve is energized as directed.

2. Unoccupied (Primary Airflow Off):

a. When pressure at primary inlet is zero or less, fan is de-energized.
b. As heating requirement increases, fan energizes to draw in warm plenum air as directed.

2.5 SERIES FAN-POWERED AIR TERMINAL UNITS

A. Configuration: Volume-damper assembly and fan in series arrangement inside unit casing with control components inside a protective metal shroud for installation above a ceiling and within a raised access floor.

1. Designed for quiet operation.
2. Low-profile design.

B. Casing: 0.040-inch- (1.0-mm-) or 0.034-inch- (0.85-mm-) thick galvanized steel, single wall as directed.

1. Casing Liner: Comply with requirements in "Casing Liner" Article for fibrous-glass or flexible elastomeric duct liner as directed.
2. Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.
3. Air Outlet: S-slip and drive connections.
4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches.
5. Fan: Forward-curved centrifugal.
6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Volume Damper: Galvanized steel with flow-sensing ring and peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: AHRI 880 rated, 2 or 3 percent of nominal airflow at 3-inch wg (750-Pa) or 6-inch wg (1500-Pa) inlet static pressure.
2. Damper Position: Normally open or closed As directed.

D. Velocity Sensors: Multipoint array with velocity sensors in air inlets and air outlets.

E. Motor:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

2. Type: Permanent-split capacitor with SCR for speed adjustment or Electronically commutated motor as directed.
3. Fan-Motor Assembly Isolation: Rubber isolators.
4. Enclosure: As directed.
5. Enclosure Materials: As directed.
6. Motor Bearings: As directed.
7. Unusual Service Conditions:

    a. Ambient Temperature: As directed.
    b. Altitude: As directed above sea level.
    c. High humidity.

8. Efficiency: Premium efficient.
9. NEMA Design: As directed.
10. Service Factor: As directed.
11. Motor Speed: Single speed or Multispeed As directed.

    a. Speed Control: Infinitely adjustable with pneumatic-electric and electronic controls.

12. Electrical Characteristics:

    a. Horsepower: As directed.
    b. Volts: As directed.
    c. Phase: Single or Poly As directed.
    d. Hertz: 60.
    e. Full-Load Amperes: As directed.
    f. Minimum Circuit Ampacity: As directed.
    g. Maximum Overcurrent Protection: As directed.

F. Filters:

1. Minimum Efficiency Reporting Value and Average Arrestance: According to ASHRAE 52.2.
2. Minimum Efficiency Reporting Value: According to ASHRAE 52.2.
3. Material: Polyurethane foam; MERV 3.
4. Material: Glass fiber treated with adhesive; MERV 5.
5. Material: Pleated cotton-polyester media MERV 7.
6. Thickness: 2 inches (50 mm) or 1 inch (25 mm) As directed.

G. Attenuator Section: 0.034-inch (0.85-mm) galvanized steel or 0.032-inch (0.8-mm) aluminum sheet As directed.

1. Attenuator Section Liner: Comply with requirements in "Casing Liner" Article for fibrous-glass or flexible elastomeric duct liner As directed.
2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

H. Hydronic Heating Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), and rated for a minimum working pressure of 200 psig (1380

kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve.

I. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware.

1. Stage(s): As directed.
2. SCR controlled.
3. Access door interlocked disconnect switch.
4. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable).
5. Nickel chrome 80/20 heating elements.
6. Airflow switch for proof of airflow.
7. Fan interlock contacts.
8. Fuses in terminal box for overcurrent protection (for coils more than 48 A).
9. Mercury contactors.
10. Pneumatic-electric switches and relays.
11. Magnetic contactor for each step of control (for three-phase coils).

J. Factory-Mounted and -Wired Controls: Electrical components mounted in control box with removable cover. Incorporate single-point electrical connection to power source.

1. Control Transformer: Factory mounted for control voltage on electric and electronic control units with terminal strip in control box for field wiring of thermostat and power source.
2. Wiring Terminations: Fan and controls to terminal strip. Terminal lugs to match quantities, sizes, and materials of branch-circuit conductors. Enclose terminal lugs in terminal box that is sized according to NFPA 70.
3. Disconnect Switch: Factory-mounted, fuse type.

K. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.

L. Control devices shall be compatible with temperature controls system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

1. Electric Damper Actuator: 24 V, powered open, spring or capacitous return As directed.
2. Pneumatic Damper Operator: 0- to 13-psig (0- to 90-kPa) As directed. spring range.
3. Electronic Damper Actuator: 24 V, powered open, spring or capacitous return As directed.
4. Electric Thermostat: Wall-mounted electronic type with clock display, temperature display in Fahrenheit and Celsius, and space temperature set point.
5. Pneumatic Thermostat: Wall-mounted pneumatic type As directed with appropriate mounting hardware.
6. Electronic Thermostat: Wall-mounted electronic type with temperature set-point display in Fahrenheit and Celsius.
7. Pneumatic Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5

percent of set point while compensating for inlet static-pressure variations up to 4-inch wg (1000 Pa); and shall have a multipoint velocity sensor at air inlet.

8. Electronic Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg (1000 Pa); and shall have a multipoint velocity sensor at air inlet.
9. Terminal Unit Controller: Pressure-independent, VAV controller with electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes, and having the following features:

M. Control Sequence:

1. Occupied (Primary Airflow On):

a. Operate as throttling control for cooling.
b. As cooling requirement decreases, control valve throttles toward minimum airflow.
c. As heating requirement increases, fan energizes to draw in warm plenum air and electric heat is energized in steps and electric heat modulates under SCR control and the hot-water coil valve is opened.

2. Unoccupied (Primary Airflow Off):

a. When externally initiated, begin the morning warm-up/cool-down function. Damper drives to the fully open position without regard for the preset maximum.
b. When pressure at primary inlet is zero or less, fan is de-energized.
c. As heating requirement increases, fan energizes to draw in warm plenum air and electric heat is energized in steps and electric heat modulates under SCR control and the hot-water coil valve is opened.

2.6 CASING LINER

A. Casing Liner: Fibrous-glass duct liner, complying with ASTM C1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Minimum Thickness: As directed.

a. Maximum Thermal Conductivity:

1) Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K) at 75 deg F (24 deg C) mean temperature.
2) Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F (0.033 W/m x K) at 75 deg F (24 deg C) mean temperature.

2. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
3. Solvent or Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C916.

B. Casing Liner: Flexible elastomeric duct liner fabricated of preformed, cellular, closed-cell, sheet materials complying with ASTM C534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.

1. Minimum Thickness: 1/2 inch (13 mm) or 3/4 inch (19 mm) As directed.
2. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
3. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

2.7 SOURCE QUALITY CONTROL

A. Factory Tests: Test assembled air terminal units according to AHRI 880.

1. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and AHRI certification seal.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 5, "Hangers and Supports" and with Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes and for slabs more than 4 inches (100 mm) thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and for slabs less than 4 inches (100 mm) thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hangers Exposed to View: Threaded rod and angle or channel supports.

D. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.2 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install hangers and braces designed to support the air terminal units and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems or ASCE/SEI 7 As directed. Comply with requirements for seismic-restraint devices in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install cable restraints on air terminal units that are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved as directed.

F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

G. Drilling for and Setting Anchors:

1. Identify position of reinforcing steel and other embedded items before drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Install heavy-duty sleeve anchors with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.3 TERMINAL UNIT INSTALLATION

A. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

B. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

C. Install wall-mounted thermostats.

D. Where installing piping adjacent to air terminal unit, allow space for service and maintenance.

E. Hot-Water Piping: Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties," and connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.

F. Comply with requirements in Section 233113 "Metal Ducts" or Section 233116 "Nonmetal Ducts for connecting ducts to air terminal units As directed.

G. Make connections to air terminal units with flexible connectors complying with requirements in Section 233300 "Air Duct Accessories."

H. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Air terminal unit will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION 233600

SECTION 233713.13 - AIR DIFFUSERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Round ceiling diffusers.
2. Rectangular and square ceiling diffusers.
3. Perforated diffusers.
4. Louver face diffusers.
5. Linear bar diffusers.
6. Linear slot diffusers.

B. Related Requirements:

1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers.
2. Section 233713.23 "Air Registers and Grilles" for adjustable-bar register and grilles, fixed-face registers and grilles, and linear bar grilles.
3. Section 233713.43 "Security Registers and Grilles" for security registers and security grilles.
4. Section 233716 "Fabric Air-Diffusion Devices" for continuous tubular diffusers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 ROUND CEILING DIFFUSERS

A. Devices shall be specifically designed for variable-air-volume flows.

B. Material: Steel or Aluminum as directed.

C. Finish: As directed.

D. Face Style: Cone as directed.

E. Mounting: Duct connection.

F. Pattern: Fully adjustable or Two-position horizontal as directed.

G. Dampers: As directed

H. Accessories:

1. Equalizing grid.
2. Plaster ring.
3. Safety chain.
4. Wire guard.
5. Sectorizing baffles.
6. Operating rod extension.

2.2 RECTANGULAR AND SQUARE CEILING DIFFUSERS

A. Devices shall be specifically designed for variable-air-volume flows.

B. Material: Steel or Aluminum as directed.

C. Finish: As directed.

D. Face Size: As directed.

E. Face Style: As directed.

F. Mounting: As directed.

G. Pattern: As directed.

H. Dampers: As directed.

I. Accessories:

1. Equalizing grid.
2. Plaster ring.
3. Safety chain.
4. Wire guard.
5. Sectorizing baffles.
6. Operating rod extension.

2.3 PERFORATED DIFFUSERS

A. Devices shall be specifically designed for variable-air-volume flows.

B. Material: Steel backpan and pattern controllers, with steel or aluminum face as directed.

C. Finish: As directed.

D. Face Size: As directed.

E. Duct Inlet: Round or Square as directed.

F. Face Style: Flush or Drop extended as directed.

G. Mounting: As directed.

H. Pattern Controller: As directed.

I. Dampers: As directed.

J. Accessories:

1. Equalizing grid.
2. Plaster ring.
3. Safety chain.
4. Wire guard.
5. Sectorizing baffles.
6. Operating rod extension.

2.4 LOUVER FACE DIFFUSERS

A. Devices shall be specifically designed for variable-air-volume flows.

B. Material: Steel or Aluminum as directed.

C. Finish: As directed

D. Face Size: As directed.

E. Mounting: As directed.

F. Pattern: Core style as directed.

G. Dampers: As directed.

H. Accessories:

1. Square to round neck adaptor.
2. Adjustable pattern vanes.
3. Throw reducing vanes.
4. Equalizing grid.
5. Plaster ring.
6. Safety chain.
7. Wire guard.
8. Sectorizing baffles.
9. Operating rod extension.

2.5 LINEAR BAR DIFFUSERS

A. Devices shall be specifically designed for variable-air-volume flows.

B. Material: As directed.

C. Finish: Baked enamel, white or Baked enamel, color selected by Architect as directed.

D. Narrow Core Spacing Arrangement: 1/8-inch- (3-mm-) thick blades spaced 1/4 inch (6 mm) apart; zero or 15-degree deflection as directed.

E. Wide Core Spacing Arrangement: 1/8-inch- (3-mm-) thick blades spaced 1/2 inch (13 mm) apart; zero or 15-degree deflection as directed.

F. Wide Core Spacing Arrangement: 3/16-inch- (5-mm-) thick blades spaced 1/2 inch (13 mm) apart; degree deflection as directed.

G. Pencil-Proof Core Spacing Arrangement: 3/16-inch- (5-mm-) thick blades spaced 7/16 inch (11 mm) apart; degree deflection as directed.

H. One or Two-Way Deflection Vanes as directed: Extruded construction fixed or adjustable louvers with removable core as directed.

I. Frame: Wide as directed.

J. Mounting Frame: Filter.

K. Mounting: As directed.

L. Damper Type: Adjustable opposed-blade assembly or Hinged single blade as directed.

M. Accessories: As directed.

2.6 LINEAR SLOT DIFFUSERS

A. Devices shall be specifically designed for variable-air-volume flows.

B. Material - Shell: As directed.

C. Material - Pattern Controller and Tees: Aluminum.

D. Finish - Face and Shell: Baked enamel, black.

E. Finish - Pattern Controller: Baked enamel, black.

F. Finish - Tees: Baked enamel, white or Baked enamel, color selected by Architect as directed.

G. Slot Width: As directed.

H. Number of Slots: As directed.

I. Length: As directed.

J. Accessories: As directed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install diffusers level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.2 ADJUSTING

A. After installation, adjust diffusers to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713.13

SECTION 233713.23 - REGISTERS AND GRILLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Adjustable blade face registers and grilles.
2. Fixed face registers and grilles.

B. Related Requirements:

1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to registers and grilles.
2. Section 233713.13 "Air Diffusers" for various types of air diffusers.
3. Section 233713.43 "Security Registers and Grilles" for security registers and security grilles.
4. Section 233716 "Fabric Air-Diffusion Devices" for continuous tubular diffusers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 REGISTERS

A. Adjustable Blade Face Register:
1. Material: as directed.
2. Finish: Baked enamel, white or Baked enamel, color selected by Architect as directed.
3. Face Blade Arrangement: Horizontal or Vertical spaced apart as directed.
4. Core Construction: Integral or Removable as directed.
5. Rear-Blade Arrangement: Horizontal or Vertical spaced 3/4 inch (19 mm) or 1/2 inch (13 mm) apart as directed.
6. Frame: 1-1/4 inches (32 mm) or 1 inch (25 mm) wide as directed.
7. Mounting Frame: Filter.
8. Mounting: As directed.
9. Damper Type: As directed.
10. Accessories:

    a. Front or Rear-blade gang operator as directed.
    b. Filter.

B. Fixed Face Register:
1. Material: Steel or Aluminum as directed.

2. Finish: Baked enamel, white or Baked enamel, color selected by Architect as directed.
3. Face Blade Arrangement: Horizontal or Vertical spaced 3/4 inch (19 mm) or 1/2 inch (13 mm) apart as directed.
4. Face Arrangement: Perforated core.
5. Core Construction: Integral or Removable as directed.
6. Frame: 1-1/4 inches (32 mm) or 1 inch (25 mm) wide as directed.
7. Mounting Frame: Filter.
8. Mounting: As directed.
9. Damper Type: As directed.
10. Accessory: Filter.

2.2 GRILLES

A. Adjustable Blade Face Grille:
1. Material: As directed.
2. Finish: Baked enamel, white or Baked enamel, color selected by Architect as directed.
3. Face Blade Arrangement: Horizontal or Vertical spaced apart as directed.
4. Core Construction: Integral or Removable as directed.
5. Rear-Blade Arrangement: Horizontal or Vertical spaced 3/4 inch (19 mm) or 1/2 inch (13 mm) apart as directed.
6. Frame: 1-1/4 inches (32 mm) or 1 inch (25 mm) wide as directed.
7. Mounting Frame: Filter.
8. Mounting: As directed.
9. Accessories:

    a. Front or Rear-blade gang operator as directed.
    b. Filter.

B. Fixed Face Grille:
1. Material: Steel or Aluminum as directed.
2. Finish: Baked enamel, white or Baked enamel, color selected by Architect as directed.
3. Face Blade Arrangement: Horizontal or Vertical; spaced 3/4 inch (19 mm) or 1/2 inch (13 mm) apart as directed.
4. Face Arrangement: Perforated core.
5. Core Construction: Integral or Removable.
6. Frame: 1-1/4 inches (32 mm) or 1 inch (25 mm) wide as directed.
7. Mounting Frame: Filter.
8. Mounting: As directed.
9. Accessory: Filter.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install registers and grilles level and plumb.

B. Outlets and Inlets Locations: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install registers and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.2 ADJUSTING

A. After installation, adjust registers and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713.23

SECTION 233713.43 - SECURITY REGISTERS AND GRILLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes security registers and grilles.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale.

PART 2 - PRODUCTS

2.1 SECURITY REGISTERS

A. Security Register:
1. Security Level: As directed.
2. Application: As directed.
3. Material: Steel or Aluminum as directed.
4. Material Thickness: 0.19 inch (4.8 mm).
5. Finish: Baked enamel, white or Baked enamel, color selected by Architect as directed.
6. Face Arrangement:

    a. Shape: As directed.
    b. Design: As directed.
    c. Frame: Yes or No as directed.
    d. Deflection: Zero or 38 degrees as directed.
    e. Core: None or Louvered as directed.
    f. 3/16-inch- (5-mm-) thick, front lattice plate with 2-by-2-inch- (50-by-50-mm-) square holes and 1-inch (25-mm) frets, 0.135-inch (3.43-mm) wire mesh, and 1/4-inch- (6-mm-) thick backer plate.
    g. 3/16-inch- (5-mm-) thick, perforated faceplate with 5/16-inch- (8-mm-) diameter holes spaced 7/16 inch (11 mm) o.c., staggered at 60 degrees.
    h. 1-1/2-inch (38-mm) bars and mandrel tubes and rods with zero or 15-degree deflection in 1-1/4-by-1-1/4-by-3/16-inch (32-by-32-by-5-mm) angle border.
    i. 1-3/8-inch (35-mm) bars and double mandrel tubes with zero or 15-degree deflection in 1-3/4-inch (45-mm) angle border.

7. Damper Operation: As directed.
8. Damper Type: As directed.

9. Wall Sleeve: As directed.
10. Mounting: As directed.

2.2 SECURITY GRILLES

A. Security Grille:
1. Security Level: As directed.
2. Application: As directed.
3. Material: Steel or Aluminum as directed.
4. Material Thickness: 0.19 inch (4.8 mm).
5. Finish: Baked enamel, white or Baked enamel, color selected by Architect as directed.
6. Face Arrangement:

a. Shape: As directed.
b. Design: As directed.
c. Frame: Yes or No as directed.
d. Deflection: Zero or 38 degrees as directed.
e. Core: None or Louvered as directed.
f. 3/16-inch- (5-mm-) thick, front lattice plate with 2-by-2-inch- (50-by-50-mm-) square holes and 1-inch (25-mm) frets, 0.135-inch (3.43-mm) wire mesh, and 1/4-inch- (6-mm-) thick backer plate.
g. 3/16-inch- (5-mm-) thick perforated faceplate with 5/16-inch- (8-mm-) diameter holes spaced 7/16 inch (11 mm) o.c., staggered at 60 degrees.
h. 1-1/2-inch (38-mm) bars and mandrel tubes and rods with zero or 15-degree deflection in 1-1/4-by-1-1/4-by-3/16-inch (32-by-32-by-5-mm) angle border.
i. 1-3/8-inch (35-mm) bars and double mandrel tubes with zero or 15-degree deflection in 1-3/4-inch (45-mm) angle border.

7. Wall Sleeve: As directed.
8. Mounting: As directed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install registers and grilles level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install registers and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.2 ADJUSTING

A. After installation, adjust registers and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713.43

SECTION 233716 - FABRIC AIR-DISTRIBUTION DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes continuous, tubular, fabric air-distribution devices.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For fabric air-distribution devices.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Continuous tubular diffuser materials shall be listed and labeled as complying As directed.

B. Air permeability of fabric will comply with ASTM D737.

2.3 CONTINUOUS TUBULAR DIFFUSERS

A. Description:

1. Fabric: Woven As directed.
2. Shape: as directed.
3. Air-Outlet Configuration: Permeable fabric.
4. Air-Outlet Configuration: Circumferential hole pattern with diffusion-hole diameter of as directed, spaced as directed o.c. circumferentially, and as directed along the length of the diffusion device.
5. Air-Outlet Configuration: Lengthwise mesh.
6. Air-Outlet Configuration: Lengthwise hole pattern; with diffusion-hole diameter as directed.
7. Air-Outlet Configuration: Periodic nozzles.
8. Air-Outlet Configuration: Linear vents.
9. Color: As directed.

B. Duct Connection Type: Round as directed.

C. Accessories:

1. Quick-connect joint.
2. Snap hooks.
3. Cleanout zipper.
4. Condensate drain.
5. Fabric damper.
6. End cap.
7. Draw cords.
8. Removable support hoops.
9. Elbows.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

END OF SECTION 233716

SECTION 233723 - HVAC GRAVITY VENTILATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Louvered-penthouse ventilators.
2. Hooded ventilators.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

C. Shop Drawings: For gravity ventilators.

1. Include plans, elevations, sections, details, ventilator attachments to curbs, and curb attachments to roof structure.
2. Show weep paths, gaskets, flashing, sealant, and other means of preventing water intrusion.

D. Samples: For each exposed product and for each color and texture specified.

E. Delegated-Design Submittal: For shop-fabricated ventilators indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of shop-fabricated ventilators.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Roof-framing plans and other details, drawn to scale, and coordinated with each other, based on input from installers of the items involved:

B. Seismic Qualification Data: Certificates for ventilators, accessories, and components, from manufacturer.

C. Welding certificates.

1.4 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
2. AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."

1.5 COORDINATION

A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design ventilators.

B. Structural Performance: Ventilators shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated without permanent deformation of ventilator components, noise or metal fatigue caused by ventilator blade rattle or flutter, or permanent damage to fasteners and anchors. Wind pressures shall be considered to act normal to the face of the building.

1. Wind Loads: Determine loads based on pressures as indicated on Drawings.
2. Wind Loads: Determine loads based on a uniform pressure of 20 (960) or 30 (1440) lbf/sq. ft. (Pa) as directed, acting inward or outward.
3. Wind Loads: Determine loads based on pressures indicated below:

    a. Corner Zone: As directed.
    b. Other Than Corner Zone: As directed.
4. Snow Load: Unit to withstand a minimum of 20- (960-) lbf/sq. ft. (Pa) snow load.

C. Seismic Performance: Ventilators, including attachments to other construction, shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 or 1.0 as directed.
3. Requirements for Component Amplification Factor and Component Response Modification Factor – As directed

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.

E. ASHRAE 62.1 Compliance: Section 5, "Systems and Equipment" and Section 7, "Construction and System Start-up."

F. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes, without buckling, opening of joints, overstressing of components, failure of connections, or other detrimental effects.

1. Temperature Change (Range):

    a. Ambient: 120 (67) deg F (deg C).
    b. Material Surfaces: 180 (100) deg F (deg C).

G. Water Entrainment: Limit water penetration through unit to comply with ASHRAE 62.1.

H. Capacities and Characteristics:

1. Drawing Tag No.: As directed.
2. Type: As directed.
3. Height: As directed.
4. Width: As directed.
5. Depth: As directed.
6. Air Flow: As directed.
7. Maximum Air Pressure Drop: Not more than 0.10- (25-) inch wg (Pa) static pressure drop
8. Maximum Free Area Velocity: As directed.
9. Function: Intake or Relief as directed.

2.2 FABRICATION

A. Factory or shop fabricate gravity ventilators to minimize field splicing and assembly. Disassemble units to the minimum extent as necessary for shipping and handling. Clearly mark units for reassembly and coordinated installation.

B. Fabricate frames, including integral bases, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.

C. Fabricate units with closely fitted joints and exposed connections accurately located and secured.

D. Fabricate supports, anchorages, and accessories required for complete assembly.

E. Perform shop welding by AWS-certified procedures and personnel.

2.3 LOUVERED-PENTHOUSE VENTILATORS

A. Description: Multitier rectangular louvered penthouse for intake or relief air as directed.

B. Construction:

1. Material: All-welded assembly with 4-inch (100-mm) or 6-inch (150-mm)-deep louvers, mitered corners, and aluminum or galvanized-steel sheet roof as directed.
2. Frame and Blade Material: Extruded aluminum, of thickness required to comply with structural performance requirements, but not less than 0.080 (2.0) inch (mm) for frames and 0.080 (2.0) or 0.060 (1.5) inch (mm)for blades with condensate deflectors.
3. Frame and Blade Material: Galvanized-steel sheet, of thickness required to comply with structural performance requirements, but not less than 0.052 (1.3) inch (mm)for frames and inch (mm)for blades with condensate deflectors as directed.

4. Insulation: None or Mineral-fiber insulation and vapor barrier as directed.
5. Wind-Driven Rain Performance: Not less than as directed percent effectiveness when subjected to a rainfall rate of 3 inches (75 mm) per hour and a wind speed of 29 (13 m/s) mph (m/s) at a free-area intake velocity of fpm (m/s) as directed.
6. AMCA Seal: Mark units with the AMCA Certified Ratings Seal.
7. Exterior Corners: Prefabricated corner units with mitered and welded blades or mitered blades with concealed close-fitting splices and with fully recessed or semirecessed mullions at corners.
8. Bird Screening: Galvanized-steel, 1/2-inch- (12.7-mm-) square mesh wire or Aluminum, 1/2-inch- (12.7-mm-) square mesh or flattened, expanded aluminum, 3/4-inch- (19-mm-) diamond mesh wire as directed.
9. Insect Screening: Aluminum, 18-by-16 (1.4-by-1.6-mm) mesh wire.
10. Galvanized-Steel Sheet Finish:

    a. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas, and repair galvanizing according to ASTM A780/A780M. Apply a conversion coating suited to the organic coating to be applied over it.
    b. Factory Priming for Field-Painted Finish: Where field painting after installation is indicated, apply an air-dried primer immediately after cleaning and pretreating.
    c. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil (0.025 mm) for topcoat and an overall minimum dry film thickness of 2 mils (0.05 mm).

        1) Color and Gloss: As directed.

C. Dampers:

1. Location: As directed.
2. Control: As directed.
3. Tray: Provide damper tray or shelf with opening 3 (76) inches (mm) less than interior curb dimensions indicated or of size indicated as directed.

D. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to fit roof opening and ventilator base.

1. Configuration: Mounting flange as directed.
2. Overall Height: 12 inches (300 mm) or 36 inches (915 mm) as directed.

2.4 HOODED VENTILATORS

A. Description: Hooded rectangular or round penthouse for intake or relief air as directed.

B. Construction:

1. Material: Galvanized steel, of thickness required to comply with structural performance requirements, but not less than 0.064-inch- (1.62 mm-) thick base and 0.040-inch- (1.0-mm-) thick hood; suitably reinforced.

2. Material: Aluminum, of thickness required to comply with structural performance requirements, but not less than 0.063-inch- (1.6-mm-) thick base and 0.050-inch- (1.27-mm-) thick hood; suitably reinforced.
3. Insulation: None or Mineral-fiber insulation and vapor barrier as directed.
4. Bird Screening: Galvanized-steel, 1/2-inch- (12.7-mm-) square mesh wire or Aluminum, 1/2-inch- (12.7-mm-) square mesh or flattened, expanded aluminum, 3/4-inch (19-mm) diamond mesh wire as directed.
5. Insect Screening: Aluminum, 18-by-16 (1.4-by-1.6-mm) mesh wire.

C. Galvanized-Steel Finish:

1. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas, and repair galvanizing according to ASTM A780/A780M. Apply a conversion coating suited to the organic coating to be applied over it.
2. Factory Priming for Field-Painted Finish: Where field painting after installation is indicated, apply an air-dried primer immediately after cleaning and pretreating.
3. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil (0.025 mm) for topcoat and an overall minimum dry film thickness of 2 mils (0.05 mm).

    a. Color and Gloss: As directed.

D. Dampers:

1. Location: Hood neck or Curb damper tray as directed.
2. Control: As directed.
3. Tray: Provide damper tray or shelf with opening 3 (76) inches (mm) less than interior curb dimensions indicated or of size indicated as directed.

E. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to fit roof opening and ventilator base.

1. Configuration: Mounting flange as directed.
2. Overall Height: 12 inches (300 mm) or 36 inches (900 mm) as directed.

2.5 MATERIALS

A. Aluminum Extrusions: ASTM B221 (ASTM B221M), Alloy 6063-T5 or T-52.

B. Aluminum Sheet: ASTM B209 (ASTM B209M), Alloy 3003 or 5005, with temper as required for forming or as otherwise recommended by metal producer for required finish.

C. Galvanized-Steel Sheet: ASTM A653/A653M, G90 (Z275) zinc coating, mill phosphatized.

D. Stainless-Steel Sheet: ASTM A666, Type 304, with No. 4 or 6 finish as directed.

E. Fasteners: Same basic metal and alloy as fastened metal or 300 Series stainless steel unless otherwise indicated. Do not use metals that are incompatible with joined materials.

1. Use types and sizes to suit unit installation conditions.
2. Use Phillips flat or hex-head or Phillips pan-head screws for exposed fasteners unless otherwise indicated.

F. Post-Installed Fasteners for Concrete and Masonry: Torque-controlled expansion anchors made from stainless-steel components, with capability to sustain without failure a load equal to 4 times the loads imposed for concrete, or 6 times the load imposed for masonry, as determined by testing according to ASTM E488/E488M, conducted by a qualified independent testing agency.

G. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D1187/D1187M.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install gravity ventilators level, plumb, and at indicated alignment with adjacent work.

B. Secure gravity ventilators to roof curbs with zinc-plated hardware, that comply with the wind and seismic fastening requirements. Use concealed anchorages where possible. Refer to Section 077200 "Roof Accessories."

C. Install gravity ventilators with clearances for service and maintenance.

D. Install perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.

E. Install concealed gaskets, flashings, joint fillers, and insulation as installation progresses. Comply with Section 079200 "Joint Sealants" for sealants applied during installation.

F. Label gravity ventilators according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

G. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.

H. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes, so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.

I. Refer to Section 077200 "Roof Accessories" for flashing and counterflashing of roof curbs.

3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in Section 233113 "Metal Ducts" and Section 233116 "Nonmetal Ducts." Drawings indicate general arrangement of ducts and duct accessories.

END OF SECTION 233723

SECTION 233813 - COMMERCIAL-KITCHEN HOODS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes Type I and Type II commercial-kitchen hoods.

B. Related Requirements:

1. Section 233533 "Listed Kitchen Ventilation System Exhaust Ducts" for fire-rated ducts connecting to kitchen hoods.

1.2 ACTION SUBMITTALS

A. Product Data: For the following:

1. Filters/baffles.
2. Fire-suppression systems.
3. Luminaires.

B. Shop Drawings: Signed and sealed by a qualified professional engineer.

1. Show plan view, elevation view, sections, roughing-in dimensions, service requirements, duct connection sizes, and attachments to other work.
2. Show cooking equipment plan and elevation to confirm minimum code-required overhang.
3. Indicate performance, exhaust and makeup air airflow, and pressure loss at actual Project-site elevation.
4. Show control cabinets.
5. Show fire-protection cylinders, piping, actuation devices, and manual control devices.
6. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
7. Design Calculations: Calculate requirements for selecting seismic restraints.
8. Include diagrams for power, signal, and control wiring.
9. Duct Connections: Detail connections between ducts and hoods, including access doors and panels.
10. Piping Diagrams: Detail fire-suppression piping and components and differentiate between manufacturer-installed and field-installed piping. Show cooking equipment plan and elevation to illustrate fire-suppression nozzle locations.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Seismic Qualification Data: Submit certification that commercial-kitchen hoods, accessories, and components will withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC."

C. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D 1.1M, "Structural Welding Code - Steel," for hangers and supports; and AWS D9.1/D9.1M, "Sheet Metal Welding Code," for joint and seam welding.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 HOOD MATERIALS

A. Stainless-Steel Sheet: ASTM A666, Type 304.

1. Minimum Thickness: 0.037 inch (0.94 mm) or 0.050 inch (1.3 mm) as directed.
2. Finish: Comply with SSINA's "Finishes for Stainless Steel" for recommendations for applying and designating finishes.

    a. Finish shall be free from tool and die marks and stretch lines and shall have uniform, directionally textured, polished finish indicated, free of cross scratches. Grain shall run with long dimension of each piece.

3. Concealed Stainless-Steel Surfaces: ASTM A480/A480M, No. 2B finish (bright, cold-rolled, unpolished finish).
4. Exposed Surfaces: ASTM A480/A480M, No. 2B finish (bright, cold-rolled, unpolished).
5. Exposed Surfaces: ASTM A480/A480M, No. 3 finish (intermediate polished surface).
6. Exposed Surfaces: ASTM A480/A480M, No. 4 finish (directional satin).
7. Exposed Surfaces: ASTM A480/A480M, No. 6 finish (dull satin).
8. Exposed Surfaces: ASTM A480/A480M, No. 7 finish (reflective, directional polish).
9. Exposed Surfaces: ASTM A480/A480M, No. 8 finish (mirrorlike reflective, nondirectional polish).
10. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

B. Zinc-Coated Steel Shapes: ASTM A36/A36M, zinc coated according to ASTM A123/A123M requirements.

C. Sealant: ASTM C920; Type S, Grade NS, Class 25, Use NT. Elastomeric sealant shall be NSF certified for commercial-kitchen hood application. Sealants, when cured and washed, shall comply with requirements in 21 CFR 177.2600, for use in areas that come in contact with food.

1. Color: As selected by Architect from manufacturer's full range.
2. Backer Rod: Closed-cell polyethylene, in diameter larger than joint width.

D. Sound Dampening: NSF-certified, non-absorbent, hard-drying, sound-deadening compound for permanent adhesion to metal in minimum 1/8-inch (3-mm) thickness that does not chip, flake, or blister.

E. Gaskets: NSF certified for end-use application indicated; of resilient rubber, neoprene, or PVC that is nontoxic, stable, odorless, nonabsorbent, and unaffected by exposure to foods and cleaning compounds, and that passes testing according to UL 710.

2.3 GENERAL HOOD FABRICATION REQUIREMENTS

A. Welding: Use welding rod of same composition as metal being welded. Use methods that minimize distortion and develop strength and corrosion resistance of base metal. Make ductile welds free of mechanical imperfections such as gas holes, pits, or cracks.

1. Welded Butt Joints: Full-penetration welds for full-joint length. Make joints flat, continuous, and homogenous with sheet metal without relying on straps under seams, filling in with solder, or spot welding.
2. Grind exposed welded joints flush with adjoining material and polish to match adjoining surfaces.
3. Where fasteners are welded to underside of equipment, finish reverse side of weld smooth and flush.
4. Coat concealed stainless-steel welded joints with metallic-based paint to prevent corrosion.
5. After zinc-coated steel is welded, clean welds and abraded areas and apply SSPC-Paint 20, high-zinc-dust-content, galvanizing repair paint to comply with ASTM A780/A780M.

B. For metal butt joints, comply with SMACNA's "Kitchen Ventilation Systems & Food Service Equipment Guidelines."

C. Where stainless steel is joined to a dissimilar metal, use stainless-steel welding material or fastening devices.

D. Form metal with break bends that are not flaky, scaly, or cracked in appearance; where breaks mar uniform surface appearance of material, remove marks by grinding, polishing, and finishing.

E. Sheared Metal Edges: Finish free of burrs, fins, and irregular projections.

F. In food zones, as defined in NSF, fabricate surfaces free from exposed fasteners.

G. Cap exposed fastener threads, including those inside cabinets, with stainless-steel lock washers and stainless-steel cap (acorn) nuts.

H. Fabricate pipe slots on equipment with turned-up edges sized to accommodate service and utility lines and mechanical connections.

I. Fabricate enclosures, including panels, housings, and skirts, to conceal service lines, operating components, and mechanical and electrical devices including those inside cabinets unless otherwise indicated.

J. Fabricate seismic restraints according to SMACNA's "Kitchen Ventilation Systems & Food Service Equipment Guidelines," Appendix A, "Seismic Restraint Details."

K. Fabricate equipment edges and backsplashes according to SMACNA's "Kitchen Ventilation Systems & Food Service Equipment Guidelines."

L. Fabricate enclosure panels to ceiling and wall as follows:

1. Fabricate panels on side(s) as directed with same material as hood, and extend from ceiling to top of hood canopy and from canopy to wall.
2. Wall Offset Spacer: Minimum of 3 inches (75 mm).
3. Wall Shelves and Overshelves: Fabricate according to SMACNA's "Kitchen Ventilation Systems & Food Service Equipment Guidelines," with minimum 0.0625-inch- (1.58-mm-) thick, stainless-steel shelf tops.

2.4 TYPE I EXHAUST HOOD FABRICATION

A. Weld all joints exposed to grease with continuous welds and make filters/baffles or grease extractors and makeup air diffusers easily accessible for cleaning.

1. Fabricate hoods according to NSF 2, "Food Equipment."
2. Hoods shall be listed and labeled, according to UL 710, by a testing agency acceptable to authorities having jurisdiction.
3. Include access panels as required for access to fire dampers and fusible links.
4. Duct Collars: Minimum 0.0598-inch- (1.5-mm-) thick steel at least 3 inches (75 mm) long, continuously welded to top of hood and at corners. Fabricate a collar with a 0.5-inch- (13-mm-) wide duct flange.
5. Duct-Collar Fire Dampers: Collar and damper shall comply with UL 710 testing and listing required for the entire hood.

    a. Collar: Minimum 0.0598-inch- (1.5-mm-) thick stainless steel, at least 3 inches (75 mm) long, continuously welded to top of hood and at corners. Fabricate a collar with a minimum 0.5-inch- (13-mm-) wide duct flange.
    b. Blades: Minimum 0.1046-inch- (2.7-mm-) thick stainless steel, counterbalanced to remain closed after actuation.
    c. Blade Pivot and Spring: Stainless steel.
    d. Fusible Link: Replaceable, 212 deg F (100 deg C) rated.

6. Makeup Air Fire Dampers: Labeled, according to UL 555, by a testing agency acceptable to authorities having jurisdiction.

a. Fire Rating: 1-1/2 hours.
b. Frame: SMACNA Type A or Type B as directed, with blades in airstream; fabricated with roll-formed, galvanized or stainless steel; with mitered and interlocking corners.
c. Blades: Roll-formed, interlocking or folded, minimum 0.034-inch- (0.86-mm-) thick, galvanized-steel sheet.
d. Horizontal Dampers: Include a blade lock and stainless-steel closure spring.
e. Fusible Link: Replaceable, 165 deg F (74 deg C) or 212 deg F (100 deg C) rated as directed.

B. Hood Configuration: Exhaust only and makeup air.

1. Makeup air shall be introduced by induction or combination of induction and diffusion inside canopy as directed. If makeup air is not heated, insulate interior of makeup air plenum with high-density insulation having maximum flame-spread and smoke-developed indexes of 25 and 50, respectively.
2. Makeup air shall be introduced through front and bottom of canopy through perforated diffusers or supply-air registers with adjustable guide vanes as directed.
3. Makeup air shall be introduced through laminar-flow-type, perforated metal panels on front of hood canopy.

C. Hood Style: As directed.

D. Filters/Baffles: Removable, as directed. Fabricate stainless steel for filter frame and removable collection cup and pitched trough. Exposed surfaces shall be pitched to drain to collection cup. Filters/baffles shall be tested according to UL 1046, "Safety for Grease Filters for Exhaust Ducts," by an NRTL acceptable to authorities having jurisdiction.

E. Luminaires: Fixtures and lamps with lenses sealed vapor tight as directed. Wiring shall be in conduit on hood exterior. Number and location of luminaires shall provide a minimum of 70 fc (753 lx) at 30 inches (762 mm) above finished floor.

1. Light switches shall be mounted as directed.
2. Luminaires: Fluorescent or Incandescent complying with UL 1598 as directed.

F. Comply with hood control requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."

G. Hood Controls: Hood or Wall-mounting control cabinet, factory wired to control groups of adjacent hoods, and fabricated of stainless steel.

1. Exhaust Fan: On-off switches shall start and stop the exhaust fan. Interlock exhaust fan with makeup air supply fan to operate simultaneously. Interlock exhaust fan with fire-suppression system to operate fan(s) during fire-suppression-agent release and to remain in operation until manually stopped. Include red pilot light to indicate fan operation.

a. Exhaust Fan Motor Starter: Comply with Section 262913.03 "Manual and Magnetic Motor Controllers."
b. Exhaust Fan Motor Starter: Comply with Section 262913.06 "Soft-Start Motor Controllers."

2. Exhaust Fan Interlock: Factory wire the exhaust fan starters in a single control cabinet for adjacent hoods to operate together.
3. High-Temperature Control: Alarm shall sound and cooking equipment shall shut down before hood discharge temperature rises to actuation temperature of fire-suppression system.

H. Capacities and Characteristics:

1. Nominal Hood Length: As directed.
2. Nominal Hood Width: As directed.
3. Canopy Height: As directed.
4. Exhaust Airflow: As directed.
5. Exhaust-Air Pressure Loss: As directed.
6. Makeup Air Airflow: As directed.
7. Makeup Air Pressure Loss: As directed.

2.5 TYPE II EXHAUST HOOD FABRICATION

A. Fabricate hoods according to NSF 2, "Food Equipment."

B. Hood Configuration: Exhaust only or and makeup air as directed.

1. Makeup air shall be introduced by induction or combination of induction and diffusion inside canopy as directed. If makeup air is not heated, insulate interior of makeup air plenum with high-density insulation having maximum flame-spread and smoke-developed indexes of 25 and 50, respectively.
2. Makeup air shall be introduced through front and bottom of canopy through supply-air registers.
3. Makeup air shall be introduced through laminar-flow-type, perforated metal panels on front of hood canopy.
4. Makeup air shall be introduced through plenum at rear of hood, extending down below appliance cooking surfaces.

C. Hood Type: Heat and vapor or Condensate removal as directed.

D. Hood Style: As directed.

E. Condensate Hood Baffles: Removable, stainless-steel baffles to drain into a hood drain trough, and stainless-steel drain piping.

F. Luminaires: Luminaires and lamps with lenses sealed vapor tight as directed. Wiring shall be installed in stainless-steel conduit on hood exterior. Number and location of luminaires shall provide a minimum of 70 fc (753 lx) at 30 inches (762 mm) above finished floor.

1. Light switches shall be mounted as directed.
2. Luminaires: Fluorescent or Incandescent complying with UL 1598 as directed.

G. Capacities and Characteristics:

1. Nominal Hood Length: As directed.

2. Nominal Hood Width: As directed.
3. Canopy Height: As directed.
4. Exhaust Airflow: As directed.
5. Exhaust-Air Pressure Loss: As directed.
6. Makeup Air Airflow: As directed.
7. Makeup Air Pressure Loss: As directed.

2.6 WET-CHEMICAL FIRE-SUPPRESSION SYSTEM

A. Description: Engineered distribution piping designed for automatic detection and release or manual release of fire-suppression agent by hood operator. Fire-suppression system shall be listed and labeled for complying with NFPA 17A, "Wet Chemical Extinguishing Systems," by a qualified testing agency acceptable to authorities having jurisdiction.

1. Steel Pipe, NPS 2 (DN 50) and Smaller: ASTM A53/A53M, Type S, Grade A, Schedule 40, plain ends.
2. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300.
3. Piping, fusible links and release mechanism, tank containing the suppression agent, and controls shall be factory installed. Controls shall be in stainless-steel control cabinet mounted on hood or wall. Furnish manual pull station for wall mounting. Exposed piping shall be covered with chrome-plated aluminum tubing. Exposed fittings shall be chrome plated.
4. Liquid Extinguishing Agent: Noncorrosive, low-pH liquid.
5. Furnish electric-operated gas shutoff valve; see Section 231123 "Facility Natural-Gas Piping." Or Section 231126 "Facility Liquefied-Petroleum Gas Piping." As directed
6. Furnish electric-operated gas shutoff valve with clearly marked open and closed indicator for field installation.
7. Fire-suppression system controls shall be integrated with controls for fans, lights, and fuel supply and located in a single cabinet for each group of hoods immediately adjacent.
8. Wiring shall have color-coded, numbered terminal blocks and grounding bar. Spare terminals for fire alarm, optional wiring to start fan with fire alarm, red pilot light to indicate fan operation, and control switches shall all be factory wired in control cabinet with relays or starters. Include spare terminals for fire alarm, and wiring to start fan with fire alarm.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Coordinate equipment layout and installation with adjacent Work, including luminaires, HVAC equipment, plumbing, and fire-suppression system components.

B. Complete field assembly of hoods where required.

1. Make closed butt and contact joints that do not require filler.
2. Grind field welds on stainless-steel equipment smooth, and polish to match adjacent finish. Comply with welding requirements in "General Hood Fabrication Requirements" Article.

C. Install hoods and associated services with clearances and access for maintaining, cleaning, and servicing hoods, filters/baffles, grease extractor, and fire-suppression systems according to manufacturer's written instructions and requirements of authorities having jurisdiction.

D. Make cutouts in hoods where required to run service lines and to make final connections, and seal openings according to UL 1978.

E. Securely anchor and attach items and accessories to walls, floors, or bases with stainless-steel fasteners unless otherwise indicated.

F. Install hoods to operate free from vibration.

G. Install seismic restraints according to SMACNA's "Kitchen Ventilation Systems & Food Service Equipment Guidelines," Appendix A, "Seismic Restraint Details."

H. Install trim strips and similar items requiring fasteners in a bed of sealant. Fasten with stainless-steel fasteners at 48 inches (1200 mm) o.c. maximum.

I. Install sealant in joints between equipment and abutting surfaces with continuous joint backing unless otherwise indicated. Provide airtight, watertight, vermin-proof, sanitary joints.

J. Install lamps, with maximum recommended wattage, in equipment with integral lighting.

K. Set initial temperatures, and calibrate sensors.

L. Set field-adjustable switches.

M. Connect ducts according to requirements in Section 233300 "Air Duct Accessories." Install flexible connectors on makeup air supply duct. Weld exhaust-duct connections with continuous liquidtight joint.

N. Install fire-suppression piping for remote-mounted suppression systems according to NFPA 17A, "Wet Chemical Extinguishing Systems."

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Test each equipment item for proper operation. Repair or replace equipment that is defective, including units that operate below required capacity or that operate with excessive noise or vibration.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Perform hood performance tests required by authorities having jurisdiction.
4. Perform fire-suppression system performance tests required by authorities having jurisdiction.

B. Commercial-kitchen hoods will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 233813

SECTION 234100 - PARTICULATE AIR FILTRATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal panel filters.
2. Flat panel filters.
3. Pleated panel filters.
4. Nonsupported bag filters.
5. Rigid cell box filters.
6. V-bank cell filters.
7. Self-supported pocket filters.
8. Front- or back-access filter frames.
9. Side-access filter housings.
10. Filter gauges.

B. Related Requirements:

1. Section 233119 "HVAC Casings" for customized housings used for particulate air filters.
2. Section 233416 "Centrifugal HVAC Fans" for customized fan and filter units.
3. Section 234133 "High-Efficiency Particulate Air Filtration" for HEPA filters used in combination with particulate air filters.
4. Section 234300 "Electronic Air Cleaners" for electronic units combined with particulate filters as part of a system.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

C. Shop Drawings: For air filters. Include plans, elevations, sections, details, and attachments to other work.

1. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
2. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for filters, accessories, and components from manufacturer.

B. Product test reports.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An NRTL.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Filters shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 or 1.0 as directed.

B. ASHRAE Compliance:

1. Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality"; Section 5 - "Systems and Equipment"; and Section 7 - "Construction and Startup."
2. Comply with ASHRAE 52.2 for MERV for methods of testing and rating air-filter units.

C. Comply with NFPA 90A and NFPA 90B.

D. Comply with UL 900.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 METAL PANEL FILTERS

A. Description: Factory-fabricated, self-supported, cleanable, all-metal, impingement-type, panel-type, permanent air filters with holding frames.

B. Capacities and Characteristics:

1. Drawing Tag No.: As directed.

2. Face Size: 24 by 24 inches (600 by 600 mm).
3. Depth: Nominal as directed.
4. Number of Filters, Wide by High: As directed.
5. System Airflow: As directed.
6. Maximum or Rated Face Velocity: As directed.
7. Initial Resistance: As directed.
8. Recommended Final Resistance: As directed.
9. Access: As directed.

C. Media: Minimum of three or four alternate layers of flat and herringbone or serpentine-crimp mesh screen as directed.

1. Non-oiled for grease removal application.
2. Adhesive coating.

D. Filter-Media Frame: Hinged, and with pull and retaining handles fastened to the media as directed.

1. Drain holes.

E. Efficiency: Minimum 90 percent efficiency on particles 10 microns and larger.

2.3 FLAT PANEL FILTERS

A. Description: Factory-fabricated, self-supported, flat, nonpleated, panel-type, disposable air filters with holding frames.

B. Capacities and Characteristics:

1. Drawing Tag No.: As directed.
2. Face Size: 24 by 24 inches (600 by 600 mm).
3. Depth: 4 inches (100 mm) nominal.
4. Number of Filters, Wide by High: As directed.
5. System Airflow: As directed.
6. Maximum or Rated Face Velocity: As directed.
7. Initial Resistance: 0.45-inch wg (112 Pa) at 500 fpm (2.5 m/s).
8. Recommended Final Resistance: As directed.
9. Minimum Efficiency Reporting Value and Average Arrestance: MERV 4, with "Composite Average Particle Size Efficiency, Percent in Size Range, Micrometers" and "Average Arrestance" according to ASHRAE 52.2.
10. Minimum Efficiency Reporting Value: MERV 6, with "Composite Average Particle Size Efficiency, Percent in Size Range, Micrometers" according to ASHRAE 52.2.
11. Access: As directed.

C. Media: Interlaced glass or Cotton and synthetic fibers coated with nonflammable adhesive.

1. Media shall be coated with an antimicrobial agent.
2. Metal Retainer: Upstream side and downstream side.

D. Filter-Media Frame: Cardboard with perforated metal retainer or Galvanized steel with metal grid on outlet side and steel rod grid on inlet side, hinged, with pull and retaining handles sealed or bonded to the media as directed.

2.4 PLEATED PANEL FILTERS

A. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters with holding frames.

B. Capacities and Characteristics:

1. Drawing Tag No.: As directed.
2. Face Size: 24 by 24 inches (600 by 600 mm).
3. Depth: As directed.
4. Number of Filters, Wide by High: As directed.
5. System Airflow: As directed.
6. Maximum or Rated Face Velocity: As directed.
7. Initial Resistance: As directed.
8. Recommended Final Resistance: As directed.
9. Minimum Efficiency Reporting Value: MERV 6 or 13 as directed, with "Composite Average Particle Size Efficiency, Percent in Size Range, Micrometers" according to ASHRAE 52.2.
10. Access: As directed.

C. Media: Interlaced glass or Cotton and synthetic fibers coated with nonflammable adhesive. Coat media with an antimicrobial agent.

1. Separators shall be bonded to the media to maintain pleat configuration.
2. Welded-wire grid shall be on downstream side to maintain pleat.
3. Media shall be bonded to frame to prevent air bypass.
4. Support members on upstream and downstream sides to maintain pleat spacing.

D. Filter-Media Frame: As directed.

2.5 NONSUPPORTED BAG FILTERS

A. Description: Factory-fabricated, dry, extended-surface, nonsupported filters with header frames.

B. Capacities and Characteristics:

1. Drawing Tag No.: As directed.
2. Face Size: 24 by 24 inches (600 by 600 mm).
3. Depth: As directed.
4. Number of Filters, Wide by High: As directed.
5. Surface Area: As directed.
6. System Airflow: As directed.
7. Maximum or Rated Face Velocity: As directed.
8. Initial Resistance: As directed.
9. Recommended Final Resistance: As directed.

10. Minimum Efficiency Reporting Value: MERV value as directed with "Composite Average Particle Size Efficiency, Percent in Size Range, Micrometers" according to ASHRAE 52.2.
11. Access: As directed.

C. Media: Glass-fiber or Synthetic material constructed so individual pockets are maintained in tapered form under rated-airflow conditions by flexible internal supports. Coat media with an antimicrobial agent.

D. Filter-Media Frame: Galvanized steel.

2.6 RIGID CELL BOX FILTERS

A. Description: Factory-fabricated, adhesive-coated, disposable, packaged air filters with media perpendicular to airflow, and with holding frames.

B. Capacities and Characteristics:

1. Drawing Tag No.: As directed.
2. Face Size: 24 by 24 inches (600 by 600 mm).
3. Depth: As directed.
4. Number of Filters, Wide by High: As directed.
5. Surface Area: As directed.
6. System Airflow: As directed.
7. Maximum or Rated Face Velocity: As directed.
8. Initial Resistance: As directed.
9. Recommended Final Resistance: As directed. LEED 2009 IEQ Prerequisite 1 and LEED v4 EQ Prerequisite "Minimum Indoor Air Quality Performance" require compliance with ASHRAE 62.1 (2007 and 2010 versions, respectively), which require a MERV rating of 6 or higher for service to occupied spaces. LEED 2009 IEQ Credit 5 and LEED v4 IEQ Credit "Enhanced Indoor Air Quality Strategies" require MERV 13 or higher. Insert values appropriate to Project sustainability goals.
10. Minimum Efficiency Reporting Value: MERV value as directed, with "Composite Average Particle Size Efficiency, Percent in Size Range, Micrometers" according to ASHRAE 52.2.
11. Access: As directed.

C. Media: Fibrous material constructed so individual pleats are maintained in tapered form under rated-airflow conditions by flexible internal supports. Coat media with antimicrobial agent.

D. Filter-Media Frames: Galvanized steel.

2.7 V-BANK CELL FILTERS

A. Description: Factory-fabricated, adhesive-coated, disposable, packaged air filters with media angled to airflow, and with holding frames.

B. Capacities and Characteristics:

1. Drawing Tag No.: As directed.
2. Face Size: 24 by 24 inches (600 by 600 mm).
3. Depth: As directed.
4. Surface Area: As directed.
5. Number of Filters, Wide by High: As directed.
6. System Airflow: As directed.
7. Maximum or Rated Face Velocity: As directed.
8. Initial Resistance: As directed.
9. Recommended Final Resistance: As directed.
10. Minimum Efficiency Reporting Value: MERV value as directed, with "Composite Average Particle Size Efficiency, Percent in Size Range, Micrometers" according to ASHRAE 52.2.
11. Access: As directed.

C. Media: Fibrous material constructed so individual mini-pleats are maintained in tapered form under rated-airflow conditions by flexible internal supports. Coat media with an antimicrobial agent.

D. Filter-Media Frames: HIPS

2.8 SELF-SUPPORTED POCKET FILTERS

A. Description: Factory-fabricated, panel-type, disposable air filters with contoured, self-supported media for extended surface.

B. Capacities and Characteristics:

1. Drawing Tag No.: As directed.
2. Face Size: 24 by 24 inches (600 by 600 mm).
3. Depth: As directed.
4. Number of Filters, Wide by High: As directed.
5. Surface Area: As directed.
6. System Airflow: As directed.
7. Maximum or Rated Face Velocity: As directed.
8. Initial Resistance: As directed.
9. Recommended Final Resistance: As directed.
10. Minimum Efficiency Reporting Value: MERV 6 or 8 as directed, with "Composite Average Particle Size Efficiency, Percent in Size Range, Micrometers" according to ASHRAE 52.2.
11. Access: As directed.

C. Media: Fibrous material constructed so individual pleats are maintained in tapered form under rated-airflow conditions by flexible internal supports. Coat media with an antimicrobial agent.

D. Configuration: Single-pocket cube or Multipocket as directed.

E. Filter-Media Frame: Galvanized steel.

2.9 FRONT- OR BACK-ACCESS FILTER FRAMES

A. Description: Galvanized-steel or Aluminum framing members as directed with access for either upstream (front) or downstream (back) filter servicing, cut to size and prepunched for assembly into modules. Vertically support filters to prevent deflection of horizontal members without interfering with filter installation or operation.

B. Prefilters: Incorporate a separate track with spring clips, removable from front or back.

C. Sealing: Factory-installed, positive-sealing device for each row of filters, to ensure seal between gasketed filter elements and to prevent bypass of unfiltered air.

2.10 SIDE-ACCESS FILTER HOUSINGS

A. Description: Factory-assembled, side-service housings, constructed of galvanized steel or aluminum as directed, with flanges to connect to duct or casing system.

B. Prefilters: Integral tracks to accommodate 2-inch- (50-mm-) thick, disposable or washable filters.

C. Access Doors: Hinged, with continuous or Continuous gaskets on perimeter and positive-locking devices, and arranged so filter cartridges can be loaded from either access door.

D. Sealing: Incorporate positive-sealing gasket material on channels to seal top and bottom of filter cartridge frames and to prevent bypass of unfiltered air.

2.11 FILTER GAUGES

A. Diaphragm-type gauge with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.
   1. Diameter: 4-1/2 inches (115 mm) or 2 inches (50 mm) as directed.
   2. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5-Inch wg (125 Pa) or Less: 0- to 0.5-inch wg (0 to 125 Pa).
   3. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5- to 1.0-Inch wg (125 to 250 Pa) or Less: 0- to 1.0-inch wg (0 to 250 Pa).
   4. Scale Range for Filter Media Having a Recommended Final Resistance of 1.0- to 2.0-Inch wg (250 to 500 Pa) or Less: 0- to 2.0-inch wg (0 to 500 Pa).
   5. Scale Range for Filter Media Having a Recommended Final Resistance of 2.0- to 3.0-Inch wg (500 to 750 Pa) or Less: 0- to 3.0-inch wg (0 to 750 Pa).
   6. Scale Range for Filter Media Having a Recommended Final Resistance of 3.0- to 4.0-Inch wg (750 to 1000 Pa) or Less: 0- to 4.0-inch wg (0 to 1000 Pa).

B. Manometer-Type Filter Gauge: Molded plastic, with epoxy-coated aluminum scale and logarithmic-curve tube gage with integral leveling gage, graduated to read from 0- to 3.0-inch wg (0 to 750 Pa), and accurate within 3 percent of the full-scale range.

C. Accessories: Static-pressure tips, tubing, gauge connections, and mounting bracket.

PART 3 - EXECUTION

3.1 INSTALLATION OF FILTERS

A. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.

B. Install filters in position to prevent passage of unfiltered air.

C. Install filter gauge for each filter bank.

D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.

E. Coordinate filter installations with duct and air-handling-unit installations.

3.2 INSTALLATION OF FILTER GAUGES

A. Install filter gauge for each filter bank.

B. Install filter-gauge, static-pressure tips upstream and downstream from filters. Install filter gauges on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gauges on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gauges.

3.3 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between pressure sensors and DDC system.

C. Connect control wiring between controlled devices.

D. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Tests and Inspections:

1. Test for leakage of unfiltered air while system is operating.

E. Air filter will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.5 CLEANING

A. After completing system installation and testing, adjusting, and balancing of air-handling and air-distribution systems, clean filter housings and install new filter media.

END OF SECTION 234100

SECTION 234133 - HIGH-EFFICIENCY PARTICULATE AIR FILTRATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. HEPA rigid-cell box filters.
2. HEPA V-bank cell filters.
3. HEPA/ULPA filter holding frames.
4. Side-access HEPA/ULPA filter housings.
5. Side-access HEPA/ULPA filter containment housings.
6. HEPA filter gauges.

B. Related Requirements:

1. Section 233119 "HVAC Casings" for customized housings used for HEPA filters.
2. Section 234100 "Particulate Air Filtration" for particulate-air filters used in combination with HEPA filters.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

C. Shop Drawings: For air filters.

1. Include plans, elevations, sections, details, and attachments to other work.
2. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
3. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for filters, accessories, and components from manufacturer.

B. Product test reports.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An NRTL.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Filters shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 or 1.0 as directed.

B. ASHRAE 62.1 Compliance:

1. Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality"; Section 5 - "Systems and Equipment"; and Section 7 - "Construction and Startup."

C. Comply with UL 900.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended use.

E. Capacities and Characteristics:

1. Drawing Tag No.: As directed.
2. Face Size: As directed.
3. Depth: As directed.
4. Surface Area: As directed.
5. Number of Filters, Wide by High: As directed.
6. System Airflow: As directed.
7. Maximum or Rated Face Velocity: As directed.
8. Initial Resistance: As directed.
9. Recommended Final Resistance: As directed.
10. Access: As directed.
11. Performance Level: 99.97 percent HEPA.

2.2 HEPA RIGID-CELL BOX FILTERS

A. Description: Factory-fabricated, disposable, packaged air filters with media perpendicular to airflow and with holding frames.

B. Standards:

1. Comply with IEST-RP-CC001.6.
2. Comply with UL 586.
3. Comply with IEST-RP-CC034.4.

C. Media: Fibrous material, constructed so individual pleats are maintained under rated-airflow conditions.

1. Internal Separators: None or Corrugated aluminum or as directed
2. Media to Filter Frame Seal Material: Polyurethane.
3. Faceguard Material: Aluminum or Stainless steel as directed.
4. Faceguard Location: None or Upstream and downstream.

D. Filter-Media Frames:

1. Material: As directed.
2. Filter Frame to Mounting Frame Seal Material: As directed.
3. Filter Frame to Mounting Frame Seal Location: Upstream or Downstream As directed.
4. Style: Box or Gel track As directed.

2.3 HEPA V-BANK CELL FILTERS

A. Description: Factory-fabricated, disposable, packaged air filters with media at an angle to airflow and with holding frames.

B. Standards:

1. Comply with IEST-RP-CC001.6.
2. Comply with UL 586.
3. Comply with IEST-RP-CC034.4.

C. Media: Fibrous material, constructed so individual pleats are maintained under rated-airflow conditions.

1. Internal Separators: None or Corrugated aluminum as directed.
2. Media to Filter Frame Seal Material: Polyurethane as directed.

D. Filter-Media Frames:

1. Material: As directed.
2. Filter Frame to Mounting Frame Seal Material: As directed.
3. Filter Frame to Mounting Frame Seal Location: Upstream or Downstream As directed.
4. Style: Box or Gel track as directed.

2.4 HEPA/ULPA FILTER HOLDING FRAMES

A. Description: Framing members with access for upstream (front) or downstream (back) filter servicing, cut to size and prepunched for assembly into modules, specifically designed for HEPA filter banks.

B. Material: Minimum 14-gauge (1.9-mm) stainless- or galvanized-steel framing members. Factory-prepunched holes and dimples for ease of filter alignment and assembly.

C. Prefilters: Incorporate a separate holding frame for prefilter, removable from front or back.

D. Gasketed Sealing: Factory-installed, positive-sealing device for each filter to ensure seal between gasketed filter elements to prevent bypass of unfiltered air. Filter latching mechanism to seat each filter firmly against holding frame surface.

E. Knife-Edge Sealing: Knife-edge to mate with HEPA filter elements to prevent bypass of unfiltered air. Factory-installed, positive-locking mechanism for each filter to seat the knife edge into the gel during installation and to remove the filter from the knife edge during filter replacement.

2.5 SIDE-ACCESS HEPA/ULPA FILTER HOUSINGS

A. Description: Factory-assembled, side-access filter housings, specifically designed for HEPA filter banks, with flanges to connect to duct or casing system.

B. Factory Testing: Factory pressure test housing and sealed joints at 6.0-inch wg (1500 Pa). Document and submit to confirm maximum leakage percentage as directed.

C. Materials: As directed.

1. Pressure taps and fittings.
2. DOP test ports.
3. Mounted magnehelic gauges.

D. Prefilters: Integral tracks to accommodate 2-inch- (50-mm-) or 4-inch- (100-mm-) thick as directed, disposable or washable filters.

E. Access Doors: Hinged, with continuous or Continuous gaskets on perimeter and positive-locking devices. Arranged for filter access from one-side or both-sides access door as directed.

F. Gasketed Sealing: Factory-installed, positive-sealing device for each filter to ensure seal between gasketed filter elements to prevent bypass of unfiltered air. Filter latching mechanism to seat each filter firmly against side-access housing channel surface.

G. Knife-Edge Sealing: Knife-edge to mate with HEPA filter elements to prevent bypass of unfiltered air. Factory-installed, positive-locking mechanism for each filter to seat the knife edge into the gel during installation and to remove the filter from the knife edge during filter replacement.

2.6 SIDE-ACCESS HEPA/ULPA FILTER CONTAINMENT HOUSINGS

A. Description: Factory-assembled, side-access housings, with bag in/bag out feature to protect maintenance personnel from coming into direct contact with the interior of the housing and the contaminated filter media during required filter change out, with flanges to connect to duct or casing system.

B. Standards: Test according to ASME AG-1.

C. Casing:

1. Material: Constructed of minimum 16-gauge- (1.5-mm-) as directed to hold filters. Side servicing through gasketed access doors on one side. Equip housings to be capable of connection to other housings. Equip housings with metal slide channel tracks and locking mechanisms to hold filters, and the following:

    a. Pressure gauge tap and fitting.
    b. DOP test ports.
    c. Lifting lugs.

2. Casing Pressure: Casing constructed for up to positive/negative 6.0-inch wg (1500 Pa) or positive/negative 10-inch wg (2500 Pa) as directed.

D. Isolation Dampers:

1. Material: Stainless-steel body, blade, and flanges.
2. Round Damper Blade: Damper diameter as directed, replaceable, solid silicone gasket sandwiched between stainless-steel plates, providing silicone gasket blade to knife edge seal.

    a. Bubble-tight seal at minimum 10-inch wg (2490-Pa) differential pressure to comply with ASME N509.

E. Prefilters: Integral tracks to accommodate 2-inch- (50-mm-) or 4-inch- (100-mm-) thick as directed, disposable filters.

F. Access Doors: Continuous gaskets on perimeter and positive-locking devices. Provide ribbed bagging rim behind access door and PVC bags for bag-in, bag-out arrangement. Arrange so filter cartridges can be loaded from an access door for each tier and section of the following:

1. Combination prefilter and HEPA filter.
2. HEPA filter.
3. Upstream and downstream test section.

G. Gasketed Sealing: Factory-installed, positive-sealing device for each filter to ensure seal between gasketed filter elements to prevent bypass of unfiltered air. Filter locking mechanism to seat each filter firmly against side-access housing channel surface.

H. Knife-Edge Sealing: Knife-edge to mate with HEPA filter elements to prevent bypass of unfiltered air. Factory-installed, positive-locking mechanism for each filter to seat the knife

edge into the gel during installation and to remove the filter from the knife edge during filter replacement.

I. Accessories:

1. Filter change-out trays.
2. Document-storage pocket.
3. Filter removal rod.

2.7 HEPA, ULPA, AND 95 PERCENT DOP FILTER GAUGES

A. Diaphragm type with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.
1. Diameter: 4-1/2 inches (115 mm) or 2-1/2 inches (75 mm) as directed.
2. Material: Stainless-steel case and die-cast aluminum or stainless-steel body as directed with wetted material matching body material.
3. Accuracy: Plus/minus 2 percent of full scale.
4. Scale Range for Filter Media Having a Recommended Final Resistance of 2.0- to 3.0-Inch wg (500 to 750 Pa) or Less: 0- to 3.0-inch wg (0 to 750 Pa).
5. Scale Range for Filter Media Having a Recommended Final Resistance of 3.0- to 4.0-Inch wg (750 to 1000 Pa) or Less: 0- to 4.0-inch wg (0 to 1000 Pa).

B. Accessories: Static-pressure tips, tubing, gauge connections, and mounting bracket.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine ducts, air-handling units, and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF FILTERS

A. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.

B. Install filters in position to prevent passage of unfiltered air.

C. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters that were used during construction and testing with new, clean filters.

D. Coordinate filter installations with duct and air-handling unit installations.

3.3 INSTALLATION OF HEPA, ULPA, AND 95 PERCENT DOP FILTER GAUGES

A. Install filter gauge for each filter bank.

B. Install filter-gauge, static-pressure tips upstream and downstream from filters. Install filter gauges on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gauges on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gauges.

C. After completing system installation and testing, adjusting, and balancing air-handling and air-distribution systems, clean filter housings and install new filter media.

D. Protect installed products and accessories from damage during construction.

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between pressure sensors and DDC system.

C. Connect control wiring between controlled devices.

D. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Tests and Inspections:

1. HEPA Filters: Pressurize housing to a minimum of 6.0-inch wg (1500 Pa), and test housing joints, door seals, and sealing edges of filter for air leaks according to pressure-decay method in ASME AG-1.

E. Air filter will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

END OF SECTION 234133

SECTION 234200 - GAS-PHASE AIR FILTRATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Gas-phase panel filters.
2. Gas-phase, V-cell filters.
3. Gas-phase, rigid-cell box filters.
4. Front- or back-access filter frames.
5. Side-access filter housings.
6. Filter gages.

B. Related Requirements:

1. Section 233119 "HVAC Casings" for customized housings used for gas-phase filters.
2. Section 233416 "Centrifugal HVAC Fans" for customized fan and filter units.
3. Section 234133 "High-Efficiency Particulate Filtration" for high-efficiency particulate air (HEPA) filters used in combination with gas-phase filters.
4. Section 234300 "Electronic Air Cleaners" for electronic units combined with gas-phase filters as part of a system.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

C. Shop Drawings: For gas-phase air filters. Include plans, elevations, sections, details, and attachments to other work.

1. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
2. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for gas-phase filters, accessories, and components from manufacturer.

B. Product test reports.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An NRTL.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply as directed.

B. Seismic Performance: Filters shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 or 1.0.

C. ASHRAE 62.1 Compliance: Section 5, "Systems and Equipment" and Section 7, "Construction and System Start-up."

D. Comply with NFPA 90A and NFPA 90B.

2.2 GAS-PHASE PANEL FILTERS

A. Description: Factory-fabricated panel or pleated adsorbent media filter.

B. Filter Unit Class: UL 900, Class 2.

C. Capacities and Characteristics:

1. Drawing Tag No.: As directed.
2. Face Size: As directed.
3. Depth: As directed.
4. System Airflow: As directed.
5. Maximum or Rated Face Velocity: 500 fpm (2.5 m/s).
6. No. of Filters, Wide by High: As directed.
7. Service Access Location (Front, Back, Side): As directed.
8. Initial Resistance: 0.50-inch wg (125 Pa).
9. Final Resistance: 1.0-inch wg (250 Pa).

D. Media:

1. Flat-panel or pleated, multilayer filter with an inlet layer of nonwoven polyester fibers, bonded or supported by a grid, to a layer of activated carbon.
2. Housed in a beverage board frame.
3. Minimum CTC activity level of 60 percent.

E. MERV Rating: Minimum MERV 6 or MERV 8 as directed, according to ASHRAE 52.2.

F. Maximum Continuous Operating Temperature: 150 deg F (65 deg C).

G. Pre-installation Protection: Package each gas-phase filter in a sealed polyethylene bag to prevent unintentional adsorption prior to installation.

2.3 GAS-PHASE, V-CELL FILTERS

A. Description: Factory-fabricated, dry, V-shaped cartridges containing loose-fill adsorbent media with holding frames.

B. Capacities and Characteristics:

1. Drawing Tag No.: As directed.
2. Face Size: As directed.
3. Depth: 12 inches (300 mm) nominal.
4. System Airflow: As directed.
5. Maximum or Rated Face Velocity: 500 fpm (2.5 m/s).
6. No. of Filters, Wide by High: As directed.
7. Service Access Location (Front, Back, or Side): As directed.
8. Resistance: 0.50-inch wg (125 Pa).
9. Recommended Change-out Interval Frequency: 1 year.

C. Cartridges: V-cell configuration; plastic enclosure caps; galvanized-steel, HIPS, or ABS frame with vertical galvanized-steel, HIPS, or ABS channel supports. Integral, 1-inch (25-mm) thick panels constructed of honeycombed paper and nylon mesh or mini-pleats on each side of adsorbent media.

D. Media: Coconut-shell activated carbon; As directed activated carbon per 1000 cfm (470 L/s) of airflow.

1. Ash Content: Percent as directed.
2. Percentage of CTC Activity: 60 percent minimum, when tested according to ASTM D3467.
3. Bulk Density: as directed.
4. Mesh Size: 4 x 6 U.S. standard mesh (4.75 x 3.35 mm) 90 percent minimum.
5. Hardness Factor: 95, when tested according to ASTM D3802.

E. Media: Activated alumina or zeolite impregnated with potassium permanganate; Lb (kg) as directed of adsorbent per 500 cfm (236 L/s) of airflow.

1. Ash Content: Percent as directed.

2. Percentage of CTC Activity: 60 percent minimum, when tested according to ASTM D3467.
3. Bulk Density: As directed.
4. Mesh Size: 4 x 6 U.S. standard mesh (4.75 x 3.35 mm), 90 percent minimum.
5. Hardness Factor: 95, when tested according to ASTM D3802.

F. Media: Caustic sodium-hydroxide-impregnated carbon; Lb (kg) as directed of adsorbent per 500 cfm (236 L/s) of airflow.

1. Ash Content: Percent as directed.
2. Percentage of CTC Activity: 60 percent minimum, when tested according to ASTM D3467.
3. Bulk Density: As directed.
4. Mesh Size: 4 x 6 U.S. standard mesh (4.75 x 3.35 mm), 90 percent minimum.
5. Hardness Factor: 95, when tested according to ASTM D3802.

G. Media: 50/50 blended carbon and alumina or zeolite impregnated with potassium permanganate; Lb (kg) as directed of adsorbent per 500 cfm (236 L/s) of airflow.

1. Ash Content: Percent as directed.
2. Percentage of CTC Activity: 60 percent minimum, when tested according to ASTM D3467.
3. Bulk Density: As directed.
4. Mesh Size: 4 x 6 U.S. standard mesh (4.75 x 3.35 mm), 90 percent minimum.
5. Hardness Factor: 95, when tested according to ASTM D3802.

H. Media: Activated carbon impregnated with phosphoric acid; Lb (kg) as directed of adsorbent per 500 cfm (236 L/s) of airflow.

1. Ash Content: Percent as directed.
2. Percentage of CTC Activity: 60 percent minimum, when tested according to ASTM D3467.
3. Bulk Density: As directed.
4. Mesh Size: 4 x 6 U.S. standard mesh (4.75 x 3.35 mm), 90 percent minimum.
5. Hardness Factor: 95, when tested according to ASTM D3802.

I. Media: Lb (kg) per 1000 cfm (470 L/s) as directed of Media and adsorbent as directed.

1. Ash Content: Percent as directed.
2. Percentage of CTC Activity: 60 percent minimum, when tested according to ASTM D3467.
3. Bulk Density: As directed.
4. Mesh Size: 4 x 6 U.S. standard mesh (4.75 x 3.35 mm), 90 percent minimum.
5. Hardness Factor: Tested according to ASTM D3802 as directed.
6. Prefilter: Comply with requirements in Section 234100 "Particulate Air Filtration" for panel as directed. Size and airflow capacity shall match those of gas-phase filters.

    a. Depth: As directed.
    b. Maximum or Rated Face Velocity: 500 fpm (2.5 m/s).
    c. Initial Resistance: As directed.
    d. Recommended Final Resistance: As directed.

e. Filter Unit Class: UL 900, Class 2.
f. Minimum Efficiency Reporting Value and Average Arrestance:

1) MERV Rating: As directed, according to ASHRAE 52.2.

g. Minimum Efficiency Reporting Value:

1) MERV Rating: MERV 6 or MERV 13 as directed, according to ASHRAE 52.2.

7. Final Filter: Comply with requirements in Section 234100 "Particulate Air Filtration" for filter as directed. Size and airflow capacity shall match those of gas-phase filters.

a. Depth: As directed.
b. Maximum or Rated Face Velocity: 500 fpm (2.5 m/s).
c. Initial Resistance: 1-inch wg (250 Pa) or 2-inch wg (500 Pa) as directed at 500 fpm (2.5 m/s).
d. Recommended Final Resistance: As directed.
e. Filter Unit Class: UL 900, Class 1 or Class 2 as directed.
f. Minimum Efficiency Reporting Value:

1) MERV Rating: MERV 13, according to ASHRAE 52.2.

J. Pre-installation Protection: Package each filter in a sealed polyethylene bag to prevent unintentional adsorption prior to installation.

2.4 GAS-PHASE, RIGID-CELL BOX FILTERS

A. Description: Factory-fabricated, adsorbent media bonded to nonwoven deep pleats with plastic pleat spacers, contained in a rigid-cell box.

B. Filter Unit Class: UL 900, Class 1 or Class 2 as directed.

C. Capacities and Characteristics:

1. Drawing Tag No.: As directed.
2. Face Size: 24 by 24 inches (600 by 600 mm) or 24 by 12 inches (600 by 300 mm) nominal as directed.
3. Depth: 12 inches (300 mm) nominal.
4. System Airflow: As directed.
5. Maximum or Rated Face Velocity: 500 fpm (2.5 m/s).
6. Initial Resistance: 0.50-inch wg (140 Pa).
7. Recommended Final Resistance: 1.5 in wg (370 Pa).
8. Minimum Toluene Removal Efficiency: 90 percent.

D. Media: Activated Carbon; As directed of activated carbon per 1000 cfm (470 L/s) of airflow.

1. Ash Content: Percent as directed.
2. Percentage of CTC Activity: 60 percent minimum, when tested according to ASTM D3467.

3. Bulk Density: As directed.
4. Mesh Size: 4 x 6 U.S. standard mesh (4.75 x 3.35 mm), 90 percent minimum.
5. Hardness Factor: 95, when tested according to ASTM D3802.

E. Media: 50/50 blended carbon and alumina or zeolite impregnated with potassium permanganate; lb (kg) as directed of adsorbent per 1000 cfm (470 L/s) of airflow.

1. Ash Content: Percent as directed.
2. Percentage of CTC Activity: 60 percent minimum, when tested according to ASTM D3467.
3. Bulk Density: As directed.
4. Mesh Size: 4 x 6 U.S. standard mesh (4.75 x 3.35 mm), 90 percent minimum.
5. Hardness Factor: 95, when tested according to ASTM D3802.

F. Media: As directed.

1. Ash Content: Percent as directed.
2. Percentage of CTC Activity: 60 percent minimum, when tested according to ASTM D3467.
3. Bulk Density: As directed.
4. Mesh Size: 4 x 6 U.S. standard mesh (4.75 x 3.35 mm), 90 percent minimum.
5. Hardness Factor: 95, when tested according to ASTM D3802.

G. Filter-Media Frame: Galvanized steel.

H. Pre-installation Protection: Package each gas-phase filter in a sealed polyethylene bag to prevent unintentional adsorption prior to installation.

2.5 FRONT- OR BACK-ACCESS FILTER FRAMES

A. Framing System: Galvanized-steel or Aluminum framing members as directed with access for upstream (front) filter servicing, cut to size and prepunched for assembly into modules. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation or operation.

B. Prefilters: Incorporate a separate track with spring clips, removable from front or back.

C. Sealing: Factory-installed, positive-sealing device for each row of filters to ensure seal between gasketed filter elements to prevent bypass of unfiltered air.

2.6 SIDE-ACCESS FILTER HOUSINGS

A. Description: Factory-assembled, side-access housings constructed of galvanized steel or aluminum as directed with flanges to connect to duct or casing system.

B. Prefilters: Integral tracks to accommodate 2-inch- (50-mm-) thick, disposable or washable filters.

C. Access Doors: Hinged with continuous or Continuous gaskets on perimeter and with positive-locking devices. Arrange so filter cartridges can be loaded from either access door.

D. Sealing: Incorporate positive-sealing gasket material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.

2.7 FILTER GAUGES

A. Diaphragm type, with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.
   1. Diameter: 4-1/2 inches (115 mm) or 2 inches (50 mm) as directed.
   2. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5-Inch wg (125 Pa) or Less: 0- to 0.5-inch wg (0 to 125 Pa).
   3. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5- to 1.0-Inch wg (125 to 250 Pa) or Less: 0- to 1.0-inch wg (0 to 250 Pa).
   4. Scale Range for Filter Media Having a Recommended Final Resistance of 1.0- to 2.0-Inch wg (250 to 500 Pa) or Less: 0- to 2.0-inch wg (0 to 500 Pa).
   5. Scale Range for Filter Media Having a Recommended Final Resistance of 2.0- to 3.0-Inch wg (500 to 750 Pa) or Less: 0- to 3.0-inch wg (0 to 750 Pa).
   6. Scale Range for Filter Media Having a Recommended Final Resistance of 3.0- to 4.0-Inch wg (750 to 1000 Pa) or Less: 0- to 4.0-inch wg (0 to 1000 Pa).

B. Manometer-Type Filter Gage: Molded plastic, with epoxy-coated aluminum scale, logarithmic-curve tube gage with integral leveling gage; graduated to read from 0- to 3.0-inch wg (0 to 750 Pa) and accurate within 3 percent of full-scale range.

C. Accessories: Static-pressure tips, tubing, gage connections, and mounting bracket.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Examine ducts, air-handling units, and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Position each filter unit with required clearance for service and maintenance. Anchor filter-mounting frames to substrate.

C. Install filters in position to prevent passage of unfiltered air.

D. Do not operate fan system until particulate filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.

E. Do not install gas-phase filters until fan system is clean and there is no risk of construction debris loading the filter.

F. Install filter-gauge, static-pressure taps upstream and downstream from each filter bank. Install filter gauges on filter banks with separate static-pressure taps upstream and downstream of

filters. Mount filter gauges on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gauges.

G. Coordinate filter installations with duct and air-handling-unit installations.

H. Install all manufacturer-provided accessories in accordance with manufacturer's written installation instructions.

3.2 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between pressure sensors and DDC control system.

C. Connect control wiring between controlled devices.

D. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.3 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Test for leakage of unfiltered air while system is operating.

D. Air filters will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.4 CLEANING

A. After completing system installation and testing, adjusting, and balancing air-handling and air-distribution systems, clean filter housings and install new particulate filter media.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain filters as directed.

END OF SECTION 234200

SECTION 234300 - ELECTRONIC AIR CLEANERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Electronic air cleaners.
2. Filters associated with electronic air cleaners.
3. Filter gauges.

B. Related Requirements:

1. Section 233119 "HVAC Casings" for customized housings used for particulate air filters.
2. Section 233416 "Centrifugal HVAC Fans" for customized fan and filter units.
3. Section 234133 "High-Efficiency Particulate Air Filtration" for high-efficiency particulate air filters used in combination with particulate air filters.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

C. Shop Drawings: For each electronic air cleaner.

1. Include plans, elevations, sections, details, and attachments to other work.
2. Show filter assembly, dimensions, materials, and methods of assembly of components.
3. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.
4. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for filters, accessories, and components, from manufacturer.

B. Product test reports.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An NRTL.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Filters shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 or 1.0 as directed.

B. ASHRAE Compliance:

1. Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality"; Section 5 - "Systems and Equipment"; and Section 7 - "Construction and Startup."
2. Comply with ASHRAE 52.2 for MERV for methods of testing and rating air-filter units.

C. Comply with AHRI 850.

D. Comply with NFPA 90A or NFPA 90B as directed.

E. Comply with UL 867.

F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 CAPACITIES AND CHARACTERISTICS

A. Drawing Tag. No.: As directed.

B. Face Size: 48 by 24 inches (1152 by 600 mm) nominal.

C. Number of Cleaner Units: As directed.

D. Unit Depth: Nominal as directed.

E. Frame Access Location: As directed.

F. System Airflow: As directed.

G. Maximum or Rated Face Velocity: 500 fpm (2.5 m/s).

H. Power Pack:

1. Volts: V as directed.
2. Phase: Single or Three as directed.
3. Hertz: 60 Hz.
4. Full-Load Amperes: A as directed.
5. Minimum Circuit Ampacity: A as directed.

I. Maximum Overcurrent Protection Device: A as directed.

J. Efficiency: As directed.

K. Initial Resistance: 0.25-inch wg (63 Pa).

L. Prefilter Type: As directed.

1. Prefilter Face Size: As directed.
2. Number of Prefilters, Wide by High: As directed.
3. Minimum Efficiency Reporting Value (MERV) and Average Arrestance: MERV 4, with "Composite Average Particle Size Efficiency and Arrestance, Percent in Size Range, Micrometers" according to ASHRAE 52.2.
4. Minimum Efficiency Reporting Value: MERV 6, with "Composite Average Particle Size Efficiency, Percent in Size Range, Micrometers" according to ASHRAE 52.2.

M. Final Filter Type: As directed.

1. Final-Filter Face Size: As directed.
2. Number of Final Filters, Wide by High: As directed.
3. Minimum Efficiency Reporting Value: MERV 6, with "Composite Average Particle Size Efficiency, Percent in Size Range, Micrometers" according to ASHRAE 52.2.

N. Fan Motor Electrical Characteristics:

1. Horsepower: hp as directed.
2. Volts: V as directed.
3. Phase: Single or 3 as directed.
4. Hertz: 60 Hz.
5. Full-Load Amperes: A as directed.
6. Minimum Circuit Ampacity: A as directed.
7. Maximum Overcurrent Protection Device: A as directed.

O. Cleaning System: Manual or automatic.

P. Reservoir Tank: 30 gal. (114 L) or 50 gal. (190 L) as directed.

Q. Connections:

1. Water Supply: NPS (DN) as directed.
2. Drain: NPS (DN) as directed.

2.3 ELECTRONIC AIR CLEANERS

A. Description: Factory-fabricated, electronic air cleaner operating by electrostatic precipitation principles.

B. Prefilter Media: As directed.

C. Prefilter: Comply with requirements in Section 234100 "Particulate Air Filtration" for panel as directed. Size and airflow capacity shall match those of electronic air cleaners.

1. Depth: As directed.
2. Comply with UL 900.

D. Final Filter: Comply with requirements in Section 234100 "Particulate Air Filtration" as directed. Size and airflow capacity shall match those of electronic air cleaners.

1. Depth: As directed.
2. Comply with UL 900.

E. Collection Cells: Aluminum, independently supported and nested.

1. Ionizing Section: Alternately spaced grounded struts and charged ionizing wires.
2. Collecting Section: Alternately grounded and charged plates, with insulators located out of airstream.

F. Power Pack: Self-contained, prewired rectifying unit to convert power, as scheduled on Drawings or identified in "Capacities and Characteristics" Article as directed, to approximately 12,000 V dc for ionizer and 6000 V dc for collector; include overload protection, on-off switch, pilot light showing operating status, and access door interlock. Alternatively provide high-voltage and high-frequency-grid excitation technology power pack and system.

G. Safety Accessories: Manual-reset safety switches and warning lights for filter plenum access doors, signal lights and safety switching upstream and downstream from unit within duct, and enameled high-voltage warning signs.

H. Collection Section Cleaning System:

1. Detergent Reservoir Tank: 30 gal. (110 L) or 55 gal. (200 L) with pump as directed, motor, solenoid valve, level sensor, backflow preventer, wye-strainer, and ball valve.
2. Detergent.
3. Dispensing System: Motor-driven oscillating copper manifolds with brass spray nozzles on each side of the collector.

I. Controls: Programmable logic controller in remotely mounted, NEMA 250, Type 12 enclosure; with integral time clock and manual override.

1. Contacts for enable-disable control by building automation system.

J. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with ASHRAE 62.1.

2.4 FILTER GAUGES

A. Diaphragm type, with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.
   1. Diameter: 4-1/2 inches (115 mm) or 2 inches (50 mm) as directed.
   2. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5-Inch wg (125 Pa) or Less: 0- to 0.5-inch wg (0 to 125 Pa).
   3. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5- to 1.0-Inch wg (125 to 250 Pa) or Less: 0- to 1.0-inch wg (0 to 250 Pa).
   4. Scale Range for Filter Media Having a Recommended Final Resistance of 1.0- to 2.0-Inch wg (250 to 500 Pa) or Less: 0- to 2.0-inch wg (0 to 500 Pa).

B. Manometer-Type Filter Gauge: Molded plastic, with epoxy-coated aluminum scale, logarithmic-curve tube gauge, with integral leveling indicator, graduated to read from 0- to 3.0-inch wg (0 to 750 Pa), and accurate within 3 percent of full-scale range.

C. Accessories: Static-pressure tips, tubing, gauge connections, and mounting bracket.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Examine electronic air cleaners and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Position each electronic air cleaner unit with clearance for normal service and maintenance. Anchor electronic air cleaners to substrate.

C. Do not operate fan system until electronic air cleaners and associated prefilters and final filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.

D. Operate electronic air cleaners for 24 hours as part of startup before units are put into operation.

E. Install filter-gauge, static-pressure taps upstream and downstream from filters. Install filter gauges on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gauges on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gauges.

F. Install and connect water-supply and drainage piping.

G. Coordinate electronic air cleaner and associated prefilter and final filter installations with duct and air-handling-unit installations.

H. Protect installed products and accessories from damage during construction.

3.2 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between pressure sensors and DDC system.

C. Connect control wiring between controlled devices.

D. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.3 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Tests and Inspections: Test for leakage of unfiltered air while system is operating.

E. Electronic air cleaner and associated filters will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.4 CLEANING

A. After completing system installation and testing, adjusting, and balancing air-handling and air-distribution systems, clean electronic air filter housings and install new prefilter and final-filter media.

END OF SECTION 234300

SECTION 235113.11 - DRAFT CONTROL FANS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Draft inducer fans.
2. Mechanical-draft vent fans.
3. Vent exhaust fans.

B. Related Requirements:

1. Section 235113.16 "Vent Dampers" for barometric dampers and vent dampers.
2. Section 235116 "Fabricated Breechings and Accessories" for listed, refractory-lined metal breechings and field-fabricated metal breechings.
3. Section 235123 "Gas Vents" for Type B and BW vents, Type L vents, and listed special gas vents.
4. Section 235133 "Insulated Sectional Chimneys" for listed chimney liners; listed building-heating-appliance chimneys; listed, refractory-lined metal chimneys; and field-fabricated chimneys.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For each type of product.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of hangers and seismic restraints.
4. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of fans as directed that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two or 10 years from date of Substantial Completion as directed.

PART 2 - PRODUCTS

2.1 DRAFT INDUCER FANS

A. Fan Construction: Galvanized or Aluminized-steel housing and radial-blade centrifugal fan as directed.

1. Fan Motor: Permanent-split-capacitor type.

B. Controls:

1. Draft-proving switch.
2. Control kit to cycle fan with gas flow to a single burner.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 MECHANICAL-DRAFT VENT FANS

A. Fan Construction: Forward-curved centrifugal fan and scroll fabricated of aluminized or galvanized steel; direct-drive, ball-bearing motor lubricated with synthetic oil; internal cooling fan; stainless-steel shaft; and integral pressure-sensing switch.

1. Fan Motor: Permanent-split-capacitor type.

B. Controls:

1. Draft-proving switch.
2. Control kit to cycle fan with gas flow to single or multiple burner(s) as directed.

C. Accessories:

1. Aluminized or Stainless-steel, wall-vent hood as directed.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 VENT EXHAUST FANS

A. General: Centrifugal fan with variable or constant-speed control mounted at end of sidewall or vertical vent as directed.

B. Test Standard: UL 378.

C. Fan Construction:

1. Housing as directed painted manufacturer's standard color of baked enamel.
2. Galvanized or Stainless-steel vent as directed.
3. Cast-aluminum or Stainless-steel wheel as directed.
4. Backward-inclined centrifugal or axial fan wheel statically and dynamically balanced.
5. Access panel at the discharge area.
6. Concentric makeup air-inlet duct surrounding the vent to allow zero clearance to combustibles.

D. Motor: Fully enclosed, variable-speed duty, permanent-split capacitor, out of the airstream, with pre-lubricated and sealed ball bearings.

E. Constant-Speed Controls: Boiler interlock relay starts fan when burner control cycles on. Pressure switch permits burner operation via interlock with boiler. Fan-proving switch is adjustable between minus 0.07- and minus 0.15-inch wg (minus 17 and minus 37 Pa).

F. Variable-Speed Controls: Boiler interlock relay starts fan when burner control cycles on. Pressure controller, control transformer, and miscellaneous controls for automatic modulation of fan speed to maintain preset negative pressure between zero- and minus 1.0-inch wg (zero and minus 249 Pa). Include controller with indicator lights, pressure-differential transmitter, chimney pressure-sensor probe, and fan-proving switch adjustable between minus 0.07- and minus 0.15-inch wg (minus 17 and minus 37 Pa). Include tubing.

G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.4 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

2.5 CAPACITIES AND CHARACTERISTICS

A. Fan:

1. Manufacturer: as directed.
2. Model No.: as directed.
3. Rated Appliance Input: as directed.
4. Airflow: as directed.
5. Speed: as directed.
6. Static Pressure: as directed.
7. Electrical Characteristics:

    a. Motor Horsepower: as directed.
    b. Volts: as directed.

c. Phase: Single or Three.
d. Hertz: 60.
e. Full-Load Amperes: as directed.
f. Minimum Circuit Ampacity: as directed.
g. Maximum Overcurrent Protection: as directed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install listed components in a manner complying with the listing.

B. Install draft inducer fans in single-wall vent section that is designed to couple with other vent materials.

C. Secure draft inducer fans to appliances, breechings, or stacks with hardware compatible with connected materials.

D. Install draft inducer fans with clearances for service and maintenance.

E. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

F. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

END OF SECTION 235113.11

SECTION 235113.16 - VENT DAMPERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Barometric dampers.
2. Vent dampers.

B. Related Requirements:

1. Section 235113.11 "Draft Control Fans" for draft inducer fans, venturi-draft inducer fans, mechanical-draft vent fans, vent exhaust fans, and combustion-air fans.
2. Section 235116 "Fabricated Breechings and Accessories" for listed, refractory-lined metal breechings and field-fabricated metal breechings.
3. Section 235123 "Gas Vents" for Type B and BW vents, Type L vents, and listed special gas vents.
4. Section 235133 "Insulated Sectional Chimneys" for listed chimney liners; listed building-heating-appliance chimneys; listed, refractory-lined metal chimneys; and field-fabricated chimneys.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For each type of product.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of hangers and seismic restraints.
4. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of barometric dampers or vent dampers that fail in materials or workmanship within specified warranty period as directed.

1. Warranty Period: Two or 10 years from date of Substantial Completion as directed.

PART 2 - PRODUCTS

2.1 BAROMETRIC DAMPERS

A. Damper Construction: High-temperature-enamel-painted steel damper and housing with galvanized-steel breeching connection. Adjustable counterweight with lock. Include knife-edge bearings that do not require lubrication.

2.2 VENT DAMPERS

A. Damper Construction: Stainless-steel damper blade, shaft, and vent pipe with metal, prelubricated bearings.

1. Electric motor sized to power damper open and closed in approximately 15 seconds in each direction. Power is off when damper is at rest.
2. Comply with ANSI Z21.66.

B. Controls:

1. Control transformer.
2. Keyed wiring harness.
3. Damper end switch to prove damper is open.
4. Interlock with boiler to permit burner operation when damper is open.
5. Hold-open switch for troubleshooting boiler controls.

2.3 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

2.4 CAPACITIES AND CHARACTERISTICS

A. Damper:

1. Manufacturer: As directed.
2. Model No.: As directed.
3. Rated Appliance Input: As directed.
4. Vent Size: As directed.

5. Electrical Characteristics:

    a. Motor Horsepower: As directed.
    b. Volts: 115.
    c. Phase: Single.
    d. Hertz: 60.
    e. Full-Load Amperes: As directed.
    f. Minimum Circuit Ampacity: As directed.
    g. Maximum Overcurrent Protection: As directed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install listed components in a manner complying with the listing.

B. Secure barometric dampers to breechings with hardware compatible with connected materials.

C. Locate barometric and motorized vent dampers as close to draft hood collar as possible.

D. Secure barometric and motorized vent dampers to appliances, breechings, or chimneys with hardware compatible with connected materials.

E. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

F. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

END OF SECTION 235113.16

SECTION 235116 - FABRICATED BREECHINGS AND ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Field-fabricated metal breechings.
2. Guying and bracing materials.

B. Related Requirements:

1. Section 235113.11 "Draft Control Fans" for draft inducer fans, venturi-draft inducer fans, mechanical-draft vent fans, vent exhaust fans, and combustion-air fans.
2. Section 235113.16 "Vent Dampers" for motorized and barometric dampers.
3. Section 235123 "Gas Vents" for Type B and BW vents, Type L vents, and listed special gas vents.
4. Section 235133 "Insulated Sectional Chimneys" for listed chimney liners; listed building-heating-appliance chimneys; listed, refractory-lined metal chimneys; and field-fabricated chimneys.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For breechings.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of hangers and seismic restraints.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Seismic Qualification Certificates: For factory-fabricated breeching, accessories, and components from manufacturer.

C. Sample Warranty: For special warranty.

1.4 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D9.1/D9.1M, "Sheet Metal Welding Code," for shop and field welding of joints and seams in breechings.

B. Certified Sizing Calculations: Manufacturer shall certify venting system sizing calculations.

PART 2 - PRODUCTS

2.1 FIELD-FABRICATED METAL BREECHINGS

A. Fabricate breechings from ASTM A1011/A1011M hot-rolled steel with continuously welded joints, complying with NFPA 211 for minimum metal thickness.

1. Equal to or Less Than 1.069 Sq. Ft. (0.099 Sq. m.) or 14 Inches (356 mm) in Diameter: 0.053 inch (1.35 mm).
2. Up to 1.396 Sq. Ft. (0.129 Sq. m) or 16 Inches (406 mm) in Diameter: 0.067 inch (1.7 mm).
3. Up to 1.764 Sq. Ft. (0.164 Sq. m.) or 18 Inches (457 mm) in Diameter: 0.093 inch (2.36 mm).
4. Larger Than 1.764 Sq. Ft. (0.164 Sq. m.) or 18 Inches (457 mm) in Diameter: 0.123 inch (3.12 mm).

B. Fabricate cleanout doors from compatible material, same thickness as breeching, bolted and gasketed.

2.2 GUYING AND BRACING MATERIALS

A. Cable: Three or Four galvanized a directed, stranded wires of the following thickness:

1. Minimum Size: 1/4 inch (6 mm) in diameter.
2. For ID Sizes 4 to 15 Inches (100 to 381 mm): 5/16 inch (8 mm).
3. For ID Sizes 18 to 24 Inches (457 to 610 mm): 3/8 inch (9.5 mm).
4. For ID Sizes 27 to 30 Inches (685 to 762 mm): 7/16 inch (11 mm).
5. For ID Sizes 33 to 36 Inches (838 to 915 mm): 1/2 inch (13 mm).
6. For ID Sizes 39 to 48 Inches (990 to 1220 mm): 9/16 inch (14.3 mm).
7. For ID Sizes 51 to 60 Inches (1295 to 1524 mm): 5/8 inch (16 mm).

B. Pipe: Two or Three galvanized steel, NPS 1-1/4 (DN 32) as directed.

C. Angle Iron: Two or Three galvanized steel, 2 by 2 by 0.25 inch (50 by 50 by 6 mm) as directed.

PART 3 - EXECUTION

3.1 INSTALLATION OF UNLISTED, FIELD-FABRICATED BREECHINGS

A. Install breechings on dual-fuel boilers, oven vents, water heaters, fireplaces, and other solid-fuel-burning appliances.

B. Suspend breechings independent of their appliance connections.

C. Install seismic restrains according to manufacturer's written instructions. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC."

D. Align breechings at connections, with smooth internal surface and a maximum 1/8-inch (3-mm) misalignment tolerance.

E. Slope breechings down in direction of appliance, with condensate drain connection at lowest point piped to nearest drain.

F. Lap joints in direction of flow.

G. Support breechings from building structure with bolts, concrete inserts, steel expansion anchors, welded studs, C clamps, or beam clamps.

H. Clean breechings internally, during and after installation, to remove dust and debris. Clean external surfaces to remove welding slag and mill film. Grind welds smooth and apply touchup finish to match factory or shop finish.

I. After completing system installation, remove burrs, dirt, and construction debris, and repair damaged finishes.

J. Provide temporary closures at ends of breechings that are not completed or connected to equipment.

END OF SECTION 235116

SECTION 235123 - GAS VENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Listed double-wall vents.

B. Related Requirements:

1. Section 235113.11 "Draft Control Fans" for draft inducer fans, venturi-draft inducer fans, mechanical-draft vent fans, vent exhaust fans, and combustion-air fans.
2. Section 235113.16 "Vent Dampers" for motorized and barometric dampers.
3. Section 235116 "Fabricated Breechings and Accessories" for listed, refractory-lined metal breechings and field-fabricated metal breechings.
4. Section 235133 "Insulated Sectional Chimneys" for listed chimney liners; listed building-heating-appliance chimneys; listed, refractory-lined metal chimneys; and field-fabricated chimneys.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For vents.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of hangers and seismic restraints.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Sample Warranty: For special warranty.

1.4 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D9.1/D9.1M, "Sheet Metal Welding Code," for shop and field welding of joints and seams in vents.

B. Certified Sizing Calculations: Manufacturer shall certify venting system sizing calculations.

PART 2 - PRODUCTS

2.1 LISTED TYPE B AND BW VENTS

A. Description: Double-wall metal vents tested according to UL 441 and rated for 480 deg F (248 deg C) continuously for Type B or 550 deg F (288 deg C) continuously for Type BW; with neutral or negative flue pressure complying with NFPA 211.

B. Construction: Inner shell and outer jacket separated by at least a 1/4-inch (6-mm) airspace.

C. Inner Shell: As directed.

D. Outer Jacket: Galvanized or Aluminized steel as directed.

E. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.

1. Termination: Stack cap designed to exclude minimum 90 percent of rainfall.
2. Termination: Round chimney top designed to exclude minimum 98 percent of rainfall.
3. Termination: Exit cone with drain section incorporated into riser.
4. Termination: Anti-backdraft.
5. Termination: As directed.

2.2 LISTED TYPE L VENTS

A. Description: Double-wall metal vents tested according to UL 641 and rated for 570 deg F (300 deg C) continuously or 1700 deg F (926 deg C) for 10 minutes; with neutral or negative flue pressure complying with NFPA 211.

B. Construction: Inner shell and outer jacket separated as directed by airspace filled with high-temperature, ceramic-fiber or mineral-wool insulation as directed.

C. Inner Shell: ASTM A666, Type 304 or Type 316 stainless steel as directed.

D. Outer Jacket: Steel as directed.

E. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.

1. Termination: Stack cap designed to exclude 90 percent of rainfall.
2. Termination: Round chimney top designed to exclude 98 percent of rainfall.
3. Termination: Exit cone with drain section incorporated into riser.
4. Termination: As directed.

2.3 LISTED SPECIAL GAS VENTS

A. Description: Double-wall metal vents tested according to UL 1738 and rated for 480 deg F (248 deg C) continuously, with positive or negative flue pressure complying with NFPA 211.

B. Construction: Inner shell and outer jacket separated by at least a 1/2-inch (13-mm) airspace.

C. Inner Shell: ASTM A959, Type 29-4C stainless steel.

D. Outer Jacket: Aluminized or Stainless steel as directed.

E. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.

1. Termination: Stack cap designed to exclude minimum 90 percent of rainfall.
2. Termination: Round chimney top designed to exclude minimum 98 percent of rainfall.
3. Termination: Exit cone with drain section incorporated into riser.
4. Termination: As directed.

PART 3 - EXECUTION

3.1 APPLICATION

A. Listed Type B and BW Vents: Vents for certified gas appliances.

B. Listed Type L Vent: Vents for low-heat appliances.

C. Listed Special Gas Vent: Condensing gas appliances.

3.2 INSTALLATION OF LISTED VENTS

A. Comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.

B. Seal between sections of positive-pressure vents according to manufacturer's written installation instructions, using sealants recommended by manufacturer.

C. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading.

D. Lap joints in direction of flow.

E. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

END OF SECTION 235123

SECTION 235133 - INSULATED SECTIONAL CHIMNEYS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Listed chimney liners.
2. Listed building-heating-appliance chimneys.
3. Guying and bracing materials.

B. Related Requirements:

1. Section 235113.11 "Draft Control Fans" for draft inducer fans, venturi-draft inducer fans, mechanical-draft vent fans, vent exhaust fans, and combustion-air fans.
2. Section 235113.16 "Vent Dampers" for motorized and barometric dampers.
3. Section 235116 "Fabricated Breechings and Accessories" for listed, refractory-lined metal breechings and field-fabricated metal breechings.
4. Section 235123 "Gas Vents" for Type B and BW vents, Type L vents, and listed special gas vents.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For chimneys and stacks.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of hangers and seismic restraints.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Seismic Qualification Certificates: For factory-fabricated chimneys and stacks, accessories, and components from manufacturer.

C. Sample Warranty: For special warranty.

1.4 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D9.1/D9.1M, "Sheet Metal Welding Code," for shop and field welding of joints and seams in stacks.

B. Certified Sizing Calculations: Manufacturer shall certify venting system sizing calculations.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of venting system that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Years as directed from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 LISTED CHIMNEY LINERS

A. Description: Straight or Corrugated as directed, single-wall chimney liner tested according to UL 1777 and rated for 1000 deg F (538 deg C) continuously or 2100 deg F (1150 deg C) for 10 minutes; with negative or positive flue pressure complying with NFPA 211.

B. Straight Liner Materials: ASTM A666, Type 304 or Type 316 stainless steel as directed.

C. Corrugated Liner Materials: Stainless steel as directed.

D. Accessories:

1. Fittings: Tees, elbows, increasers, draft-hood connectors, metal caps with bird barriers, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar or compatible materials and designs.
2. Sealant: Manufacturer's standard high-temperature sealant.
3. Insulating Fill: Manufacturer's standard high-temperature insulation fill material in annular space surrounding chimney liner, including high-temperature, ceramic-fiber insulation required to seal chimney at top and bottom.

2.2 LISTED BUILDING-HEATING-APPLIANCE CHIMNEYS

A. Description: Double-wall metal vents tested according to UL 103 and rated for 1000 deg F (538 deg C) continuously or 1700 deg F (926 deg C) for 10 minutes; with neutral or negative flue pressure complying with NFPA 211.

B. Construction: Inner shell and outer jacket separated as directed by at least a annular space filled with high-temperature, ceramic-fiber insulation.

C. Inner Shell: ASTM A666, Type 304 or Type 316 stainless steel as directed.

D. Description: Double-wall metal vents tested according to UL 103 and UL 959 and rated for 1400 deg F (760 deg C) continuously or 1800 deg F (982 deg C) for 10 minutes; with positive or negative flue pressure complying with NFPA 211.

E. Construction: Inner shell and outer jacket separated by at least a 1-inch (25-mm), 2-inch (50-mm), 3-inch (75-mm) or 4-inch (100-mm) annular space as directed filled with high-temperature, ceramic-fiber insulation.

F. Inner Shell: ASTM A666, Type 304 or Type 316 stainless steel as directed.

G. Description: Double-wall metal vents tested according to UL 103 and rated for 1000 deg F (538 deg C) continuously or 2100 deg F (1150 deg C) for 10 minutes; with neutral or negative flue pressure complying with NFPA 211.

H. Construction: Inner shell and outer jacket separated as directed by at least an annular space filled with high-temperature, ceramic-fiber insulation.

I. Inner Shell: Stainless steel as directed.

J. Outer Jacket: Steel as directed.

K. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.

1. Termination: Stack cap designed to exclude minimum 90 percent of rainfall.
2. Termination: Round chimney top designed to exclude minimum 98 percent of rainfall.
3. Termination: Exit cone with drain section incorporated into riser.
4. Termination: As directed.

2.3 GUYING AND BRACING MATERIALS

A. Cable: Three or Four galvanized, stranded wires as directed of the following thickness:

1. Minimum Size: 1/4 inch (6 mm) in diameter.
2. For ID Sizes 4 to 15 Inches (100 to 381 mm): 5/16 inch (8 mm).
3. For ID Sizes 18 to 24 Inches (457 to 610 mm): 3/8 inch (9.5 mm).
4. For ID Sizes 27 to 30 Inches (685 to 762 mm): 7/16 inch (11 mm).
5. For ID Sizes 33 to 36 Inches (838 to 915 mm): 1/2 inch (13 mm).
6. For ID Sizes 39 to 48 Inches (990 to 1220 mm): 9/16 inch (14.3 mm).
7. For ID Sizes 51 to 60 Inches (1295 to 1524 mm): 5/8 inch (16 mm).

B. Pipe: Two or Three galvanized steel as directed, NPS 1-1/4 (DN 32).

C. Angle Iron: Two or Three galvanized steel as directed, 2 by 2 by 0.25 inch (50 by 50 by 6 mm).

PART 3 - EXECUTION

3.1 APPLICATION

A. Listed Chimney Liners: High-efficiency boiler or furnace vents in masonry chimney.

B. Listed Building-Heating-Appliance Chimneys: Dual-fuel boilers, oven vents, water heaters, exhaust for engines, fireplaces, and other solid-fuel-burning appliances.

3.2 INSTALLATION OF LISTED CHIMNEYS

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Comply with requirements in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" for concrete as directed, reinforcement, and formwork.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."

C. Comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.

D. Seal between sections of positive-pressure vents according to manufacturer's written installation instructions, using sealants recommended by manufacturer.

E. Lap joints in direction of flow.

F. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

G. Provide temporary closures at ends of chimneys and stacks that are not completed or connected to equipment.

END OF SECTION 235133

SECTION 235213 - ELECTRIC BOILERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes electric boilers, trim, and accessories for generating hot water.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For boilers, boiler trim, and accessories.

1. Include plans, elevations, sections, and mounting or attachment details as directed.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal: For each boiler.

1. Design calculations and vibration isolation base details, signed and sealed by a qualified professional engineer.

a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
b. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for boilers, accessories, and components, from manufacturer.

B. Source quality-control reports.

C. Field quality-control reports.

D. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace pressure vessels of boilers that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 MANUFACTURED UNITS

A. Description: Factory-fabricated, -assembled, and -tested electric boilers with trim and controls necessary to generate hot water.

B. Pressure Vessel: Carbon-steel or Cast-iron pressure vessel mounted on structural-steel base as directed.

C. Nozzles: Flanges for water inlet and outlet and heating element inserts; threaded connections for trim and controls.

D. Insulation: One layer or Two layers of minimum 1-inch- (25-mm-) or 2-inch- (50-mm-) thick as directed, glass-fiber insulation.

E. Jacket: Galvanized sheet metal casing with baked-enamel or powder-coated protective finish as directed and removable panels with snap-in or interlocking closures for access to pressure vessel.

F. Lifting Lugs: Welded to pressure vessel, extending above jacket.

G. Heating Elements: Copper or Incoloy-sheathed, replaceable electric-resistance element, rated 20-kW maximum, with maximum 50 W/sq. in. (7.7 W/sq. cm) or 75 W/sq. in. (11.5 W/sq. cm) over heat-transfer length as directed.

H. Mounting Base: For securing boiler to concrete base.

1. Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC" when mounting base is anchored to building structure.

I. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

J. ASME Compliance: Fabricate and label boilers to comply with 2013 ASME Boiler and Pressure Vessel Code.

K. NFPA Compliance: Design and fabricate boilers to comply with NFPA 70, Article 424, Paragraphs G and H.

L. UL Compliance: Test boilers for compliance with UL 834. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

M. CSA Compliance: Test boilers for compliance with CSA B51.

2.3 TRIM FOR HOT-WATER BOILERS

A. Include devices sized to comply as directed.

B. Aquastat Controllers: Operating auto-reset high limit.

C. Safety Relief Valve: ASME rated.

D. Pressure and Temperature Gage: Minimum 3-1/2-inch- (89-mm-) diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges, so normal operating range is about 50 percent of full range.

E. Boiler Air Vent: Automatic or Manual as directed.

F. Dip-tube in water outlet.

G. Drain Valve: Minimum NPS 3/4 (DN 20) hose-end ball valve sized according to requirements of authorities having jurisdiction.

H. Tankless Heater: Carbon-steel header with copper-tube heat exchanger, mounted in an upper port of pressure vessel and sealed with fiber gasket.

1. Tappings NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.
2. Tappings NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.

2.4 CONTROLS

A. Refer to Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."

B. Boiler operating controls shall include the following devices and features:

1. Control transformer.
2. Step controller.
3. Recycling relay returns controller to off position after power failure.
4. Multistage thermostat.
5. Control-circuit switch.
6. Visual indication for each step.
7. Supply-voltage indicator.

8. Set-Point Adjust: Set points shall be adjustable.
9. Sequence of Operation: Electric, factory-fabricated and field-installed panel to control element sequence controller to maintain space temperature in response to thermostat with heat anticipator located in heated space.

    a. Include automatic, alternating-operation sequence for multiple boilers to provide equal runtime for boilers.

10. Sequence of Operation: Electric, factory-fabricated and field-installed panel to control element sequence controller to reset supply-water temperature inversely with outside-air temperature. At 0 deg F (minus 17 deg C) outside-air temperature, set supply-water temperature at 200 deg F (93 deg C); at 60 deg F (15 deg C) outside-air temperature, set supply-water temperature at 140 deg F (60 deg C).

    a. Include automatic, alternating-operation sequence for multiple boilers to provide equal runtime for boilers.

C. Safety Controls: To maintain safe operating conditions, safety controls limit boiler operation.

1. High Cutoff: Manual or Automatic reset stops boiler if operating conditions rise above set point or maximum boiler design temperature as directed.
2. Low-Water Cutoff Switch: Electronic or Float and electronic probe as directed shall prevent boiler operation on low water. Cutoff switch shall be manual-reset type.
3. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.

D. Building Management System Interface: Factory install hardware and software to enable building management system to monitor, control, and display boiler status and alarms.

1. Hardwired Points:

    a. Monitoring: On/off status, common trouble alarm or low-water-level alarm as directed.
    b. Control: On/off operation, hot water supply temperature set-point adjustment.

2. A communication interface with building management system shall enable building management system operator to remotely control and monitor the boiler from an operator workstation. Control features available and monitoring points displayed locally at boiler control panel shall be available through building management system.

2.5 ELECTRICAL POWER

A. Single-Point Field Power Connection: Factory-installed and -wired switches, transformers, and electrical devices necessary shall provide a single-point field power connection to boiler.

1. Field power interface shall be as directed.
2. Interlock with door to de-energize power with door open.

B. Electrical Enclosures: NEMA 250, Type 1 enclosure with hinged door and key-locking handle.

C. Install factory wiring outside of an enclosure in a metal raceway.

D. Comply with NFPA 70.

1. Electrical Circuits: 48 A, maximum.

E. Connectors: Mechanical lugs bolted to copper bus bars or distribution blocks with pressure connectors.

F. Fuses: NEMA FU 1, Class J or K5; 60 A, maximum.

G. Contactors: Three-pole magnetic contactors, listed for 500,000 cycles at full load.

H. Factory-wired internal control devices and heating elements.

1. Wiring shall be numbered and color coded to match wiring diagram.

2.6 CAPACITIES AND CHARACTERISTICS

A. Hot-Water Heating:

1. Design Water-Pressure Rating: 160 psig (1100 kPa).
2. Safety Relief Valve Setting: As directed.
3. Entering-Water Temperature: As directed.
4. Leaving-Water Temperature: As directed.
5. Design Water Flow Rate: As directed.
6. Design Pressure Drop: As directed.

B. Output Capacity: As directed.

C. Equivalent Direct Radiation: As directed.

D. Electrical Characteristics:

1. Kilowatts: As directed.
2. Volts: 208 or 480 V as directed.
3. Phase: Three.
4. Hertz: 50 or 60 Hz as directed.
5. Full-Load Amperes: As directed.
6. Minimum Circuit Ampacity: As directed.
7. Maximum Overcurrent Protection: As directed.

2.7 SOURCE QUALITY CONTROL

A. Test and inspect factory-assembled boilers, before shipping, according to 2013 ASME Boiler and Pressure Vessel Code or CSA B51 as directed.

B. Hydrostatic Test: Factory test assembled boiler, including hydrostatic test.

PART 3 - EXECUTION

3.1 BOILER INSTALLATION

A. Equipment Mounting:

1. Install boilers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed
2. Comply with requirements for vibration isolation and seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

B. Install electrical devices furnished with boiler but not specified to be factory mounted.

3.2 CONNECTIONS

A. Piping installation requirements are specified in Section 232113 "Hydronic Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to boiler to allow service and maintenance.

C. Connect hot-water piping to supply- and return-boiler tappings, with shutoff valve and union or flange at each connection.

D. Install piping from safety relief valves to nearest floor drain.

E. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform installation and startup checks according to manufacturer's written instructions.
2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

    a. Check and adjust initial operating set points and high- and low-limit safety set points of water level and water temperature.
    b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

B. Remove and replace malfunctioning units and retest as specified above.

C. Boiler will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.4 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain boilers. Refer to Section 017900 "Demonstration and Training."

END OF SECTION 235213

SECTION 235216 - CONDENSING BOILERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes gas-fired as directed condensing boilers, trim, and accessories for generating hot water.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

C. Shop Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, and mounting or attachment details as directed.

1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.

D. Delegated-Design Submittal: For each boiler.

1. Design calculations and vibration isolation base details signed and sealed by a qualified professional engineer.

a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
b. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for boiler, accessories, and components, from manufacturer.

B. Source quality-control reports.

C. Field quality-control reports.

D. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Fire-Tube Condensing Boilers:

a. Leakage and Materials: 10 years from date of Substantial Completion.
b. Heat Exchanger Damaged by Thermal Stress and Corrosion: Prorated or Nonprorated as directed for five years from date of Substantial Completion.

2. Warranty Period for Water-Tube Condensing Boilers: 20 years from date of Substantial Completion.
3. Warranty Period for Water-Jacketed Condensing Boilers:

a. Leakage and Materials: Eight years from date of Substantial Completion.
b. Heat Exchanger Damaged by Thermal Stress and Corrosion: Prorated or Nonprorated as directed for five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASME Compliance: Fabricate and label boilers to comply with 2010 ASME Boiler and Pressure Vessel Code.

C. ASHRAE/IES 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."

D. DOE Compliance: Minimum efficiency shall comply with 10 CFR 430, Subpart B, Appendix N.

E. UL Compliance: Test boilers for compliance with UL 795. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

F. CSA Compliance: Test boilers for compliance with CSA B51.

G. Mounting Base: For securing boiler to concrete base.

1. Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler pressure vessel, accessories, and components with reinforcement strong enough to

withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC" when mounting base is anchored to building structure.

2.2 FORCED-DRAFT, FIRE-TUBE CONDENSING BOILERS

A. Description: Factory-fabricated, -assembled, and -tested, fire-tube condensing boiler with heat exchanger sealed pressure tight, built on a steel base, including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Water-heating service only.

B. Heat Exchanger: Nonferrous, corrosion-resistant combustion chamber.

C. Pressure Vessel: Carbon steel with welded heads and tube connections.

D. Burner: Natural or Propane gas as directed, forced draft.

E. Blower: Centrifugal fan to operate during each burner firing sequence and to prepurge and postpurge the combustion chamber.

1. Motors: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

    a. Motor Sizes: Minimum size as indicated; if not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

F. Gas Train: Combination gas valve with manual shutoff and pressure regulator.

G. Ignition: Spark ignition with 100 percent main-valve shutoff with electronic flame supervision.

H. Casing:

1. Jacket: Sheet metal or Plastic as directed, with snap-in or interlocking closures.
2. Control Compartment Enclosures: NEMA 250, Type 1A.
3. Finish: Baked-enamel or Powder-coated protective finish as directed.
4. Insulation: Minimum 2-inch- (50-mm-) thick, mineral-fiber or polyurethane-foam insulation surrounding the heat exchanger as directed.
5. Combustion-Air Connections: Inlet and vent duct collars.

I. Capacities and Characteristics:

1. Heating Medium: Hot water.
2. Design Water-Pressure Rating: 160 psig (1100 kPa).
3. Safety Relief Valve Setting: As directed.
4. Entering-Water Temperature: As directed.
5. Leaving-Water Temperature: As directed.
6. Design Water Flow Rate: As directed.
7. Minimum Water Flow Rate: As directed.
8. Design Pressure Drop: As directed.

9. Minimum Efficiency AFUE: Percent As directed.
10. Minimum Thermal Efficiency: Percent As directed.
11. Minimum Combustion Efficiency: Percent As directed.
12. AGA Input: As directed.
13. Gas Input: As directed.
14. AGA Output Capacity: As directed.
15. DOE Output Capacity: As directed.
16. Equivalent Direct Radiation: As directed.
17. Blower:

    a. Motor Horsepower: As directed.
    b. RPM: As directed.

18. Electrical Characteristics:

    a. Volts: As directed.
    b. Phase: Single or Three as directed.
    c. Hertz: 50 or 60 Hz as directed.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed.
    f. Maximum Overcurrent Protection: As directed.

2.3 WATER-TUBE CONDENSING BOILERS

A. Description: Factory-fabricated, -assembled, and -tested, copper-finned, water-tube condensing boiler with heat exchanger sealed pressure tight, built on a steel base, including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Water-heating service only.

B. Heat Exchanger: Finned-copper primary and stainless-steel secondary heat exchangers.

C. Combustion Chamber: Stainless steel, sealed.

D. Burner: Natural or Propane gas as directed, forced draft drawing from gas premixing valve.

E. Blower: Centrifugal fan to operate during each burner firing sequence and to prepurge and postpurge the combustion chamber.

1. Motors: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

    a. Motor Sizes: Minimum size as indicated; if not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

F. Gas Train: Combination gas valve with manual shutoff and pressure regulator.

G. Ignition: Silicone carbide hot-surface ignition that includes flame safety supervision and 100 percent main-valve shutoff.

H. Integral Circulator: Cast-iron body and stainless-steel impeller sized for minimum flow required in heat exchanger.

I. Casing:

1. Jacket: Sheet metal, with snap-in or interlocking closures.
2. Control Compartment Enclosures: NEMA 250, Type 1A.
3. Finish: Textured epoxy.
4. Insulation: Minimum 1-inch- (25-mm-) or 2-inch- (50-mm-) thick as directed, mineral-fiber insulation surrounding the heat exchanger.
5. Combustion-Air Connections: Inlet and vent duct collars.

J. Capacities and Characteristics:

1. Heating Medium: Hot water.
2. Design Water-Pressure Rating: 160 psig (1100 kPa).
3. Safety Relief Valve Setting: As directed.
4. Entering-Water Temperature: As directed.
5. Leaving-Water Temperature: As directed.
6. Design Water Flow Rate: As directed.
7. Minimum Water Flow Rate: As directed.
8. Design Pressure Drop: As directed.
9. Minimum Efficiency AFUE: Percent as directed.
10. Minimum Thermal Efficiency: Percent as directed.
11. Minimum Combustion Efficiency: Percent as directed.
12. AGA Input: As directed.
13. Gas Input: As directed.
14. AGA Output Capacity: As directed.
15. DOE Output Capacity: As directed.
16. Blower:
    a. Motor Horsepower: As directed.
    b. RPM: As directed.
17. Electrical Characteristics:
    a. Volts: As directed.
    b. Phase: Single or Three As directed.
    c. Hertz: 50 or 60 As directed Hz.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed.
    f. Maximum Overcurrent Protection: As directed.

2.4 WATER-JACKETED CONDENSING BOILERS

A. Description: Factory-fabricated, -assembled, and -tested, water-jacketed condensing boiler with heat exchanger sealed pressure tight, built on a steel base, including insulated jacket; flue-gas vent; water supply, return, and condensate drain connections; and controls. Water-heating service only.

B. Heat Exchanger: Stainless-steel primary and secondary combustion chamber.

C. Pressure Vessel: Carbon steel with welded heads and tube connections where not in contact with combustion or flue gases.

D. Burner: Natural or Propane gas as directed, forced draft; swing-open front and burner observation port.

E. Blower: Centrifugal fan, forced draft. Include prepurge and postpurge of the combustion chamber.

1. Motors: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

a. Motor Sizes: Minimum size as indicated; if not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

F. Gas Train: Combination gas valve with manual shutoff and pressure regulator. Include 100 percent safety shutoff with electronic flame supervision.

G. Ignition: Electric-spark ignition with 100 percent main-valve shutoff with electronic flame supervision.

H. Casing:

1. Jacket: Sheet metal, with snap-in or interlocking closures.
2. Control Compartment Enclosures: NEMA 250, Type 1A.
3. Finish: Powder-coated protective finish.
4. Insulation: Minimum 4-inch- (100-mm-) thick, mineral-fiber insulation surrounding the heat exchanger.
5. Combustion-Air Connections: Inlet and vent duct collars.

I. Capacities and Characteristics:

1. Heating Medium: Hot water.
2. Design Water-Pressure Rating: 30 psig (207 kPa).
3. Safety Relief Valve Setting: As directed.
4. Maximum Design Temperature: 210 deg F (99 deg C).
5. Entering-Water Temperature: As directed.
6. Leaving-Water Temperature: As directed.
7. Design Water Flow Rate: As directed.
8. Design Pressure Drop: As directed.
9. Minimum Efficiency AFUE: Percent As directed.
10. Minimum Thermal Efficiency: Percent As directed.
11. Minimum Combustion Efficiency: Percent As directed.
12. AGA Input: As directed.
13. Gas Input: As directed.
14. AGA Output Capacity: As directed.
15. DOE Output Capacity: As directed.
16. Equivalent Direct Radiation: As directed.

17. Blower:

    a. Motor Horsepower: As directed.
    b. RPM: As directed.

18. Electrical Characteristics:

    a. Volts: As directed.
    b. Phase: Single or Three as directed.
    c. Hertz: 50 or 60 Hz.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed.
    f. Maximum Overcurrent Protection: As directed.

2.5 TRIM

A. Include devices sized to comply with ASME B31.1 or ASME B31.9 as directed.

B. Aquastat Controllers: Operating, firing rate, and high limit.

C. Safety Relief Valve: ASME rated.

D. Pressure and Temperature Gage: Minimum 3-1/2-inch- (89-mm-) diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges, so normal operating range is about 50 percent of full range.

E. Boiler Air Vent: Automatic or Manual as directed.

F. Drain Valve: Minimum NPS 3/4 (DN 20) hose-end gate valve.

G. Circulation Pump: Non-overloading, in-line pump with split-capacitor motor having thermal-overload protection and lubricated bearings; designed to operate at specified boiler pressures and temperatures.

2.6 CONTROLS

A. Refer to Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."

B. Boiler operating controls shall include the following devices and features:

1. Control transformer.
2. Set-Point Adjust: Set points shall be adjustable.
3. Sequence of Operation: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain space temperature in response to thermostat with heat anticipator located in heated space.

    a. Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.

4. Sequence of Operation: Electric, factory-fabricated and field-installed panel to control burner firing rate to reset supply-water temperature inversely with outside-air temperature. At 0 deg F (minus 17 deg C) outside-air temperature, set supply-water temperature at 200 deg F (93 deg C); at 60 deg F (15 deg C) outside-air temperature, set supply-water temperature at 140 deg F (60 deg C).

    a. Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.

C. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.

1. High Cutoff: Manual or Automatic reset stops burner if operating conditions rise above maximum boiler design temperature as directed.
2. Low-Water Cutoff Switch: Electronic probe shall prevent burner operation on low water. Cutoff switch shall be manual or automatic-reset type as directed.
3. Blocked Inlet Safety Switch: Manual-reset pressure switch field mounted on boiler combustion-air inlet.
4. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.

D. Building Automation System Interface: Factory install hardware and software to enable building automation system to monitor, control, and display boiler status and alarms.

1. Hardwired Points:

    a. Monitoring: On/off status, common trouble alarm or low-water-level alarm as directed.
    b. Control: On/off operation, hot-water-supply temperature set-point adjustment.

2. A communication interface with building automation system shall enable building automation system operator to remotely control and monitor the boiler from an operator workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building automation system.

2.7 ELECTRICAL POWER

A. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in electrical Sections.

B. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.

1. House in NEMA 250, Type 1 enclosure.
2. Wiring shall be numbered and color coded to match wiring diagram.
3. Install factory wiring outside of an enclosure in a metal raceway.
4. Field power interface as directed.

5. Provide branch power circuit to each motor and to controls with a disconnect switch or circuit breaker.
6. Provide each motor with overcurrent protection.

2.8 VENTING KITS

A. Kit: Complete system, ASTM A959, Type 29-4C stainless steel, pipe, vent terminal, thimble, indoor plate, vent adapter, condensate trap and dilution tank, and sealant.

B. Combustion-Air Intake: Complete system, stainless steel, pipe, vent terminal with screen, inlet air coupling, and sealant.

2.9 SOURCE QUALITY CONTROL

A. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.

B. Test and inspect factory-assembled boilers, before shipping, according to 2010 ASME Boiler and Pressure Vessel Code.

PART 3 - EXECUTION

3.1 BOILER INSTALLATION

A. Equipment Mounting:

1. Install boilers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

B. Install gas-fired boilers according to NFPA 54.

C. Assemble and install boiler trim.

D. Install electrical devices furnished with boiler but not specified to be factory mounted.

E. Install control wiring to field-mounted electrical devices.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to boiler to allow service and maintenance.

C. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

D. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service. Flexible connectors and their installation are specified in Section 232116 "Hydronic Piping Specialties."

E. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas-train connection. Provide a reducer if required.

F. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.

G. Install piping from safety relief valves to nearest floor drain.

H. Boiler Venting:

1. Install flue venting kit and combustion-air intake.
2. Connect full size to boiler connections. Comply with requirements in Section 235123 "Gas Vents."

I. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

J. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform installation and startup checks according to manufacturer's written instructions.
2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

    a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and water temperature.
    b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

B. Boiler will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

D. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.4 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain boilers. Refer to Section 017900 "Demonstration and Training."

END OF SECTION 235216

SECTION 235223 - CAST-IRON BOILERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes cast-iron boilers, trim, and accessories for generating hot water.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For boilers, boiler trim, and accessories.

1. Include plans, elevations, sections, and mounting or attachment details as directed.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal: For each boiler.

1. Design calculations and vibration isolation base details signed and sealed by a qualified professional engineer.

a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
b. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for boiler, accessories, and components, from manufacturer.

B. Source quality-control reports.

C. Field quality-control reports.

D. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace controls and heat exchangers of boilers that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Controls: Two years from date of Substantial Completion.
2. Warranty Period for Heat Exchangers: Years as directed from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASME Compliance: Fabricate and label boilers to comply with 2010 ASME Boiler and Pressure Vessel Code.

C. ASHRAE/IES 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."

D. DOE Compliance: Minimum efficiency shall comply with 10 CFR 430, Subpart B, Appendix N.

E. I=B=R Compliance: Boilers shall be tested and rated according to AHRI's "Rating Procedure for Heating Boilers" and "Testing Standard for Commercial Boilers," with I=B=R emblem on a nameplate affixed to boiler.

F. UL Compliance: Test boilers for compliance as directed. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

G. CSA Compliance: Test boilers for compliance with CSA B51.

H. Mounting Frame: Steel rails used to mount assembled boiler package on concrete base.

1. Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC" when mounting base is anchored to building structure.

2.2 MANUFACTURERS

2.3 MANUFACTURED UNITS

A. Description: Factory fabricated and assembled.

1. Cast-iron sections shall be sealed pressure tight and held together with tie rods set on an insulated steel base, including insulated jacket and flue-gas vent connection.

B. Cast-Iron Section Design:

1. Configuration: Wet as directed.
2. Number of Passes: Single or Multiple as directed.
3. Sectional Joints: High-temperature sealant to seal flue-gas passages not in contact with heating medium, as directed and held together with tie rods.
4. Drain and blowdown tappings.
5. Return injection tube to equalize water flow to all sections.
6. Crown inspection tappings with brass plugs.
7. Built-in air separator.

C. Combustion Chamber: Equipped as directed flame observation ports, front and back.

D. Casing:

1. Jacket: Galvanized sheet or Sheet metal as directed, with snap-in or interlocking closures and baked-enamel or powder-coated protective finish as directed.
2. Insulation: As directed Minimum 1-inch- (25-mm-) or 2-inch- (50-mm-) thick, mineral-fiber insulation surrounding the heat exchanger.
3. Combustion Chamber Access: Refractory lined, hinged, front.
4. Access: For cleaning between cast-iron sections.
5. Draft Hood: Flue canopy and top or rear flue connection shall be constructed of aluminized or stainless steel containing adjustable outlet damper assembly as directed.
6. Insulated base constructed of aluminized steel to permit boiler to be installed on combustible floor.
7. Control Cabinet: Sheet metal casing shall cover all controls, gas train, and burner.

2.4 ATMOSPHERIC-GAS BURNER

A. Burner Tubes and Orifices: Stainless steel or Cast iron, for natural or propane gas as directed.

B. Gas Train: Control devices and as directed control sequence shall comply with requirements as directed.

C. Gas Train: Combination-gas valve with manual shutoff, pressure regulator, and pilot adjustment.

D. Pilot: Standing or Intermittent-electric-spark pilot ignition as directed with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.

2.5 TRIM FOR HOT-WATER BOILERS

A. Include devices sized to comply with ASME B31.9.

B. Aquastat Controllers: Operating, firing rate, and high limit.

C. Safety Relief Valve: ASME rated.

D. Pressure and Temperature Gage: Minimum 3-1/2-inch- (89-mm-) diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges, so normal operating range is about 50 percent of full range.

E. Boiler Air Vent: Automatic or Manual as directed.

F. Drain Valve: Minimum NPS 3/4 (DN 20) hose-end gate valve.

2.6 CONTROLS

A. Refer to Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."

B. Boiler operating controls shall include the following devices and features:

1. Control transformer.
2. Set-Point Adjust: Set points shall be adjustable.
3. Low-Water Cutoff and Pump Control: Cycle feedwater pump(s) for makeup water control.
4. Sequence of Operation: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain space temperature in response to thermostat with heat anticipator located in heated space.

    a. Include automatic, alternating-firing sequence for multiple boilers to provide equal runtime for boilers.

5. Sequence of Operation: Electric, factory-fabricated and field-installed panel to control burner firing rate to reset supply-water temperature inversely with outside-air temperature. At 0 deg F (minus 17 deg C) outside-air temperature, set supply-water temperature at 200 deg F (93 deg C); at 60 deg F (15 deg C) outside-air temperature, set supply-water temperature at 140 deg F (60 deg C).

    a. Include automatic, alternating-firing sequence for multiple boilers to provide equal runtime for boilers.

C. Safety Controls: To maintain safe operating conditions, burner safety controls limit burner operation.

1. Low-Water Cutoff Switch: Electronic probe shall prevent burner operation on low water. Cutoff switch shall be manual or automatic-reset type as directed.
2. Blocked Vent Safety Switch: Manual-reset switch factory mounted on draft diverter.
3. Rollout Safety Switch: Factory mounted on boiler combustion chamber.
4. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.

D. Building Management System Interface: Factory install hardware and software to enable building management system to monitor, control, and display boiler status and alarms.

1. Hardwired Points:

    a. Monitoring: On/off status, as directed.
    b. Control: On/off operation, hot-water-supply temperature set-point adjustment.

2. A communication interface with building management system shall enable building management system operator to remotely control and monitor the boiler from an operator workstation. Control features available and monitoring points displayed, locally at boiler control panel shall be available through building management system.

2.7 ELECTRICAL POWER

A. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in electrical Sections.

B. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.

1. House in NEMA 250, Type 1 enclosure.
2. Wiring shall be numbered and color coded to match wiring diagram.
3. Install factory wiring outside of an enclosure in a metal raceway.
4. Field power interface as directed.
5. Provide branch power circuit to each motor and to controls with disconnect switch or circuit breaker.
6. Provide each motor with overcurrent protection.

2.8 CAPACITIES AND CHARACTERISTICS

A. Hot-Water Heating:

1. Design Water-Pressure Rating: As directed.
2. Safety Relief Valve Setting: As directed.
3. Entering-Water Temperature: As directed.
4. Leaving-Water Temperature: As directed.
5. Design Water Flow Rate: As directed.
6. Design Pressure Drop: As directed.

B. Minimum Efficiency AFUE: Percent As directed.

C. Minimum Thermal Efficiency: Percent As directed.

D. Minimum Combustion Efficiency: Percent As directed.

E. Number of Passes: One or Two As directed.

F. Input Rating Method:

1. AGA Input: As directed.
2. I=B=R Input: As directed.

3. Gas Input: As directed.

G. Output Capacity

1. AGA Output Capacity: As directed.
2. DOE Output Capacity: As directed.
3. Net I=B=R Output Capacity: As directed.
4. Gross I=B=R Output Capacity: As directed.
5. Equivalent Direct Radiation: As directed.

H. Blower:

1. Motor Horsepower: As directed.
2. RPM: As directed.

I. Electrical Characteristics:

1. Volts: As directed.
2. Phase: Single or Three As directed.
3. Hertz: 50or 60 Hz as directed.
4. Full-Load Amperes: As directed.
5. Minimum Circuit Ampacity: As directed.
6. Maximum Overcurrent Protection: As directed.

2.9 SOURCE QUALITY CONTROL

A. Test and inspect factory-assembled boilers, before shipping, according to 2010 ASME Boiler and Pressure Vessel Code or CSA B51 as directed.

B. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.

PART 3 - EXECUTION

3.1 BOILER INSTALLATION

A. Equipment Mounting:

1. Install boilers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed
2. Comply with requirements for vibration isolation and seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

B. Install gas-fired boilers according to NFPA 54.

C. Assemble and install boiler trim.

D. Install electrical devices furnished with boiler but not specified to be factory mounted.

E. Install control wiring to field-mounted electrical devices.

3.2 CONNECTIONS

A. Piping installation requirements are specified in Section 232113 "Hydronic Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to boiler to allow service and maintenance.

C. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas-train connection. Provide a reducer if required.

D. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.

E. Install piping from safety relief valves to nearest floor drain.

F. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

G. Connect breeching full size to boiler outlet. Comply with requirements in Section 235116 "Fabricated Breechings and Accessories" for venting materials.

H. Install flue-gas recirculation duct from vent to burner. Comply with requirements in Section 235123 "Gas Vents" for recirculation duct materials.

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform installation and startup checks according to manufacturer's written instructions.
2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

    a. Burner Test: Adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency.
    b. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and water temperature.

B. Remove and replace malfunctioning units and retest as specified above.

C. Boiler will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.4 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain boilers. Refer to Section 017900 "Demonstration and Training."

END OF SECTION 235223

SECTION 235233 - WATER-TUBE BOILERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes packaged, factory-fabricated and -assembled, gas-fired, finned water-tube boilers for generating hot water.

B. Section includes packaged, factory- or field-assembled, water-tube boilers for generating hot water or steam.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product, include the following:

B. Sustainable Design Submittals:

C. Shop Drawings: For boilers, boiler trim, and accessories.

1. Include plans, elevations, sections, and mounting or attachment details as dircted.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Design calculations and base details signed and sealed by a qualified professional engineer.

    a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing bases.
    b. Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

4. Include diagrams for power, signal, and control wiring. Differentiate between factory and field installation.
5. Include piping diagrams of factory-furnished piping that indicate size and each piping component.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan and elevation views, drawn to scale, indicating equipment manufacturers' service clearances, structure and base attachment, piping, power, controls, and flues.

B. Seismic Qualification Certificates: For boilers, accessories, and components, from manufacturer.

C. Installation instructions.

D. Source quality-control reports.

E. Field quality-control reports.

F. Sample Warranty: For special warranty.

G. Other Informational Submittals:

1. ASME "A" Stamp Certification and Report: Submit "A" stamp certificate of authorization as required by authorities having jurisdiction, and document hydrostatic testing of piping external to boiler.
2. Startup service reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace heat exchangers damaged by thermal shock and vent dampers of boilers that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Heat Exchangers: 20 years from date of Substantial Completion.
2. Warranty Period for Vent Dampers: Five years from date of Substantial Completion.

B. Special Warranty: Manufacturer agrees to repair or replace drums, tubes, headers, cabinets, atmospheric gas burners, and pressure vessels of boilers that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Drums, Tubes, Headers, Cabinets, and Atmospheric Gas Burner: Five years from date of Substantial Completion, pro rata.
2. Warranty Period for Pressure Vessel: 20 years from date of Substantial Completion, for thermal shock.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Fuel-to steam or water efficiency indicated shall be based on the following as directed:

1. Efficiency Testing Method: BTS-2000.
2. Efficiency Testing Method: ASME Performance Test Code (PTC) 4, Input-Output or Heat Loss method as directed.
3. Efficiency Testing Method: As directed.
4. Test Operating Conditions:

a. Ambient Temperature: As directed.
b. Ambient Relative Humidity: As directed.
c. Percent Excess Air in Exhaust Flue Gas: 15.
d. Fuel Heating Value: As directed.

B. Gas-Fired Boiler Emissions: Not to exceed allowable ambient-air quality standards in governing jurisdiction and indicated values.

1. Carbon monoxide:

a. 50 parts per million at any point from 100 percent to 50 percent fire.
b. 150 parts per million at any point below 50 percent fire.

2. Nitrogen compounds: Parts per million as directed (dry volume basis and corrected to 3 percent oxygen) at any point from 100 percent to low fire.
3. Sulfur compounds: One part per million (dry volume basis and corrected to 3 percent oxygen) at any point from 100 percent to low fire.
4. Hydrocarbon and Volatile Organic Compounds: 10 parts per million (dry volume basis and corrected to 3 percent oxygen) at any point from 100 percent to low fire.
5. Particulate Matter: 0.01 lb/MMBtu.
6. Smoke: Not visible and not to exceed No. 1 on the Bacharach smoke scale.

C. Oil-Fired Boiler Emissions: Not to exceed allowable ambient-air quality standards in governing jurisdiction and indicated values.

1. Carbon monoxide:

a. 50 parts per million at any point from 100 percent to 50 percent fire.
b. 150 parts per million at any point below 50 percent fire.

2. Nitrogen compounds: 30 or 20 or 10 parts per million as directed (dry volume basis and corrected to 3 percent oxygen) at any point from 100 percent to low fire.
3. Sulfur compounds: One part per million (dry volume basis and corrected to 3 percent oxygen) at any point from 100 percent to low fire.
4. Hydrocarbon and Volatile Organic Compounds: 10 parts per million (dry volume basis and corrected to 3 percent oxygen) at any point from 100 percent to low fire.
5. Particulate Matter: 0.01 lb/MMBtu.
6. Smoke: Not visible and not to exceed No. 1 on the Bacharach smoke scale.

D. Multiple Boiler Operation: Equip individual boilers in multiple boiler applications with integral controls to provide multiple boiler operation for optimum system performance, energy efficiency, and the following:

1. Equalize runtime of boilers in service.
2. Operate multiple boilers hot to minimize disruption of service in the event of single boiler failure.
3. Configure controls so any boiler can be taken out of service with power disconnected and not impact multiple boiler operation.

E. Seismic Performance: Boiler shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the boiler will remain in place without separation of any parts when subjected to the seismic forces specified and the boiler will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 or 1.0.

F. Sound: Boiler sound level, measured according to parameters defined in ABMA publication "Boiler 304 Measurement of Sound from Steam Generators" shall not exceed as directed.

G. Steam Quality: 99 or 99.5 percent dry and saturated as directed.

H. Operation Following Loss of Normal Power:

1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to back-up power system shall automatically return equipment and associated controls to the operating state occurring immediately before loss of normal power without need for manual intervention by an operator when power is restored either through a back-up power source or through normal power if restored before back-up power is brought online.
2. Refer to Drawings for equipment served by back-up power systems.
3. Provide means and methods required to satisfy requirement even if not explicitly indicated.

I. Outdoor Installations:

1. Boiler shall be suitable for outdoor installation indicated. Provide adequate weather protection to ensure reliable service life over a 25-year period, with minimal degradation due to exposure to outdoor ambient conditions.
2. Boilers equipped to provide safe and stable operation while achieving performance indicated when operating at extreme outdoor temperatures encountered by the installation. Review historical weather database and provide equipment that can operate at extreme outdoor temperatures recorded over past 30-year period. Provide as part of boiler package, products, such as combustion-air pre-heaters and other means and methods required.

J. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

K. ASME Compliance: Fabricate and label boilers to comply with 2010 ASME Boiler and Pressure Vessel Code.

L. ASHRAE/IES 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."

M. DOE Compliance: Minimum efficiency for boilers with capacity of 300,000 Btu/h (87.9 kW) shall comply with 10 CFR 430, Subpart B, Appendix N, "Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers."

N. UL Compliance: Test boilers for compliance as directed. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

2.2 FINNED WATER-TUBE BOILERS

A. Description: Factory-fabricated, -assembled, and -tested boiler, with tubes sealed into headers pressure tight, and set on a steel base; including insulated jacket, flue-gas vent, combustion-air-intake connections, water supply and return connections, and controls.

B. Heat Exchanger:

1. Finned copper or steel or copper-nickel tubing with stainless-steel baffles.
2. Bronze or Cast-iron or Steel headers.
3. Single or Two-pass, horizontal or vertical or coil configuration.
4. Tubes shall be sealed in header with silicone O-ring gaskets or by welding or by mechanically rolling tubes in header.

C. Combustion Chamber Internal Insulation: Interlocking panels of refractory insulation, high-temperature cements, mineral fiber, and ceramic refractory tile for service temperatures of up to 2000 deg F (1100 deg C).

D. Casing:

1. Jacket: Sheet metal or Stainless steel, with snap-in or interlocking closures.
2. Control Compartment Enclosure: NEMA 250, Type 1A.
3. Finish: As directed Baked enamel over primer, Baked enamel over galvanizing or Powder coated.
4. Insulation: Minimum 1-inch- (25-mm-) or 2-inch- (50-mm-) thick, mineral-fiber insulation surrounding the heat exchanger as directed.
5. Draft Hood: Integral or External as directed.
6. Combustion-Air Connection: Inlet duct collar and sheet metal closure over burner compartment.
7. Mounting base to secure boiler with accessory for mounting on combustible surface.

E. Burner:

1. Burner Tubes and Orifices: Stainless steel, for natural or propane gas as directed. Mount burner tubes in a slide-out burner drawer for ease of inspection.

    a. Sealed Combustion: Factory-mounted centrifugal fan to draw outside air into boiler and discharge into burner compartment.
    b. Direct Vent: Factory-mounted centrifugal fan to draw flue gas out of boiler and discharge into boiler vent.

2. Vertical Burner:

    a. High-temperature stainless steel or Ceramic to fire in a 360-degree pattern as directed.
    b. Burner shall have a viewing port for observation of burner operation and a factory-mounted centrifugal fan to supply room or outdoor air through a replaceable 99 percent efficient (1-micrometer particles) filter to boiler burner.
    c. Fan shall be controlled to prepurge and postpurge the combustion chamber before firing.

3. Gas Train: Control devices and control sequence shall comply as directed with requirements. In addition to these requirements, include shutoff cock, pressure regulator, and control valve.
4. Gas Train: Combination gas valve with manual shutoff, pressure regulator, and pilot adjustment.
5. Pilot: Pilot ignition as directed with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
6. Flue-Gas Recirculation System: Centrifugal fans on burner assembly to recirculate flue gas to decrease emissions to requirements indicated. Complete package integrating burner, fan, damper, fuel train, and controls. Provide interconnecting external ducting if required by manufacturer's design.
7. Motors: Comply with requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

F. Hot-Water Boiler Trim:

1. Hot-Water Temperature Controllers: Operating, firing rate, and high limit.
2. Safety Relief Valve: ASME rated.
3. Pressure and Temperature Gage: Minimum 3-1/2-inch- (89-mm-) diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges, so normal operating range is about 50 percent of full range.
4. Boiler Air Vent: Automatic or Manual as directed.
5. Drain Valve: Minimum NPS 3/4 (DN 20) hose-end valve.
6. Circulation Pump: Non-overloading, in-line pump with split-capacitor motor having thermal-overload protection and lubricated bearings; designed to operate at boiler flow rate, pressures, and temperatures.

G. Controls:

1. Boiler operating controls shall include the following devices and features:

    a. Control transformer.
    b. Motorized Vent Damper: Interlocked with burner to open before burner starts. If damper fails to open, stop burner operation.
    c. Set-Point Adjust: Set points shall be adjustable.
    d. Sequence of Operation: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain space temperature in response to thermostat with heat anticipator located in heated space.
    e. Sequence of Operation: Electric, factory-fabricated and field-installed panel to control burner firing rate to reset supply-water temperature inversely with outdoor-air temperature. At 0 deg F (minus 17 deg C) outdoor-air temperature, set supply-water temperature at 200 deg F (93 deg C); at 60 deg F (15 deg C) outdoor-air temperature, set supply-water temperature at 140 deg F (60 deg C).
    f. Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.

2. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.

    a. High Cutoff: Manual or Automatic reset stops burner if operating conditions rise above maximum boiler design temperature as directed.

b. Water Flow Switch: Automatic-reset paddle-switch shall prevent burner operation on low water flow.
c. Blocked Vent Safety Switch: Manual-reset switch factory mounted on draft diverter.
d. Rollout Safety Switch: Factory mounted on boiler combustion chamber.
e. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.

3. Building Automation or DDC System Interface as directed: Factory install hardware and software to enable system to monitor, control, and display boiler status and alarms.

a. Hardwired I/O Points:

1) Monitoring: On/off status, common trouble alarm or low-water-level alarm as directed.
2) Control: On/off operation, hot-water-supply temperature set-point adjustment.

b. Communication Interface: Communication interface shall enable control system operator to remotely control on/off operation and capacity of boiler and monitor the boiler operation from an operator workstation as directed. The control features and monitoring points at the boiler-control panel shall be available to the control system through an interface.

2.3 STEEL OR FLEXIBLE WATER-TUBE BOILERS

A. Description: Factory-fabricated and field-assembled water-tube boiler, with heat exchanger sealed pressure tight, and built on a steel base; including insulated jacket, flue-gas vent, supply and return connections, and controls.

B. Heat-Exchanger Design: Straight steel tubes rolled into steel headers.

1. Accessible head plates at both ends.
2. Handholes or couplings in headers for waterside inspections.
3. Accessible drain and blowdown tappings, both high and low, for surface and mud removal.
4. Lifting lugs on top of boiler.
5. Built-in air separator.

C. Heat-Exchanger Design: Bent steel tubes swaged or welded into steel headers with membrane waterwall design as directed.

1. Limit tube configurations to two or four as directed.
2. Accessible drain and blowdown tappings, both high and low, for surface and mud removal.
3. Accessible inspection ports in drum, mud legs, and tube manifolds.
4. Lifting lugs on top of boiler.
5. Built-in air separator.

D. Combustion Chamber: Equipped with minimum inch as directed, 2700 deg F (1482 deg C) poured refractory on floor and minimum 2-inch (50-mm) or 3-1/2-inch (89-mm) lap-jointed cast

refractory as directed with fiber-blanket joint seals on side walls. Combustion chamber shall have flame observation ports in front and or back.

E. Casing:

1. Insulation: Minimum 2-inch (50-mm) thick, lightweight refractory; 1-inch (25-mm) thick insulating board; galvanized-steel membrane; and 2-inch (50-mm) thick, mineral-fiber insulation surrounding the heat exchanger and combustion chamber.
2. Top Flue Connection: Constructed of aluminized or stainless steel.
3. Jacket: Mirror-finish stainless steel, with screw-fastened closures.
4. Jacket: Galvanized sheet metal, with screw-fastened closures and baked-enamel or powder-coated protective finish as directed.
5. Mounting Base: Secures boiler to concrete base.

F. Draft Diverter or Barometric Damper as directed: Galvanized-steel assembly with flue-gas thermometer.

G. Atmospheric Gas Burner:

1. Burner and Orifices: Stainless steel or Cast iron, for natural or propane gas as directed.
2. Gas Train: Control devices and full-modulation or on/off or low/high/low control sequence as directed.
3. Gas Train: Combination gas valve with manual shutoff, pressure regulator, and pilot adjustment.
4. Pilot: Standing or Intermittent-electric-spark pilot ignition as directed with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.

H. Forced-Draft Gas Burner:

1. Burner: Welded construction with multi-vane, stainless-steel, flame-retention diffuser for natural or propane gas as directed. Mount burner on hinged access door to permit access to combustion chamber.
2. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.
3. Gas Train: Control devices and control sequence shall comply as directed with requirements.
4. Pilot: Intermittent or Interrupted-electric-spark pilot ignition as directed with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.

I. Forced-Draft Oil Burner:

1. Burner: Welded construction with multi-vane, stainless-steel, flame-retention diffuser for fuel oil. Mount burner on hinged access door to permit access to combustion chamber.
2. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.
3. Oil Supply: Control devices and modulating or on/off or low/high/low control sequence shall comply as directed with requirements.

    a. Oil Pump: Two-stage, gear-type oil pump integral to and directly driven by blower shall be capable of producing 300-psig (2070-kPa) discharge pressure and 15-inch Hg (50.7-kPa) vacuum.
    b. Oil Piping Specialties:

1) Suction-line, manual, gate valve.
2) Removable-mesh oil strainer.
3) 0- to 30-inch Hg (0- to 101.3-kPa) vacuum; 0- to 30-psig (0- to 207-kPa) vacuum-pressure gage.
4) 0- to 300-psig (0- to 2070-kPa) oil-nozzle pressure gage.
5) Nozzle-line, solenoid-safety-shutoff oil valve.

4. Pilot: Intermittent or Interrupted-electric-spark pilot ignition as directed with 100 percent main-valve and pilot-safety-shutoff solenoid using cadmium sulfide or UV scanner flame-safety control as directed.

J. Forced-Draft Combination Gas and Oil Burner:

1. Burner: Welded construction with multi-vane, stainless-steel, flame-retention diffuser for fuel oil and natural or propane gas as directed. Mount burner on hinged access door to permit access to combustion chamber.
2. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.
3. Oil Supply: Control devices and modulating or on/off or low/high/low control sequence shall comply as directed with requirements.

a. Oil Pump: Two-stage, gear-type oil pump integral to and directly driven by blower shall be capable of producing 300-psig (2070-kPa) discharge pressure and 15-inch Hg (50.7-kPa) vacuum.
b. Oil Piping Specialties:

1) Suction-line, manual, gate valve.
2) Removable-mesh oil strainer.
3) 0- to 30-inch Hg (0- to 101.3-kPa) vacuum; 0- to 30-psig (0- to 207-kPa) vacuum-pressure gage.
4) 0- to 300-psig (0- to 2070-kPa) oil-nozzle pressure gage.
5) Nozzle-line, solenoid-safety-shutoff oil valve.

4. Gas Train: Control devices and modulating or on/off or low/high/low control sequence shall comply as directed with requirements.
5. Gas Pilot: Intermittent or Interrupted-electric-spark pilot ignition as directed with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
6. Oil Pilot: Intermittent or interrupted-electric-spark pilot ignition as directed with 100 percent main-valve and pilot-safety-shutoff solenoid with cadmium sulfide or UV scanner flame-safety control.

K. Motors: Comply with requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment" unless more stringent requirements are indicated below:

1. Efficiency: Premium efficient.
2. Enclosure: Open dripproof or Totally enclosed or Totally enclosed, fan cooled.
3. Insulation Class: F or H as directed.
4. Service Factor: 1.15.
5. Motors operated through variable-frequency controllers shall be inverter duty rated according to NEMA MG-1.
6. Motor Sizes: Minimum size as indicated and large enough so driven load does not require motor to operate in service factor.

L. Flue-Gas Recirculation System:

1. Equip boiler with packaged flue-gas recirculation system if required to satisfy emission requirements.
2. Complete package integrating burner, combustion-air blower and damper, fuel train, and controls. Provide interconnecting external ducting if required by manufacturer's design.

M. Hot-Water Boiler Trim:

1. Include devices sized to comply with ASME B31.1 or ASME B31.9 as directed.
2. Hot-Water Temperature Controllers: Operating, firing rate, and high limit.
3. Safety Relief Valve: ASME rated.
4. Pressure and Temperature Gage: Minimum 3-1/2-inch- (89-mm-) diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges, so normal operating range is about 50 percent of full range.
5. Boiler Air Vent: Automatic or Manual.
6. Drain Valve: Minimum NPS 3/4 (DN 20) hose-end valve.
7. Tankless Heater: Carbon-steel or Bronze header as directed with copper-tube heat exchanger, mounted in a port of upper drum and sealed with fiber gasket.

    a. Tappings NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.
    b. Tappings NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.

N. Steam Boiler Trim:

1. Include devices sized to comply with ASME B31.1 or ASME B31.9.
2. Pressure Controllers: Operating, firing rate, and high limit.
3. Safety Relief Valve:

    a. Size and Capacity: As required for equipment according to 2010 ASME Boiler and Pressure Vessel Code.
    b. Description: Fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.

        1) Drip-Pan Elbow: Cast iron and having threaded inlet and outlet with threads complying with ASME B1.20.1.
        2) Exhaust Head: Install exhaust head on vent pipe connected to safety relief valve.

4. Pressure Gage: Minimum 3-1/2-inch (89-mm) diameter. Gage shall have normal operating pressure of about 50 percent of full range.
5. Water Column: Minimum 12-inch (300-mm) glass gage with gage rods to protect glass, ball check and shutoff cocks, water column blowdown valves, and vacuum breaker. Midpoint of gauge shall be at normal operating water level.
6. Bottom Blowdown Valves: Factory-installed, duty-rated, slow-acting blowdown valves and interconnecting piping same size as boiler nozzle. Blowdown valves shall be combination of slow and quick acting as required by ASME B31.1.

7. Surface Blowdown Valves: Factory-installed, duty-rated isolation valves and interconnecting piping. In addition, provide electrically operated control valve, duty rated, to control total dissolved solids (TDS) through boiler controls.
8. Stop Valves: Boiler outlets, except safety relief valves, shall be equipped with stop valve in an accessible location as near as is practical to boiler nozzle and same size or larger than nozzle. Valves larger than NPS 2 (DN 50) shall have rising stem.
9. Stop-Check Valves: Factory-installed, stop-check valve and stop valve at boiler outlet with free-blow drain valve factory installed between the two valves and visible when operating stop-check valve.
10. Feedwater Valves: Factory-installed, duty-rated stop and check valves and interconnecting piping. Stop valves larger than NPS 2 (DN 50) shall have rising stem.
11. Feedwater Valves: Factory-installed, three-valve bypass arrangement with modulating control valve positioned between duty-rated stop valves, bypass piping with throttling valve, check valve, and interconnecting piping. Stop and throttling valves larger than NPS 2 (DN 50) shall have rising stem. Modulating control valve shall have the following features and characteristics:

    a. Duty rated with electric operator to control water level through boiler controls.
    b. Equal percentage flow characteristic.
    c. Valve Flow: Indicated on Drawings or 1.25 times boiler output.
    d. Valve Pressure and Temperature Rating: Equal to boiler.
    e. Shut-off Leakage: 0.0001 percent of valve coefficient.

12. Chemical Injection Assembly: Factory-installed, duty-rated injection quill with ball check valve and isolation valve compatible with dispensed chemical.
13. Sample Cooler: Factory installed or furnished for field installation, with needle valve for each connection. Constructed of 316 stainless steel.
14. Tankless Heater: Carbon-steel header with copper-tube heat exchanger, mounted in a port of upper manifold and sealed with fiber gasket.

    a. Tappings NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.
    b. Tappings NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.

O. Controls:

1. Boiler operating controls shall include the following devices and features:

    a. Control transformer(s) with fuse protection, as required by manufacturer, to implement requirements indicated. Provide transformer with 25 percent spare capacity.
    b. Set-Point Adjust: Operating and alarm set points shall be field adjustable.

2. Pressure Control for Steam Boilers:

    a. Operating-Pressure Control: Factory wired and mounted to control boiler to maintain boiler at constant pressure within 2 percent of set point.
    b. High-Pressure Cutoff with Automatic Reset: Control stops burner if operating conditions rise above normal operating-pressure set point. Set point shall be adjustable.

c. High-Pressure Cutoff with Manual Reset: Control stops burner operation upon reaching adjustable high limit set point that is below safety valve setting.

3. Water-Level Control for Steam Boilers:

a. Operating Water-Level Control: Cycle feedwater pump(s) or Operate feedwater pump(s) continuously and modulate boiler feedwater valve for water-level control as directed.
b. Low-Water Cutoff Switch: Electronic or Float and electronic probe shall prevent burner operation on low water as directed. Cutoff switch shall be manual or automatic-reset type as directed.
c. Auxiliary Low-Water Cutoff Switch: Electronic or Float and electronic probe shall prevent burner operation on low-water alarm limit as directed. Cutoff switch shall be manual-reset type.
d. Microprocessor-based control.
e. Accuracy within 0.01 in. (0.25 mm).
f. Visual indication of level, alarms, and errors through alphanumeric display.
g. Features:

1) Continuous water-level indication.
2) Low-water cutoff and alarm.
3) High-water alarm.
4) Low- and high-water warning.
5) Control of feedwater pump.
6) Control of modulating feedwater control valve.
7) Continuous monitoring of float operation.
8) Column blowdown detection and reminder.
9) Auxiliary low-water cutoff check.
10) Auto and manual reset.
11) Alarm annunciation.

4. Operating Controls for Hot-Water Boilers:

a. Sequence of Operation: Electric, factory-fabricated and field-installed panel to control burner firing rate to reset supply-water temperature inversely with outdoor-air temperature. At 0 deg F (minus 17 deg C) outdoor-air temperature, set supply-water temperature at 200 deg F (93 deg C); at 60 deg F (15 deg C) outdoor-air temperature, set supply-water temperature at 140 deg F (60 deg C).
b. Sequence of Operation: Indicated on Drawings.

5. Multiple Boiler Operation: Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.
6. Boiler Emergency Shutdown: Interlock with field-installed boiler emergency shutdown switch to shut down boiler when activated. Manufacturer to furnish break-glass-type switch with permanent nameplate titled "Boiler Emergency Shutdown" for field installation.
7. Chemical Feed System Interface: Dry contacts to interface control and operation of chemical feed pump.
8. Burner Safety Controls for Steam Boilers: To maintain safe operating conditions, burner safety controls limit burner operation.

a. High Cutoff: Automatic and Manual reset stops burner if operating conditions rise above maximum boiler operating pressure.
b. Low-Water Cutoff Switch: Float and electronic probe shall prevent burner operation on low water. Cutoff switch shall be automatic-reset type.
c. Auxiliary Low-Water Cutoff Switch: Float and electronic probe shall prevent burner operation on low-water alarm limit. Cutoff switch shall be manual-reset type.
d. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.

9. Burner Safety Controls for Hot-Water Boilers: To maintain safe operating conditions, burner safety controls limit burner operation.

a. High Cutoff: Automatic and Manual reset stops burner if operating conditions rise above boiler design temperature.
b. Low-Water Cutoff Switch: Electronic probe shall prevent burner operation on low water. Cutoff switch shall be manual or automatic-reset type.
c. Auxiliary Low-Water Cutoff Switch: Electronic probe shall prevent burner operation on low-water alarm limit. Cutoff switch shall be manual-reset type.
d. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.

10. Burner Flame Safeguard Controls:

a. Factory equipped with flame safeguard control and infrared flame scanner.
b. Microprocessor-based, solid-state control having sequence and flame-on visual indication and fault code indications of flame safeguard trip functions.
c. Control shall include dynamic self-check logic.
d. Control shall have a fixed operating sequence incapable of being manually altered that includes start, prepurge, pilot and main fuel ignition run, and postpurge cycles.
e. Control shall be nonrecycle type for maximum safety that shall shut down the burner and indicate, as a minimum, the following trip functions:

1) Pilot and main flame failure.
2) High- and low-fire proving switch faults.
3) Running interlocks open.
4) False flame signal and fuel valve open.

f. Control shall include a run/test switch to allow interruptions to sequence just after prepurge and during pilot ignition trial, and run cycles for adjustments to firing rate motor, damper linkages, and pilot flame for minimum turndown tests.

11. Combustion-Air Controls: Factory equipped with motor-operated combustion-air damper and blower control to regulate burner fire according to load demand.
12. Oxygen Trim Control:

a. Provide oxygen trim system to continuously monitor and display oxygen concentrations in boiler flue gas and adjust fuel and airflow to maintain an adjustable oxygen-level set point.
b. System shall compensate for changes in ambient temperature, barometric pressure, humidity, and variations in fuel characteristics.

13. Surface Blowdown Control: Provide a conductivity sensor and control circuitry to operate an automatic control valve in surface blowdown piping to maintain total dissolved solids (TDS) within boiler manufacturer's prescribed level.
14. Building Automation or DDC System Interface as directed: Factory install hardware and software to enable system to monitor, control, and display boiler status and alarms.

    a. Hardwired I/O Points:

        1) Monitoring: On/off status, common trouble alarm or low-water-level alarm as directed.
        2) Control: On/off operation, hot-water-supply temperature set-point adjustment or steam pressure adjustment as directed.

    b. Communication Interface: Communication interface as directed shall enable control system operator to remotely control on/off and capacity of boiler and monitor the boiler operation from an operator workstation. Control features are available, and monitoring points are displayed locally at boiler control panel through the interface.

15. Integrated Boiler Control System:

    a. Integral control of burner management for flame safety, boiler modulation, and operator interface functions with features and functions indicated.
    b. Factory preconfigured.
    c. Utilizing solid-state controls and sensors to provide various control functions, including the following:

        1) Automatic sequencing of the boiler through standby, prepurge, pilot flame establishing period, main flame establishing period, run, flame proving and lockout, and postpurge.
        2) Full modulating control of air and fuel through Proportional-Integral-Derivative (PID) algorithm.
        3) Thermal shock protection.
        4) High and low limit alarms and shutdowns.

    d. Local operator interface through nominal 10-inch (250-mm) color touch screen graphical display for setup, monitoring, and data acquisition.

        1) Manual control of the boiler firing rate using control screens to increment or decrement firing rate.
        2) Indication of burner management controller status and diagnostics.
        3) Display of system alarms and faults.
        4) Display of history of alarms and faults.
        5) Display of recommendations for troubleshooting of fault conditions.
        6) Display of water-level indication and alarm(s).
        7) Stack flue-gas, combustion-air, and shell water-temperature indication.
        8) Boiler efficiency calculation and display.
        9) Low-fire hold with minimum temperature control.
        10) Assured low-fire cutoff (ALFCO).
        11) High stack temperature annunciation with auto cutoff.
        12) Audible alarm and silencing through touch screen intervention.

e. Fully integrated control of the following:

1) Blower operation and combustion-air damper for varying operating conditions.
2) Oxygen trim and monitoring to compensate for combustion-air variations.
3) Parallel positioning for independent fuel and air control for enhanced fuel efficiency.
4) Multiple boiler lead/lag control with hot standby.
5) Draft control for maintaining proper and consistent draft for enhanced fuel efficiency.

f. E-mail and paging feature to multiple contacts via Internet and phone line independent of control system interface.
g. LAN/WAN interface with remote monitoring software to allow remote monitoring independent of control system interface.

16. Control Enclosures:

a. NEMA 250, Type 1.

1) Provide enclosure with integral vents, fans, heater, and air conditioner as required to automatically control temperature inside enclosure within safe operating limits of devices installed within the enclosure.

b. Wiring shall be numbered and color-coded to match wiring diagram. Provide a laminated wiring diagram located inside enclosure.
c. Mounted on boiler assembly at a location convenient to operator.
d. Provide hinged full-size door with key lock. Provide common key for all locks.
e. Enclosure shall consist of multiple sections divided by a partition with a separate hinged door for each section. One section shall house low-voltage controls and other section shall house line voltage controls.
f. Enclosure shall house the following:

1) Control transformers with fuses.
2) Labeled terminal strips.
3) Controller(s) to provide control and alarm functions indicated.
4) Audible indication of safety alarms.

g. Face of enclosure shall provide the following:

1) Visual indication of operating components and alarms.
2) Auto/local capability to allow operator to manually operate boiler locally.
3) Audible alarm-silence capability.
4) Labels for switches, lights, and displays to provide clear indication of service.

17. Control Instrument Enclosures: Control instruments and devices that are mounted on the boiler assembly and cannot be installed inside the control enclosure shall have same or higher level of protection indicated for control enclosures.
18. Control Cable and Wire:

a. Control cable and wiring shall be numbered and color-coded to match wiring diagram.
b. Install cable and wiring located outside of enclosure(s) in a metal raceway. Use flexible conduit to make final terminations. Provide watertight installation for applications exposed to moisture.

2.4 ELECTRICAL POWER

A. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.

1. Enclosure: NEMA 250, Type 1.

a. Enclosure shall have integral vents, fans, heat, and air conditioner as required to automatically control temperature inside enclosure within safe operating limits of devices installed within the enclosure.
b. Mounted on boiler assembly at a location convenient to operator.
c. Enclosure shall have hinged full-size door with key lock with common key for all locks.

2. Wiring shall be numbered and color-coded to match wiring diagram. Provide a laminated wiring diagram located inside enclosure.
3. Install factory wiring outside of an enclosure in a metal raceway. Make final connections to motors using flexible conduit. Provide watertight installation for applications exposed to moisture.
4. Field power interface shall be as directed. Withstanding rating of disconnecting means shall protect equipment. Coordinate requirements with field electrical power source.
5. Provide branch power circuit to each motor and to controls with disconnect switch or circuit breaker.
6. Provide each motor with NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection. Provide variable-frequency controller with manual bypass and line reactors for each variable-speed motor indicated.
7. Provide transformer with fuses and power wiring to power a 20-A 120-V duplex receptacle mounted in each boiler control panel for use in connecting analytical and testing equipment.

2.5 VENTING KITS

A. Vent Damper: Motorized; UL listed for use on atmospheric burner boiler equipped with draft hood; motor to open and close damper; stainless-steel vent coupling and damper blade; keyed wiring harness connector plug; and dual-position switches to permit burner operation.

B. Kit: Complete system, ASTM A959, Type 29-4C stainless steel, pipe, vent terminal, thimble, indoor plate, vent adapter, condensate trap, and sealant.

C. Combustion-Air Intake: Stainless steel, pipe, vent terminal with screen, inlet air coupling, and sealant.

2.6 CAPACITIES AND CHARACTERISTICS

A. Heating Medium: Hot water or Steam as directed.

B. Design Pressure and Temperature Rating: 160 psig (1100 kPa), 250 deg F (120 deg C).

C. Design Pressure Rating: As directed.

D. Design Pressure Rating: As directed.

E. Safety Relief Valve Setting: As directed.

F. Entering-Water Temperature: As directed.

G. Leaving-Water Temperature: As directed.

H. Design Water-Flow Rate: As directed.

I. Design Pressure Drop: As directed.

J. Steam Operating Pressure: As directed.

K. Steam-Flow Rate: As directed.

L. Minimum Efficiency AFUE: Percent as directed.

M. Minimum Thermal Efficiency: Percent as directed.

N. Minimum Combustion Efficiency: Percent as directed.

O. Fuel-to-Steam or Water Efficiency: Percent as directed.

P. Number of Passes: One or two as directed.

Q. Gas Input: As directed.

R. Gas Input Flow: As directed.

S. Gas Pressure: As directed.

T. Oil Input: As directed.

U. Oil Input Flow: As directed.

V. Output Capacity: As directed.

W. Tankless Water Heater:

1. Design Water Flow: As directed.
2. Design Pressure Drop: As directed.
3. Entering-Water Temperature: As directed.
4. Leaving-Water Temperature: As directed.

X. Burner Blower:

1. Motor Horsepower: As directed.

Y. Electrical Characteristics:

1. Volts: As directed.
2. Phase: Single or Three As directed.
3. Hertz: 50 or 60 hz as directed.
4. Full-Load Amperes: As directed.
5. Minimum Circuit Ampacity: As directed.
6. Maximum Overcurrent Protection: As directed.

Z. Sound (decibels, A weighted): As directed.

2.7 SOURCE QUALITY CONTROL

A. Test and inspect factory-assembled boilers, before shipping, according to 2010 ASME Boiler and Pressure Vessel Code.

B. Burner and Hydrostatic Test:

1. Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve performance requirements indicated.
2. Perform hydrostatic test of pressure vessel, piping, and trim of assembled boiler.

C. Witness Testing:

1. Allow Owner access to witness source quality-control testing of boilers.
2. Notify Architect or Owner 15 days in advance of testing as directed.

PART 3 - EXECUTION

3.1 BOILER INSTALLATION

A. Coordinate size and location of bases. Cast anchor-bolt inserts into concrete bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

B. Equipment Mounting:

1. Install boilers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed
2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

C. Install gas-fired boilers according to NFPA 54.

D. Install oil-fired boilers according to NFPA 31.

E. Assemble boiler tubes in sequence and seal each tube joint.

F. Assemble and install boiler trim, components, and accessories that are not factory installed.

G. Install control and electrical devices furnished with boiler that are not factory mounted.

H. Install control and power wiring to field-mounted control and electrical devices furnished with boiler that are not factory installed.

I. Perform boil-out and cleaning procedures according to manufacturer's written instructions after completion of hydrostatic testing and before performing other field tests. Boiler manufacturer's factory-authorized representative shall witness boil-out and cleaning procedures. Following boil-out and cleaning procedures, boiler shall be washed and flushed until water leaving boiler is clear.

J. Protect boiler fireside and waterside from corrosion.

1. Before boiler is filled with water, protect by dry storage method recommended by boiler manufacturer.
2. After boiler is filled with water, and left not fired for more than 10 days, protect by wet storage method recommended by boiler manufacturer.
3. Chemical Treatment: Quality of water in boilers shall be maintained by a professional water-treatment organization that shall provide on-site supervision to maintain the required water quality during periods of boiler storage as well as during operating, standby, and test conditions. Refer as directed for additional requirements.

3.2 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to boiler(s), allow space for service and maintenance.

C. Connect gas piping to boiler gas-train inlet with dirt leg, shutoff valve, and union or flange. Piping shall be at least full size of gas-train connection. Provide a reducer if required.

D. Connect oil piping to oil-train connection with dirt leg, shutoff valve, and union. Piping shall be at least full size of oil-train connection. Provide a reducer if required. Provide drain valve with threaded plug at piping low point.

E. Connect hot-water piping to supply- and return-boiler connections with shutoff valve and union or flange at each connection.

F. Connect steam and condensate piping to supply-, return-, and blowdown-boiler connections with union or flange at each connection. Provide each connection with shutoff valve if shutoff valves are not factory furnished with boiler trim. Provide check valves in blowdown piping of each boiler that connects multiple boilers.

G. Install piping from safety relief valves to nearest floor drain.

H. Install piping from safety valves and drip-pan elbows. Extend piping from safety valves and terminate to vent outdoors. Extend piping from drip-pan elbow drain to nearest floor drain.

I. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

J. Hot equipment drains connected to sanitary drainage system shall be cooled before discharging into the system if required to comply with more stringent of governing code requirements and requirements indicated.

1. Provide a temperature-controlled nonpotable domestic cold water source to cool hot equipment drains to deliver a discharge temperature as directed.

K. Connect chemical-treatment piping to each boiler chemical-treatment connection with check valve and isolation valve.

3.3 FLUE CONNECTIONS

A. Boiler Flue Venting:

1. Install venting kit and combustion-air intake.
2. Connect full size to boiler connections. Comply with requirements in Section 235123 "Gas Vents."

B. Connect breeching to full size of boiler outlet. Comply with requirements in Section 235116 "Fabricated Breechings and Accessories" and Section 235133 "Insulated Sectional Chimneys" for venting materials.

C. Install flue-gas recirculation duct from vent to burner if not factory furnished and installed. Comply with requirements in Section 235116 "Fabricated Breechings and Accessories" for recirculation duct materials.

D. Install easily accessible test ports for field testing of flue gas from each boiler.

3.4 ELECTRICAL POWER CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.5 CONTROLS CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between boilers and other equipment to interlock operation as required, to provide a complete and functioning system.

C. Connect control wiring between boiler control interface and DDC control system for remote monitoring and control of boilers. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC".

3.6 NETWORK AND PHONE CONNECTIONS

A. Connect LAN/WAN network cable to boiler controls to provide connectivity for remote monitoring through integrated boiler control system.

B. Connect phone system cable to boiler controls to provide connectivity for remote monitoring and alarm notification through integrated boiler control system.

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage or Engage a qualified testing agency to perform tests and inspections as directed.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform installation and startup checks according to manufacturer's written instructions.
2. Hydrostatic Leak Test: Repair leaks and retest until no leaks exist.
3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

    a. Burner Test: Adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency.
    b. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and water temperature or steam pressure as directed.
    c. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Boiler will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

F. Performance Tests:

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
2. Boilers shall comply with performance requirements indicated, as determined by field-performance tests. Adjust, modify, or replace equipment in order to comply.
3. Perform field-performance tests to determine the capacity and efficiency of the boilers.

    a. For dual-fuel boilers, perform tests for each fuel.
    b. Test for full capacity.
    c. Test for boiler efficiency at low fire, 10, 20, 30, 40, 50, 60, 70, 80, 90, and high fire (100) percent of full capacity. Determine and document efficiency at each test point.

4. Test each safety valve. Record pressure at valve blowdown and reset. Test valve(s) with boiler operating at full capacity to ensure valve has capacity to prevent further rise in pressure.
5. For boilers equipped with automatic oxygen trim control, conduct tests with automatic oxygen trim control on manual at zero trim and record performance. Repeat tests with automatic oxygen trim control under automatic control and record performance.
6. Repeat tests until results comply with requirements indicated.
7. Provide measurement and analysis equipment required to determine performance.
8. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are inadequate.
9. Notify Architect Owner 20 days in advance of test dates.
10. Document test results in a report and submit with informational submittals.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain boilers.

END OF SECTION 235233

SECTION 235239 - FIRE-TUBE BOILERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes horizontal or vertical, packaged, factory-fabricated and -assembled fire-tube boilers, trim, and accessories for generating hot water as directed.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For boilers, boiler trim, and accessories.

1. Include plans, elevations, sections, and mounting or attachment details as directed.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Design calculations and base details signed and sealed by a qualified professional engineer.

    a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing bases.
    b. Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

4. Include diagrams for power, signal, and control wiring. Differentiate between factory and field installation.
5. Include piping diagrams of factory-furnished piping that indicate size and each piping component.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan and elevation views, drawn to scale, indicating equipment manufacturers' service clearances, structure and base attachment, piping, power, controls, and flues.

B. Seismic Qualification Certificates: For boilers, accessories, and components, from manufacturer.

C. Installation instructions.

D. Source quality-control reports.

E. Field quality-control reports.

F. Sample warranty.

G. Other Informational Submittals:

1. ASME Stamp Certification and Report: Submit "A," "S," or "PP" stamp certificate of authorization, as required by authorities having jurisdiction, and document hydrostatic testing of piping external to boiler.
2. Startup service reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace front- and rear-door refractories and heat exchangers of boilers that fail in materials or workmanship within specified warranty period.

1. Horizontal Fire-Tube Boilers: Refractory in front and rear doors, 10 years from date of startup by factory-authorized personnel.
2. Vertical Fire-Tube Boilers and Heat Exchanger: Five years from date of Substantial Completion, if following water-treatment program recommended by manufacturer.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Fuel-to-water efficiency indicated shall be based on the following:

1. ASME Performance Test Code (PTC) 4, Input-Output or Heat Loss method as directed.
2. Test Operating Conditions:

a. Ambient Temperature: As directed.
b. Ambient Relative Humidity: As directed.
c. Percent Excess Air in Exhaust Flue Gas: 15.
d. Fuel Heating Value: As directed.

B. Gas-Fired Boiler Emissions: Not to exceed allowable ambient air quality standards in governing jurisdiction and indicated values.

1. Carbon monoxide:

a. 50 parts per million at any point from 100 percent to 50 percent fire.
b. 150 parts per million at any point below 50 percent fire.

2. Nitrogen compounds: Parts per million as directed (dry volume basis and corrected to 3 percent oxygen) at any point from 100 percent to low fire.

3. Sulfur compounds: One part per million (dry volume basis and corrected to 3 percent oxygen) at any point from 100 percent to low fire.
4. Hydrocarbon and Volatile Organic Compounds: 10 parts per million (dry volume basis and corrected to 3 percent oxygen) at any point from 100 percent to low fire.
5. Particulate Matter: 0.01 lb/MMBtu.
6. Smoke: Not visible and not to exceed No. 1 on the Bacharach smoke scale.

C. Multiple Boiler Operation: Equip individual boilers in multiple boiler applications with integral controls to provide multiple boiler operation for optimum system performance, energy efficiency, and the following:

1. Equalize runtime of boilers in service.
2. Operate multiple boilers hot to minimize disruption of service in the event of single boiler failure.
3. Configure controls so any boiler can be taken out of service with power disconnected and not impact multiple boiler operation.

D. Seismic Performance: Boiler shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the boiler will remain in place without separation of any parts when subjected to the seismic forces specified and the boiler will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 or 1.0 as directed.

E. Sound: Boiler sound level, measured according to parameters defined in ABMA publication "Boiler 304 Measurement of Sound from Steam Generators" as directed.

F. Operation Following Loss of Normal Power:

1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to back-up power system shall automatically return equipment and associated controls to the operating state occurring immediately before loss of normal power without need for manual intervention by an operator when power is restored either through a back-up power source or through normal power if restored before back-up power is brought online.
2. Refer to Drawings for equipment served by back-up power systems.
3. Provide means and methods required to satisfy requirement even if not explicitly indicated.

G. Outdoor Installations:

1. Boiler shall be suitable for outdoor installation indicated. Provide adequate weather protection to ensure reliable service life over a 25-year period, with minimal degradation due to exposure to outdoor ambient conditions.
2. Boilers equipped to provide safe and stable operation while achieving performance indicated when operating at extreme outdoor temperatures encountered by the installation. Review historical weather database and provide equipment that can operate at extreme outdoor temperatures recorded over past 30-year period. Provide as part of boiler package, products such as combustion-air pre-heaters, and other means and methods required.

H. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

I. ASME Compliance: Fabricate and label boilers to comply with 2010 ASME Boiler and Pressure Vessel Code.

J. ASHRAE/IES 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."

K. ISO 14000 Certification: Boiler manufacturer to provide certification stating that it has self-certified its company to ISO 14000.

L. UL Compliance: Test Boilers for compliance with UL 795. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

2.2 HORIZONTAL FIRE-TUBE BOILERS

A. Pressure Vessel Design: Dry- or waterback design with the following:

1. One, Two, Three or Four passes.
2. Minimum Heat-Exchanger Surface: 5 sq. ft./bhp (2.1 sq. m/10 kW) As required to achieve performance indicated value as directed.
3. Provisions for lifting boiler in-place.

B. Base:

1. Factory-mounted pressure vessel and other boiler components on steel saddles or supports that are fastened securely to a structural steel base that is constructed to make a complete self-supported unit requiring only a flat level surface for support.
2. Base included with attachments if required to secure boiler to structure.
3. Manufacturer's standard provisions for lifting include the following.

    a. Designed for handling and installation conditions encountered.
    b. Sufficient to carry total weight of fully assembled boiler with a safety factor of 1.2.

C. Shell:

1. Horizontal, cylindrical, steel pressure vessel of size to satisfy performance requirements indicated.
2. Manholes and Handholes:

    a. Manhole for waterside inspection and access.
    b. Handholes at front and rear of boiler for waterside inspections.
    c. According to 2010 ASME Boiler and Pressure Vessel Code.

3. Hot-Water Boilers:

    a. Supply- and return-water piping connections.
    b. Connections with safety relief valve(s).
    c. Drain connection(s), each with drain valve, at shell low point.

d. Connections for other trim indicated.
e. Built-in air separator.

D. Furnace:

1. Welded cylindrical steel chamber that is welded to steel tube sheets.
2. Arranged to provide uniform heat distribution under all firing conditions with no flame impingement on any refractory-covered or waterbacked surface.
3. Surrounded by water without interfering with natural circulation of water within shell.
4. Positioned from shell to inhibit unequal thermal stresses during operation.

E. Fire Tubes:

1. Steel, seamless or resistance welded.
2. Fitted in accurately sized holes in tube sheets and rolled or welded in place.
3. Aligned to prevent noticeable deformation with undue stress when boiler is put in service.
4. Tube and tube sheet assembly shall be water- and gastight.
5. Arranged not to interfere with natural circulation of water in shell or to inhibit cleaning and flushing of water sides.
6. Readily removable from one end of boiler.
7. Provided without spinners, turbulators, and other inserted devices.

F. Flue:

1. Flanged connection located along top centerline of boiler and capable of supporting a field-installed flue stack with a weight of at least 2000 lb (8.9 kN).
2. Equip boiler flue with bimetal thermometer in a stainless-steel case, with angle position adjustment and nominal 5-inch (120-mm) diameter face having a graduated scale and range of approximately 1.5 times the outlet temperature. Mount thermometer in a Type 316 stainless-steel thermowell that is located in a visible location to indicate flue-gas temperature.

G. Front and Rear Doors:

1. Bolted, Hinged or davited, sealed with heat-resistant gaskets and fastened with lugs and cap screws.
2. Designed so tube sheets and flues are fully accessible for inspection or cleaning when doors are open without the need to disconnect burner, blower, and fuel piping.
3. Include observation ports in doors at both ends of boiler for inspection of flame conditions.
4. Door refractory or and insulation shall be accessible for inspection and maintenance.
5. Reinforce doors of dryback boilers to limit deflection due to thermal stresses and burner combustion pulsations to prevent progressive cracking and loosening of refractory.

H. Refractories:

1. Refractories retained shall withstand temperature occurring under maximum load conditions.
2. Formed or cast-in sections shall be easily replaceable through factory openings.
3. Secure refractory sections in position to withstand vibration and shock occurring during shipment, and to withstand burner combustion pulsations.

4. Where used for the burner combustion ring and rear or target baffle, refractories shall have a parametric cone equivalent of not less than 33.
5. Provide refractory for doors and end covers exposed to temperatures of 600 deg F (316 deg C) and higher.

I. Insulation:

1. Minimum 2-inch- (50-mm-) thick, mineral-fiber insulation surrounding the boiler shell and secured in place to prevent sagging or displacement.
2. Insulation of sufficient density or attached with reinforcement to prevent permanent deformation of protective jacket when subjected to an impact force as directed and forces associated with service personnel walking, kneeling, and laying on boiler while performing service.
3. Insulating value sufficient to limit exterior surface temperature of pressure vessel jacket, doors, and end covers from exceeding a temperature as directed while operating in an ambient environment with a temperature as directed, surface wind velocity as directed, and boiler operating at full capacity.

J. Jacket: Galvanized sheet or Sheet metal, with factory-applied protective finish as directed.

1. Nominal Thickness: Not less than 0.030 inch (0.8 mm) or 0.048 inch (1.2 mm) as directed.
2. Preformed shape to follow a smooth and uniform contour of pressure vessel and encapsulating insulation.
3. Consisting of multiple removable sections attached with corrosion-resistant screw-fasteners to facilitate removal and replacement multiple times.
4. Painted after assembly.

2.3 VERTICAL FIRE-TUBE BOILERS

A. Description: Factory-fabricated, -assembled, and -tested, vertical fire-tube boilers with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket, flue-gas vent, water-supply and -return connections, and controls.

B. Pressure Vessel Design: Straight, steel pipe welded in a concentric pattern to separate flue-gas and heating media to form two or four passes as directed with welded fins to improve heat transfer in secondary flue-gas passages. Include the following accessories:

1. Handholes for waterside inspections.
2. Lifting lugs on top of boiler.
3. Minimum NPS 1 (DN 25) hose-end drain valves at water passage low point.
4. Tappings or flanges for water-supply and -return piping.
5. Built-in air separator.

C. Combustion Chamber: Equipped with flame retainer to lengthen flame-residence time.

D. Insulation: Minimum 4-inch- (100-mm-) thick, mineral-fiber insulation surrounding the heat exchanger and combustion chamber.

E. Flue: Top connection, constructed of aluminized or stainless steel as directed.

F. Jacket:

1. Mirror-finish stainless steel with screw-fastened closures.
2. Galvanized sheet or Sheet metal as directed, with screw-fastened closures and baked-enamel or powder-coated protective finish.
3. Mounting base to secure boiler to concrete base.

G. Barometric Damper: Galvanized-steel assembly with flue-gas thermometer having a minimum 3-1/2-inch- (89-mm-) diameter dial.

2.4 BURNER

A. Burner designed to fire gas.

B. Welded construction with multivane, stainless-steel, flame-retention diffuser.

C. Mount burner on hinged front access door to permit unrestricted access to combustion chamber.

D. Burner Operation: On/off, Low-high fire or full modulating control to return to low-fire position for ignition.

1. Gas-Fired Burner: Turndown as directed.
2. A lesser turndown shall be considered if published factory performance testing shows no loss in operating performance and no negative impact on service life and maintenance while operating throughout full range of system operating conditions encountered.

E. Burner Fuel Combustion Efficiency: Minimum 99.9 percent.

F. Gas Pilot: Premix type with automatic electric ignition, complete with electronic flame scanner to monitor the pilot, so primary fuel valve cannot open until pilot flame has been established.

G. Manual adjustments not required to operate at varying loads.

H. Performance shall be repeatable after changes in firing rate.

I. Control devices and sequence shall comply with requirements as directed.

J. Damper: Designed to provide accurate control of combustion air with minimum hysteresis. Damper shall close when boiler is off.

2.5 BLOWER

A. Combustion air supplied by a forced-draft blower assembly that is isolated to reduce vibration and noise.

B. Mount blower integral to burner or on hinged front access door to permit unrestricted access to combustion chamber.

C. Centrifugal type, with a forward-curve, backward-inclined airfoil or radial blade wheel.

D. Blower and drive assembly shall be controlled through boiler's integral controls in response boiler manufacturer's prescribed sequence of operation that is coordinated with burner and fuel train to achieve performance indicated.

1. Where indicated or required to achieve performance, provide blower with unit-mounted variable-frequency controller to vary blower speed in response to prescribed control set point and changes in operating conditions.
2. Variable-speed fan operation shall be checked for resonant frequencies and adjusted to provide no resonant frequencies throughout entire operating range.

E. Blower Drive Assembly: Belt or direct drive.

1. Belts: Multiple matching belts that are oil resistant, non-static conducting and sized for a 2.0 service factor.
2. Belt Guards: Easily removable guard that encloses drive.

F. Blower Motor:

1. General Requirements: Comply with requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment" unless more stringent requirements are indicated below:

   a. Efficiency: Premium efficient.
   b. Enclosure: Open dripproof, totally enclosed or totally enclosed, fan cooled.
   c. Insulation Class: F or H as directed.
   d. Service Factor: 1.15.
   e. Motors operated through variable-frequency controllers shall be inverter duty rated according to NEMA MG-1.

2. Motor Sizes: Minimum size as indicated and large enough so driven load does not require motor to operate in service factor.

2.6 GAS TRAIN

A. Comply with Owner insurance underwriter requirements. In absence of specific requirements, comply with more stringent requirements indicated.

B. Pilot gas piping train shall include:

1. One manually operated, lubricated plug cock or ball valve upstream of all valves and accessories.
2. One pressure regulator with vent.
3. Pressure gage located downstream of pressure regulator. Nominal 2-inch (50-mm) or 4-inch (100-mm) diameter face as directed with graduated scale to indicate gas pressure. Gage shall have normal operating pressure of about 50 percent of full range.
4. Primary and secondary automatic valves to operate simultaneously.
5. Normally open, full port electrically operated valve in a vent pipe connected between automatic valves.
6. Manually operated valve with threaded plug located downstream of both automatic gas valves to permit leakage testing.

C. Main gas piping train shall include:

1. Threaded pressure tapping with threaded plug upstream and downstream of valve and regulator.
2. One manually operated, lubricated plug cock, ball valve, or butterfly valve upstream and downstream of all valves and accessories.
3. One main pressure regulator with vent.
4. Primary and secondary automatic valves to operate simultaneously.
5. Manually operated gas valve with threaded plug located downstream of both automatic gas valves to permit leakage testing.
6. Normally open, full port electrically operated valve in a vent pipe connected between automatic valves.
7. Pressure gage with isolation valve located upstream and downstream of pressure regulator and at inlet to burner. Nominal 2-inch (50-mm) diameter face with graduated scale to indicate gas pressure. Gage shall have normal operating pressure of about 50 percent of full range.
8. Proof of closure switch for each motor-operated valve and pressure regulator.
9. Low-gas-pressure and high-gas-pressure switch.

D. Control devices and sequence shall comply with ASME CSD-1, NFPA 85, FM Global, Industrial Risk Insurers (IRI) and or UL requirements.

E. Main gas valves shall be wired to close automatically in the event of power failure or any safety shutdown condition.

F. Mount pilot and main gas trains on side of boiler and support from boiler base.

2.7 FLUE-GAS RECIRCULATION

A. Equip boiler with packaged flue-gas recirculation system if required to satisfy emission requirements.

B. Complete package integrating burner, combustion-air blower and damper, fuel train, and controls. Provide interconnecting external ducting if required by manufacturer's design.

2.8 HOT-WATER BOILER TRIM

A. Include devices sized to comply with ASME B31.1 or ASME B31.9.

B. Water Temperature Controllers: Operating, firing rate, and high limit.

C. Safety Relief Valve: ASME rated.

D. Pressure and Temperature Gage: Minimum 3-1/2-inch- (89-mm-) diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges, so normal operating range is about 50 percent of full range.

E. Boiler Air Vent: Automatic or Manual as directed.

F. Drain Valve: Minimum NPS 3/4 (DN 20) hose-end valve with threaded cap and chain.

2.9 CONTROLS

A. Boiler operating controls shall include the following devices and features:

1. Control transformer(s) with fuse protection, as required by manufacturer, to implement requirements indicated. Provide transformer with 25 percent spare capacity.
2. Set-Point Adjust: Operating and alarm set points shall be field adjustable.

B. Operating Controls for Hot-Water Boilers:

1. Sequence of Operation: Electric, factory-fabricated and field-installed panel to control burner firing rate to reset supply-water temperature inversely with outdoor-air temperature. At 0 deg F (minus 17 deg C) outdoor-air temperature, set supply-water temperature at 200 deg F (93 deg C); at 60 deg F (15 deg C) outdoor-air temperature, set supply-water temperature at 140 deg F (60 deg C).
2. Sequence of Operation: Indicated on Drawings.
3. Sequence of Operation:

C. Multiple Boiler Operation: Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.

D. Boiler Emergency Shutdown: Interlock with field-installed boiler emergency shutdown switch to shut down boiler when activated. Manufacturer to furnish break-glass-type switch with permanent nameplate titled "Boiler Emergency Shutdown" for field installation.

E. Burner Safety Controls for Hot-Water Boilers: To maintain safe operating conditions, burner safety controls limit burner operation.

1. High Cutoff: Automatic and Manual reset stops burner if operating conditions rise above boiler design temperature.
2. Low-Water Cutoff Switch: Electronic probe shall prevent burner operation on low water. Cutoff switch shall be manual or automatic-reset type as directed.
3. Auxiliary Low-Water Cutoff Switch: Electronic probe shall prevent burner operation on low-water alarm limit. Cutoff switch shall be manual-reset type.
4. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.

F. Burner Flame Safeguard Controls:

1. Factory equipped with flame safeguard control and infrared flame scanner.
2. Microprocessor-based, solid-state control having sequence and flame-on visual indication and fault code indications of flame safeguard trip functions.
3. Control shall include dynamic self-check logic.
4. Control shall have a fixed operating sequence incapable of being manually altered that includes start, prepurge, pilot and main fuel ignition run, and postpurge cycles.
5. Control shall be nonrecycle type for maximum safety that shall shut down the burner and indicate, as a minimum, the following trip functions:

a. Pilot and main flame failure.
b. High- and low-fire proving switch faults.

c. Running interlocks open.
d. False flame signal and fuel valve open.

6. Control shall include a run/test switch to allow interruptions to sequence just after prepurge and during pilot ignition trial, and run cycles for adjustments to firing rate motor, damper linkages, and pilot flame for minimum turndown tests.

G. Combustion-Air Controls: Factory equipped with motor-operated combustion-air damper and blower control to regulate burner fire according to load demand.

H. Oxygen Trim Control:

1. Provide oxygen trim system to continuously monitor and display oxygen concentrations in boiler flue gas and adjust fuel and airflow to maintain an adjustable oxygen-level set point.
2. System shall compensate for changes in ambient temperature, barometric pressure, humidity, and variations in fuel characteristics.

I. Building Automation or DDC System Interface as directed: Factory install hardware and software to enable system to monitor, control, and display boiler status and alarms.

1. Hardwired I/O Points:

a. Monitoring: On/off status, common trouble alarm or low-water-level alarm as directed.
b. Control: On/off operation, hot-water-supply temperature set-point adjustment.

2. Communication Interface: Communication interface shall enable control system operator to remotely control on/off and capacity of boiler and monitor the boiler operation from an operator workstation as directed. Control features are available, and monitoring points are displayed locally at boiler-control panel through the interface.

J. Integrated Boiler-Control System:

1. Integral control of burner management for flame safety, boiler modulation, and operator interface functions with features and functions indicated.
2. Factory preconfigured.
3. Utilizing solid-state controls and sensors to provide various control functions, including the following:

a. Automatic sequencing of the boiler through standby, prepurge, pilot flame establishing period, main flame establishing period, run, flame proving and lockout, and postpurge.
b. Full modulating control of air and fuel through Proportional-Integral-Derivative (PID) algorithm.
c. Thermal shock protection.
d. High and low limit alarms and shutdowns.

4. Local operator interface through nominal 10-inch (250-mm) color touch screen graphical display for setup, monitoring, and data acquisition.

a. Manual control of the boiler firing rate using control screens to increment or decrement firing rate.
b. Indication of burner management controller status and diagnostics.
c. Display of system alarms and faults.
d. Display of history of alarms and faults.
e. Display of recommendations for troubleshooting of fault conditions.
f. Display of water-level indication and alarm(s).
g. Stack flue-gas, combustion-air, and shell water-temperature indication.
h. Boiler efficiency calculation and display.
i. Low-fire hold with minimum temperature control.
j. Assured low-fire cutoff (ALFCO).
k. High stack temperature annunciation with auto cutoff.
l. Audible alarm and silencing through touch screen intervention.

5. Fully integrated control of the following:

a. Blower operation and combustion-air damper for varying operating conditions.
b. Oxygen trim and monitoring to compensate for combustion-air variations.
c. Parallel positioning for independent fuel and air control for enhanced fuel efficiency.
d. Multiple boiler lead/lag control with hot standby.
e. Draft control for maintaining proper and consistent draft for enhanced fuel efficiency.

6. E-mail and paging feature to multiple contacts via Internet and phone line independent of control system interface.
7. LAN/WAN interface with remote monitoring software to allow remote monitoring independent of control system interface.

K. Control Enclosures:

1. NEMA 250, Type As directed.

a. Provide enclosure with integral vents, fans, heater, and air conditioner as required to automatically control temperature inside enclosure within safe operating limits of devices installed within the enclosure.

2. Wiring shall be numbered and color-coded to match wiring diagram. Provide a laminated wiring diagram located inside enclosure.
3. Mounted on boiler assembly at a location convenient to operator.
4. Provide hinged full-size door with key lock. Provide common key for all locks.
5. Enclosure shall consist of multiple sections divided by a partition with a separate hinged door for each section. One section shall house low-voltage controls and other section shall house line voltage controls.
6. Enclosure shall house the following:

a. Control transformers with fuses.
b. Labeled terminal strips.
c. Controller(s) to provide control and alarm functions indicated.
d. Audible indication of safety alarms.

7. Face of enclosure shall provide the following:

    a. Visual indication of operating components and alarms.
    b. Auto/local capability to allow operator to manually operate boiler locally.
    c. Audible alarm-silence capability.
    d. Labels for switches, lights, and displays to provide clear indication of service.

L. Control Instrument Enclosures: Control instruments and devices that are mounted on the boiler assembly and cannot be installed inside the control enclosure shall have same or higher level of protection indicated for control enclosures.

M. Control Cable and Wire:

1. Control cable and wiring shall be numbered and color-coded to match wiring diagram.
2. Install cable and wiring located outside of enclosure(s) in a metal raceway. Use flexible conduit to make final terminations. Provide watertight installation for applications exposed to moisture.

2.10 ELECTRICAL POWER

A. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.

1. Enclosure: NEMA 250, Type as directed.

    a. Enclosure shall have integral vents, fans, heat, and air conditioner as required to automatically control temperature inside enclosure within safe operating limits of devices installed within the enclosure.
    b. Mounted on boiler assembly at a location convenient to operator.
    c. Enclosure shall have hinged full-size door with key lock with common key for all locks.

2. Wiring shall be numbered and color-coded to match wiring diagram. Provide a laminated wiring diagram located inside enclosure.
3. Install wiring outside of an enclosure in a metal. Make final connections to motors using flexible conduit. Provide watertight installation for applications exposed to moisture.
4. Field power interface as directed. Withstanding rating of disconnecting means shall protect equipment. Coordinate requirements with field electrical power source.
5. Provide branch power circuit to each motor and to controls with a disconnect switch or circuit breaker.
6. Provide each motor with NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection. Provide variable-frequency controller with manual bypass and line reactors for each variable-speed motor indicated.
7. Provide transformer with fuses and power wiring to power a 20-A 120-V duplex receptacle mounted in each boiler control panel for use in connecting analytical and testing equipment.

2.11 FINISH

A. General:

1. Paint boiler, using manufacturer's standard procedures, except comply with requirements indicated.
2. Miscellaneous surfaces shall be finished to match continuous surfaces.
3. Manufacturer shall field touch up or entirely repaint surface finishes, which were damaged during shipment, to original condition, using original materials and methods.
4. Paint shall be suitable for temperatures encountered on painted surfaces.
5. Requirements indicate minimum quality level. Provide more robust paint system if required to comply with other requirements indicated.

B. Preparation:

1. Follow paint manufacturer's published preparation and application instructions.
2. When paint manufacturer's recommended preparation requirements differ from those specified, use more stringent requirements.
3. Structural steel with visible corrosion shall be sandblasted according to SSPC SP-6 or SSPC SP-10 before applying primer and paint.
4. Before application of a primer and a top coat, remove oil and grease from surfaces to be coated using clean rags soaked in thinner according to SSPC SP-1.
5. Treat galvanized-steel surfaces that cannot be procured with a phosphatized finish with a phosphate rinse to ensure proper paint adhesion.

C. Primer:

1. Rust-inhibiting type with a minimum dry film thickness of 2 mils (0.05 mm).
2. Provide multiple passes if required to prevent runs.
3. Select a primer that is compatible with substrate and finish coat.

D. Finish Coat:

1. Finish coat as directed.
2. Use dry film thickness recommended by paint manufacturer, but not less than 2 mils (0.05 mm). Provide multiple passes if required to prevent runs.

E. Paint the following surfaces with both a primer and finish coat:

1. Base and miscellaneous supports that are not hot dip galvanized.
2. Carbon steel that is not galvanized.
3. Exterior surfaces of unit exposed to view.
4. Piping and trim.

F. Do not paint aluminum or stainless steel.

2.12 CAPACITIES AND CHARACTERISTICS

A. Heating Medium: Hot water.

B. Design Pressure Rating: As directed.

C. Safety Relief Valve Setting: As directed.

D. Entering-Water Temperature: As directed.

E. Leaving-Water Temperature: As directed.

F. Design Water-Flow Rate: As directed.

G. Design Pressure Drop: As directed.

H. Fuel-to-Water Efficiency: Percent as directed.

I. Number of Passes: As directed.

J. Gas Input: As directed.

K. Gas Input Flow: As directed.

L. Gas Pressure: As directed.

M. Output Capacity: As directed.

N. Burner Blower:

1. Motor Horsepower: As directed.

O. Electrical Characteristics:

1. Volts: As directed.
2. Phase: Single or Three as directed.
3. Hertz: 50 or 60 Hz as directed.
4. Full-Load Amperes: As directed.
5. Minimum Circuit Ampacity: As directed.
6. Maximum Overcurrent Protection: As directed.

P. Sound (decibels, A weighted): As directed.

2.13 SOURCE QUALITY CONTROL

A. Test and inspect factory-assembled boilers, before shipping, according to 2010 ASME Boiler and Pressure Vessel Code.

B. Burner and Hydrostatic Test:

1. Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve performance requirements indicated.
2. Perform hydrostatic test of pressure vessel, piping, and trim of assembled boiler.

C. Witness Testing:

1. Allow Owner access to witness source quality-control testing of boilers.
2. Notify Architect or Owner 15 days in advance of testing as directed.

PART 3 - EXECUTION

3.1 BOILER INSTALLATION

A. Coordinate size and location of bases. Cast anchor-bolt inserts into concrete bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

B. Equipment Mounting:

1. Install boilers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." Or Section 033053 "Miscellaneous Cast-in-Place Concrete." As directed
2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

C. Install gas-fired boilers according to NFPA 54.

D. Assemble and install boiler trim, components, and accessories that are not factory installed.

E. Install control and electrical devices furnished with boiler that are not factory mounted.

F. Install control and power wiring to field-mounted control and electrical devices furnished with boiler that are not factory installed.

G. Perform boil-out and cleaning procedures according to manufacturer's written instructions after completion of hydrostatic testing and before performing other field tests. Boiler manufacturer's factory-authorized representative shall witness boil-out and cleaning procedures. Following boil-out and cleaning procedures, boiler shall be washed and flushed until water leaving boiler is clear.

H. Protect boiler fireside and waterside from corrosion.

1. Before boiler is filled with water, protect by dry storage method recommended by boiler manufacturer.
2. After boiler is filled with water, and left not fired for more than 10 days, protect by wet storage method recommended by boiler manufacturer.
3. Chemical Treatment: Quality of water in boilers shall be maintained by a professional water-treatment organization that shall provide on-site supervision to maintain the required water quality during periods of boiler storage as well as during operating, standby, and test conditions. Refer as directed for additional requirements.

3.2 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to boiler(s), allow space for service and maintenance.

C. Connect gas piping to boiler gas-train inlet with dirt leg, shutoff valve, and union or flange. Piping shall be at least full size of gas-train connection. Provide a reducer if required.

D. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.

E. Install piping from safety relief valves to nearest floor drain.

F. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

G. Hot equipment drains connected to sanitary drainage system shall be cooled before discharging into the system if required to comply with more stringent of governing code requirements and requirements indicated.

1. Provide a temperature-controlled nonpotable domestic cold water source to cool hot equipment drains to deliver a discharge temperature as directed.

3.3 FLUE CONNECTIONS

A. Connect breeching to full size of boiler outlet. Comply with requirements in Section 235116 "Fabricated Breechings and Accessories" and Section 235133 "Insulated Sectional Chimneys" for venting materials.

B. Install flue-gas recirculation duct from vent to burner if not factory furnished and installed. Comply with requirements in Section 235116 "Fabricated Breechings and Accessories" for recirculation duct materials.

C. Install easily accessible test ports for field testing of flue gas from each boiler.

3.4 ELECTRICAL POWER CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.5 CONTROLS CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between boilers and other equipment to interlock operation as required, to provide a complete and functioning system.

C. Connect control wiring between boiler control interface and DDC control system for remote monitoring and control of boilers. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."

3.6 NETWORK AND PHONE CONNECTIONS

A. Connect LAN/WAN network cable to boiler controls to provide connectivity for remote monitoring through integrated boiler control system.

B. Connect phone system cable to boiler controls to provide connectivity for remote monitoring and alarm notification through integrated boiler control system.

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage or Engage a qualified testing agency as directed to perform tests and inspections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform installation and startup checks according to manufacturer's written instructions.
2. Hydrostatic Leak Test: Repair leaks and retest until no leaks exist.
3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

    a. Burner Test: Adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency.
    b. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and water temperature.
    c. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Boiler will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

F. Performance Tests:

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.

2. Boilers shall comply with performance requirements indicated, as determined by field-performance tests. Adjust, modify, or replace equipment in order to comply.
3. Perform field-performance tests to determine the capacity and efficiency of boilers.

    a. For dual-fuel boilers, perform tests for each fuel.
    b. Test for full capacity.
    c. Test for boiler efficiency at low fire, 10, 20, 30, 40, 50, 60, 70, 80, 90, and high fire (100) percent of full capacity. Determine and document efficiency at each test point.

4. Test each safety valve. Record pressure at valve blowdown and reset. Test valve(s) with boiler operating at full capacity to ensure valve has capacity to prevent further rise in pressure.
5. For boilers equipped with automatic oxygen trim control, conduct tests with automatic oxygen trim control on manual at zero trim and record performance. Repeat tests with automatic oxygen trim control under automatic control and record performance.
6. Repeat tests until results comply with requirements indicated.
7. Provide measurement and analysis equipment required to determine performance.
8. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are inadequate.
9. Notify Architect or Owner 20 days in advance of test dates as directed.
10. Document test results in a report and submit with informational submittals.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain boilers as directed.

END OF SECTION 235239

SECTION 235313 - BOILER FEEDWATER PUMPSGENERAL

1.1 SUMMARY

A. Section includes packaged, factory-assembled, boiler feedwater pumps.

1.2 DEFINITIONS

A. NPSHR: Net-positive suction head required.

1.3 ACTION SUBMITTALS

A. Product Data: For each unit.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting or attachment details as directed.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring. Differentiate between factory and field installation.
4. Include piping diagrams of factory-furnished piping that indicate size and each piping component.

C. Delegated-Design Submittal: For boiler feedwater pumps.

1. Include design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
2. Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan and elevation views, drawn to scale, indicating equipment manufacturer's service clearances, structure and base attachment, piping, power, and controls.

B. Seismic Qualification Data: For feedwater equipment, accessories, and components, from manufacturer.

C. Source quality-control reports.

D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design equipment bases, vibration isolation, and seismic restraints for boiler feedwater pumps.

B. Seismic Performance: Boiler feedwater pumps shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the boiler feedwater pumps will remain in place without separation of any parts when subjected to the seismic forces specified and the boiler feedwater pumps will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 or 1.0.

C. ASME Compliance:

1. Fabricate and label unit receivers of boiler feedwater pumps according to ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.
2. Factory-installed piping that connects pumps to receivers shall comply with ASME B31.1, "Power Piping or ASME B31.9, "Building Services Piping as directed
3. Safety valves and pressure vessels shall bear the appropriate ASME label.

D. Operation Following Loss of Normal Power:

1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to backup power system shall automatically return equipment and associated controls to the state in which equipment was operating immediately before loss of normal power. This shall be accomplished without need for manual intervention by an operator when power is restored either through a backup power source or through normal power if restored before backup power is brought on-line.
2. See Drawings for equipment served by backup power systems.
3. Provide means and methods required to satisfy requirement even if not explicitly indicated.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 FEEDWATER UNITS

A. Description: Factory-assembled and -tested unit consisting of a receiver, feedwater pumps, controls, and the following features and accessories:

1. Liquid-filled industrial or Bimetal dial-type thermometer graduated in Fahrenheit and Celsius.
2. Level gage glass, reflex flat type, with stops at top and bottom.
3. Lifting eyes.
4. Companion flanges.
5. Pump, suction and discharge isolation valve, inlet strainer, discharge check valve, and liquid-filled pressure gage.
6. Makeup Water Assembly: Float operated with integral valve or Electric level controller and valve as directed; with inlet strainer and three-valve bypass.
7. Feedwater Heater: Sparge tube, thermostat, and control valve.
8. Factory-Installed Pipe, NPS 2-1/2 (DN 65) and Smaller: ASTM A53/A53M, Type S (seamless), Grade B; or ASTM A106/A106M, Type S, Grade B, Schedule 40 or Schedule 80 as directed, with threaded joints and fittings.

    a. Cast-Iron Threaded Fittings: ASME B16.4; Class 125 or 250 as directed.
    b. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150 or 300 as directed.
    c. Forged-Steel Fittings: ASME B16.11, Class 3000.
    d. Malleable-Iron Unions: ASME B16.39; Class 150 or 300 as directed.
    e. Forged-Steel Unions: MSS SP-83, Class 3000.

9. Factory-Installed Pipe, NPS 3 (DN 80) and Larger: ASTM A53/A53M, Type E (electric-resistance welded), Grade B; or ASTM A106/A106M, Type S, Grade B, Schedule 40 or 80 as directed; with welded joints and carbon-steel fittings and flanges.

    a. Wrought-Steel Fittings: ASME B16.9, wall thickness to match adjoining pipe.
    b. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, Class 150 or 300 as directed, including bolts, nuts, and gaskets.

10. Pump-discharge bypass with relief valve or orifice plate sized to provide continuous pump operation with boiler feedwater valve closed.
11. Threaded connection and provision for chemical injection quill.
12. Sample cooler.

B. Receiver:

1. Material: As directed
2. Additional corrosion protection: Thickness allowance as directed.
3. Finish: As directed.
4. Factory-Applied Insulation and Jacket: Minimum thickness of 2 inches (50 mm) for mineral-fiber pipe and tank insulation. Cover insulation with jacket as directed.
5. Mounting Arrangement: Recessed below floor or Floor mounted as directed.
6. Mounting Frame: Structural-steel stand to support receiver and pumps. Fabricate stand with bracing adequate for seismic forces, according to authorities having jurisdiction, and to allow anchoring mounting frame to floor.
7. Drain connection with valve.

C. Vertical Feedwater Pump: Flange-mounted, close-coupled, single-stage, multistage, radially split-case-design centrifugal pump; rated for 175-psig (1205-kPa) minimum working pressure and a continuous water temperature of at least 225 deg F (107 deg C); with the following features:

1. Impeller: Bronze or Stainless steel as directed.
2. Seals: Mechanical.
3. Motor: Enclosure as directed. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

D. Horizontal Feedwater Pump: Base-mounted, single-stage, multistage, radially split-case-design centrifugal pump; rated for 175-psig (1205-kPa) minimum working pressure and a continuous water temperature of at least 225 deg F (107 deg C); with the following features:

1. Impeller: Bronze or Stainless steel as directed.
2. Coupling: Close or Flexible as directed.
3. Seals: Mechanical.
4. Motor: Enclosure as directed. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

E. Control panel shall be unit mounted and factory wired and shall include the following:

1. NEMA 250, Enclosure as directed.
2. Single-point field power interface as directed. Withstanding rating of disconnecting means shall protect equipment. Coordinate requirements with field electrical power source.

    a. Branch power circuit to each motor and to controls with a disconnect switch or circuit breaker.

3. NEMA-rated motor controller for each motor, and include a hand-off-auto switch and overcurrent protection.

    a. Alternating controls for multiple-pump units with intermittent operation as indicated by control sequence.
    b. Provide variable-frequency controller with manual bypass and line reactors for each variable-speed motor.

4. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
5. Wiring outside of an enclosure in a metal raceway. Make connections to motor with liquid tight conduit.
6. Removable control mounting plate.
7. Visual indication of status and alarm with momentary test push button.
8. Audible alarm and silence switch.
9. Visual indication of elapsed run time graduated in hours.
10. Fused control-circuit transformer.

F. Feedwater Single-Pump Control Sequence:

1. Boiler water-level controller starts and stops pump to maintain boiler water-level set point.
2. Visual indication of pump on and off status.
3. Visual and audible alarm indication of pump failure.

G. Receiver Makeup Water Control Sequence:

1. Electric level controller operates electric control valve to maintain receiver water-level set point.
2. Mechanical float operates integral valve to maintain water-level set point.
3. Visual and audible alarm indication of low and high receiver-water level.

H. Control System Interface: Factory install hardware to enable remote monitoring.

1. Hardwired Monitoring Points: On/off status for each pump, failure alarm for each pump , receiver low-water-level alarm , receiver high-water-level alarm, feedwater temperature.

I. Capacities and Characteristics:

1. Condensate Receiver:

a. Volume: As directed.
b. Diameter: As directed.
c. Length: As directed.
d. Height to Condensate Inlet: As directed.
e. Condensate Return Minimum Inlet Size: As directed.
f. Makeup Water Minimum Inlet Size: As directed.
g. Sparge-Tube Steam Supply: As directed.

2. Feedwater Pumps:

a. No. of Pumps: Simplex or Duplex As directed.
b. Flow Rate: As directed.
c. NPSHR: As directed.
d. Rated Operating Temperature: As directed.
e. Head Pressure: As directed.
f. Horsepower: As directed
g. Speed: As directed

3. Unit Single-Point Power Electrical Characteristics:

a. Volts: 208 or 460 As directeda
b. Phase: Three.
c. Hertz: 60.
d. Full-Load Amperes: As directed.
e. Minimum Circuit Ampacity: As directed.
f. Maximum Overcurrent Protection: As directed.

2.3 SOURCE QUALITY CONTROL

A. Factory Tests: Test performance and submit test results on packaged boiler feedwater pump units, according to ASME PTC 12.1, before shipping to Project.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Coordinate size and location of bases. Cast anchor-bolt inserts into concrete bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

B. Equipment Mounting:

1. Install feedwater units on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete or Section 033053 "Miscellaneous Cast-in-Place Concrete As directed
2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

C. Install unit to permit access for maintenance.

D. Support piping independent of equipment.

E. Install parts and accessories shipped loose.

F. Install control and electrical devices furnished with units that are not factory mounted.

G. Install control and power wiring to field-mounted control and electrical devices furnished with units that are not factory installed.

H. Protect units from corrosion.

1. Before filling with water, protect by dry storage method recommended by manufacturer.
2. After filled with water, protect by wet storage method recommended by manufacturer.

I. Chemical Treatment: Quality of water in units shall be maintained by a professional water treatment organization that shall provide on-site supervision to maintain the required water quality during periods of storage, operating, standby, and test conditions. Comply with requirements in Section 232500 "HVAC Water Treatment or Section 232519 "Water Treatment for Steam System Feedwater for additional requirements as directed.

3.2 PIPING CONNECTIONS

A. Comply with requirements for piping specified in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to boiler feedwater pumps, allow space for service and maintenance.

C. Connect makeup water piping and cooling-water piping with reduced-pressure backflow preventers.

D. Install overflow drain piping to nearest floor drain.

E. Install piping from unit drain connections and extend to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation if required.

F. Install vents and extend to outdoors; terminate with elbow turned down and an insect screen.

G. Hot equipment drains connected to sanitary drainage system shall be cooled before discharging into the system if required to comply with more stringent of governing code requirements and requirements indicated.

1. Provide a temperature-controlled, non-potable, domestic cold water source to cool hot equipment drains to deliver a discharge temperature as directed.

H. Connect chemical treatment piping to each boiler feedwater pump unit chemical treatment connection with check valve and isolation valve.

3.3 ELECTRICAL POWER CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.4 CONTROLS CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between boiler feedwater pump units and other equipment to interlock operation as required to provide a complete and functioning system.

C. Connect control wiring between boiler feedwater pump unit control interface and control system to provide remote monitoring.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage or Engage a qualified testing agency to perform tests and inspections as directed.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Inspect field-assembled components, equipment installation, and piping and electrical connections for compliance with manufacturer's written instructions.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Check bearing lubrication.
4. Verify proper motor rotation.

5. Startup service.
6. Report results in writing.

C. Boiler feedwater pump will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust boiler water-level controls to properly stage unit.

B. Set field-adjustable controls.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain boiler feedwater units as directed.

END OF SECTION 235313

SECTION 235316 - DEAERATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes packaged, factory-assembled deaerators.

1.2 DEFINITIONS

A. DDC: Direct digital control.

B. Feedwater Pump: Pump that moves feedwater from the deaerator to the boiler.

C. NPSHR: Net-positive suction head required.

D. Transfer Pump: Pump that moves feedwater from the surge tank to the deaerator.

1.3 ACTION SUBMITTALS

A. Product Data: For each unit.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring. Differentiate between factory and field installation.
4. Include piping diagrams of factory-furnished piping that indicate size and each piping component.

C. Delegated-Design Submittal: For deaerators, signed and sealed by a qualified professional engineer.

1. Include design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
2. Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan and elevation views, drawn to scale as directed, indicating equipment manufacturer's service clearances, structure and base attachment, piping, power, and controls. Each view to show screened background with the following:

B. Seismic Qualification Certificates: For deaerators, accessories, and components, from manufacturer.

C. Source quality-control reports.

D. Field quality-control reports.

E. Startup service reports.

F. ASME Stamp Certification and Report: Submit "A," "S," or "PP" stamp certificate of authorization, as required by authorities having jurisdiction, and document hydrostatic testing of piping external to deaerator.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Deaerator shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the deaerator will remain in place without separation of any parts when subjected to the seismic forces specified and the deaerator will be fully operational after the seismic event.
2. Component Importance Factor: 1.5 or 1.0 as directed.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. ASME Compliance: Fabricate and label deaerators and components to comply with ASME Boiler and Pressure Vessel Code.

2.3 MANUFACTURED UNITS

A. Horizontal or Vertical as directed, tray, single-compartment deaerator and separate surge tank, both mounted on same factory-fabricated stand with necessary transfer and feedwater pumps and controls.

B. Material for Wetted Components: Components in contact with water that has not been deaerated shall be made of Type 304 stainless steel.

C. Vent Condenser: Stainless steel, with automatic and manual vent valves.

D. Deaerator and Storage Tank:

1. Material: As directed.
2. Additional Corrosion Protection:

    a. Thickness allowance as directed.
    b. Electrolytic corrosion-inhibitor anode.

3. Access: Manhole in deaerator and storage tank for access to internal components for inspection and service.

    a. Manhole cover shall be davited or hinged.

4. Factory-Applied Insulation and Jacket:

    a. Minimum thickness of 2 inches (50 mm) for mineral-fiber pipe and tank insulation.
    b. Cover insulation with preformed and removable sections of painted steel, stucco-embossed aluminum or stainless-steel jacket to uniformly follow the contour of the tank. Jacket nominal thickness is not less than 0.030 inch (0.8 mm) or 0.048 inch (1.2 mm) as directed.

5. Factory-Installed Pipe, NPS 2-1/2 (DN 65) and Smaller: ASTM A53/A53M, Type S (seamless), Grade B; or ASTM A106/A106M, Type S, Grade B, Schedule 40 or 80 as directed; with threaded joints and fittings.

    a. Cast-Iron Threaded Fittings: ASME B16.4, Class 125 or 250 as directed.
    b. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150 or 300 as directed.
    c. Forged-Steel Fittings: ASME B16.11, Class 3000.
    d. Malleable-Iron Unions: ASME B16.39, Class 150 or 300 as directed.
    e. Forged-Steel Unions: MSS SP-83, Class 3000.

6. Factory-Installed Pipe, NPS 3 (DN 80) and Larger: ASTM A53/A53M, Type E (electric-resistance welded), Grade B; or ASTM A106/A106M, Type S, Grade B, Schedule 40 or 80 as directed; with welded joints and carbon-steel fittings and flanges.

    a. Wrought-Steel Fittings: ASME B16.9, wall thickness to match adjoining pipe.
    b. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, Class 150 or 300 as directed, including bolts, nuts, and gaskets.

E. Accessories:

1. Lifting eyes.
2. Companion flanges.
3. Pump suction piping with vortex breaker, isolation valve, strainer, and flexible connector.
4. Pump discharge piping with check valve, isolation valve, and liquid-filled pressure gage graduated as directed.
5. Pump-discharge bypass sized to provide continuous pump operation with boiler feedwater valve closed.
6. Makeup Water Assembly:

a. Factory-mounted modulating valve with mechanical level control, external float cage, and stainless-steel float.
b. Factory or Field-mounted as directed, three-valve bypass and inlet strainer.

7. Steam Pressure-Reducing Valve(s): Operated with three-valve bypass as directed, and sized to reduce boiler outlet pressure to the deaerator design pressure.
8. Tank Overflow Drain: Sized to relieve full capacity at operating pressure.
9. Tank Overflow Drainer: Float-type trap, sized to relieve full capacity at operating pressure, with steel housing and stainless-steel float ball.
10. Safety Valve(s): ASME labeled and sized to relieve full capacity of pressure-reducing valve. Provide each safety valve with a drip-pan elbow. For units installed outdoors, provide each safety valve vent with an exhaust head.
11. Vents: Manual and automatic vent valves.

    a. Automatic air vents shall be thermostatically controlled to provide a fast means of venting when a sudden buildup of gas occurs.
    b. Manual air vents shall have an orifice to provide continuous venting at a rate of up to 0.1 percent of rated deaerator capacity at operating pressure indicated.
    c. For units installed outdoors, provide each vent with a drip-pan elbow and exhaust head.

12. High-temperature condensate diffuser tube.
13. Vacuum breaker.
14. Meters and Gages:

    a. Full-height, water-level gage glass, reflex flat type, with gage rods to protect glass and stop valve set, ball check and shutoff cocks, water-column blowdown valves, and vacuum breaker.
    b. Thermometer:

        1) Liquid-filled industrial or Bimetal dial-type thermometer graduated as directed mounted to measure temperature in storage and steam section of tank.
        2) Graduated scale with a range of approximately 1.5 times the normal operating temperature.
        3) Any angle position adjustment.
        4) Stainless-steel case with nominal 5-inch- (125-mm-) diameter face.
        5) Mount thermometer in a Type 316 stainless-steel thermowell.

    c. Pressure Gage:

        1) Pressure gage graduated as directed mounted to measure pressure in steam section of tank and pressure at feedwater discharge manifold pipe.
        2) Nominal 4-inch- (100-mm-) diameter face with graduated scale and siphon with isolation valve. Gage shall have normal operating pressure about 50 percent of full range and an accuracy of 0.5 or 1 percent as directed.

    d. Flow meter mounted in feedwater discharge manifold pipe and positioned to measure and display flow supplied by deaerator to boilers. Accuracy within 2 of actual reading when measured across design to minimum flow range.

e. Meters and gages shall be easily readable by operator standing at grade adjacent to unit. Provide remote reading gages if required to comply with requirement.

15. Provision for chemical injection quill.
16. Sample Cooler: Factory installed or furnished for field installation, with needle valve for each connection. Constructed of Type 316 stainless steel.
17. Tank drain connection with valve.
18. Oxygen test kit.

F. Support Frame: Structural-steel frame for supporting tank and pumps. Weld or bolt to tank.

1. Fabricate support frame with bracing adequate for seismic forces according to authorities having jurisdiction and to allow installation by anchoring deaerators to floor only.
2. Minimum height of frame shall be as required by application, but not less than as directed.

G. Feedwater Pump: Cast-iron, flange or base-mounted volute; with impeller as directed, renewable bronze case ring, and stainless-steel shaft.

1. Seals: Mechanical, suitable for 250 deg F (121 deg C).
2. Pump Motor: Coupled to pump as directed. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment" unless more stringent requirements are indicated below:

a. Efficiency: Premium efficient.
b. Enclosure: Open dripproof, totally enclosed or totally enclosed fan cooled.
c. Insulation Class: F or H as directed.
d. Service Factor: 1.15.
e. Motors operated through variable-frequency controllers shall be inverter duty rated per NEMA MG-1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."

3. Motor Sizes: Minimum size as indicated and large enough so driven load does not require motor to operate in service factor.

2.4 SURGE TANK ASSEMBLY

A. Description: Factory-assembled and -tested unit consisting of a condensate receiver, transfer pumps, and controls.

B. Accessories:

1. Thermometer:

a. Liquid-filled industrial or Bimetal dial-type thermometer as directed graduated in Fahrenheit, Celsius or both Fahrenheit and Celsius as directed.
b. Graduated scale with a range of approximately 1.5 times the normal operating temperature.
c. Any angle position adjustment.

d. Stainless-steel case with nominal 5-inch- (125-mm-) diameter face.
e. Mount thermometer in a Type 316 stainless-steel thermowell.

2. Full-height, water-level gage glass, reflex flat type, with gage rods to protect glass and stop valve set, ball check and shutoff cocks, water-column blowdown valves, and vacuum breaker.
3. Lifting eyes.
4. Companion flanges.
5. Pump suction piping with vortex breaker, isolation valve, strainer, and flexible connector.
6. Pump discharge piping with check valve, isolation valve, and liquid-filled pressure gage graduated as directed. Gage with nominal 4-inch- (100-mm-) diameter face, isolation valve, normal operating pressure about 50 percent of full range, and an accuracy of 0.5 or 1 percent as directed.
7. Gages shall be easily readable by operator standing at grade adjacent to unit. Provide remote reading gages if required to comply with requirement.
8. Pump-discharge bypass sized as directed to provide continuous pump operation.

C. Factory-Installed Pipe, NPS 2-1/2 (DN 65) and Smaller: ASTM A53/A53M, Type S (seamless), Grade B; or ASTM A106/A106M, Type S, Grade B, Schedule 40 or 80; with threaded joints and fittings as directed.

1. Cast-Iron Threaded Fittings: ASME B16.4, Class 125 or 250 as directed.
2. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150 as directed 300.
3. Forged-Steel Fittings: ASME B16.11, Class 3000.
4. Malleable-Iron Unions: ASME B16.39, Class 150 as 300.
5. Forged-Steel Unions: MSS SP-83, Class 3000.

D. Factory-Installed Pipe, NPS 3 (DN 80) and Larger: ASTM A53/A53M, Type E (electric-resistance welded), Grade B; or ASTM A106/A106M, Type S, Grade B, Schedule 40 or 80 as directed; with welded joints and carbon-steel fittings and flanges.

1. Wrought-Steel Fittings: ASME B16.9, wall thickness to match adjoining pipe.
2. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, Class 150 or 300 as directed, including bolts, nuts, and gaskets.

E. Tank:

1. Material: As directed.
2. Additional Corrosion Protection:

a. Thickness allowance as directed.
b. Electrolytic corrosion-inhibitor anode.

3. Access: Manhole in tank for access to internal components for inspection and service.

a. Manhole cover shall be davited or hinged.

4. Factory-Applied Insulation and Jacket:

a. Minimum thickness of 2 inches (50 mm) for mineral-fiber pipe and tank insulation.

b. Cover insulation with preformed and removable sections of jacket as directed to uniformly follow the contour of the tank. Jacket nominal thickness is not less than 0.030 inch (0.8 mm) or 0.048 inch (1.2 mm) as directed.

F. Support Frame: Structural-steel frame for supporting tank. Weld or bolt to tank.

1. Fabricate support frame with bracing adequate for seismic forces according to authorities having jurisdiction and to allow installation by anchoring deaerators to floor only.
2. Minimum height of frame shall be as required by application, but not less than as directed.

G. Transfer Pump: Vertical, flange-mounted, close-coupled, single-stage or multistage as directed, radially split-case centrifugal pump; rated for 175-psig (1205-kPa) minimum working pressure and a continuous water temperature of 225 deg F (107 deg C); with the following features:

1. Impeller: Bronze or Stainless steel as directed.
2. Seals: Mechanical.

H. Transfer Pump Motor: Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment" unless more stringent requirements are indicated below:

1. Efficiency: Premium efficient.
2. Enclosure: Open dripproof, totally enclosed or totally enclosed fan cooled.
3. Insulation Class: F or H as directed.
4. Service Factor: 1.15.
5. Motors operated through variable-frequency controllers shall be inverter duty rated per NEMA MG-1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
6. Motor Sizes: Minimum size as indicated and large enough so driven load does not require motor to operate in service factor.

2.5 CONTROLS

A. Factory-installed and -wired controllers, meters, sensors, switches, transformers, transmitters, valves, and other control devices necessary to provide a complete and functioning unit to operate as indicated and connect to field control interfaces indicated.

B. Operating controls shall include the following devices and features:

1. Control transformer(s) with fuse protection, as required by manufacturer, to implement requirements indicated. Provide transformer with 25 percent spare capacity.
2. Set-Point Adjust: Operating and alarm set points shall be field adjustable.

C. Control Enclosures:

1. NEMA 250, Type as directed.

a. Provide enclosure with integral vents, fans, heat, and air conditioner as required to automatically control temperature inside enclosure within safe operating limits of devices installed within the enclosure.

2. Wiring shall be numbered and color-coded to match wiring diagram. Provide a laminated wiring diagram located inside enclosure.
3. Mounted on deaerator assembly at a location convenient to operator.
4. Provide hinged full-size door with key lock. Provide common key for all locks.
5. Enclosure shall consist of multiple sections divided by a partition with a separate hinged door for each section. One section shall house low-voltage controls; other section shall house line voltage controls.
6. Enclosure shall house the following:

    a. Control transformers with fuses.
    b. Labeled terminal strips.
    c. Controller(s) or Microprocessor-based controller(s) as directed to provide control and alarm functions indicated.
    d. Audible indication of safety alarms.
    e. Dry Contacts:

        1) For interface with chemical feed pump controls.

7. Face of enclosure shall provide the following:

    a. Visual indication of operating components and alarms with momentary test push button.
    b. Visual indication of elapsed run time graduated in hours.
    c. Auto/local capability to allow operator to manual operate unit locally.
    d. Audible alarm silence capability.
    e. Labels for switches, lights, and displays to provide clear indication of service.

D. Control Instrument Enclosures: Control instruments and devices that are mounted on the deaerator assembly and cannot be installed inside the control enclosure shall have same or higher level of protection indicated for control enclosures.

E. Control Cable and Wire:

1. Control cable and wiring shall be numbered and color-coded to match wiring diagram.
2. Install cable and wiring located outside of enclosure(s) in a metal raceway.
3. Use flexible conduit to make final terminations.
4. Provide watertight installation for applications exposed to moisture.

F. Feedwater Pump Start-Stop Control Sequence:

1. Boiler water-level controller starts and stops lead pump to maintain boiler water-level set point.
2. Lead and lag pumps alternate after each start or to equalize run time as directed.
3. Lead pump failure automatically starts lag pump if lead pump cannot maintain set point or manually starts lag pump as directed.
4. Visual indication of pump on and off status.
5. Visual indication of pump starts.
6. Visual indication of pump run time.
7. Visual indication of pump lead/lag status.
8. Visual and audible alarm indication of pump failure.

G. Makeup Water Control Sequence:

1. Electric level controller operates electric control valve to maintain tank water-level set point.
2. Pneumatic level controller operates pneumatic control valve to maintain tank water-level set point.
3. Mechanical float operates valve to maintain water-level set point.
4. Visual and audible alarm indication of low and high tank water level.
5. Low-water level stops pumps.
6. Visual indication of makeup water flow rate.

H. Transfer Pump Start-Stop Control Sequence: Deaerator water-level controller controls lead pump; alternator switches lead and lag pump(s) after each start or to equalize run time as directed; failure of lead pump switches to lag pump and sounds audible alarm.

2.6 ELECTRICAL POWER

A. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to unit.

1. Enclosure: NEMA 250, Type as directed.

    a. Enclosure shall have integral vents, fans, heat, and air conditioner as required to automatically control temperature inside enclosure within safe operating limits of devices installed within the enclosure.
    b. Mounted on deaerator assembly at a location convenient to operator.
    c. Enclosure shall have hinged full-size door with key lock with common key for all locks.

2. Wiring shall be numbered and color-coded to match wiring diagram. Provide a laminated wiring diagram located inside enclosure.
3. Install wiring outside of an enclosure in a metal raceway. Make final connections to motors using flexible conduit. Provide watertight installation for applications exposed to moisture.
4. Field power interface shall be as directed. Withstanding rating of disconnecting means shall protect equipment. Coordinate requirements with field electrical power source.
5. Provide branch power circuit to each motor and to controls with a disconnect switch or circuit breaker.
6. Provide each motor with NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection. Provide variable-frequency controller with manual bypass and line reactors for each variable-speed motor indicated.

    a. Alternating control as indicated by control sequence for each pump.

7. Provide transformer with fuses and power wiring to power a 20-A, 120-V duplex receptacle mounted in each control panel for use in connecting analytical and testing equipment.

2.7 FACTORY FINISHES

A. Manufacturer's standard paint in standard colors, applied to factory-assembled and -tested unit before shipping.

B. Do not paint aluminum, galvanized-steel, and stainless-steel surfaces.

2.8 CAPACITIES AND CHARACTERISTICS

A. Nominal Capacity: As directed.

B. Design Feedwater Flow Rate: As directed.

C. Steam Flow Rate: As directed.

D. Steam Condensate Flow Rate: As directed.

E. Steam Condensate Temperature: As directed.

F. Makeup Water Flow Rate: As directed.

G. Makeup Water Temperature: As directed.

H. Capacity: Capable of raising temperature of condensate and makeup water to within 3 deg F (2 deg C) of saturated steam temperature.

I. Minimum Working Pressure: 50 psig (345 kPa).

J. Operating Pressure Range: Atmospheric or from 2 to 15 psig (14 to 104 kPa).

K. Resultant Oxygen Content: Not more than 0.03 or 0.005 cc/L as directed through an operating range between zero, 3 or 5 as directed and 100 percent of full load.

L. Storage Tank:

1. Tank Capacity to Overflow: As directed.
2. Storage Time: 10.

M. Feedwater Pumps:

1. No. of Pumps: Duplex.
2. Design Flow Rate: As directed.
3. Minimum Flow Rate: As directed.
4. NPSHR: As directed.
5. Rated Operating Temperature: As directed.
6. Head Pressure: As directed.
7. Close-off Pressure: As directed.
8. Horsepower: As directed.
9. Speed: As directed.

N. Surge Tank:

1. Tank Capacity to Overflow: As directed.
2. Storage Time: Minutes as directed.

O. Transfer Pumps:

1. No. of Pumps: Duplex.
2. Design Flow Rate: As directed.
3. Minimum Flow Rate: As directed.
4. NPSHR: As directed.
5. Rated Operating Temperature: As directed.
6. Head Pressure: As directed.
7. Close-off Pressure: As directed.
8. Horsepower: As directed.
9. Speed: As directed.

P. Deaerator Assembly Single-Point Power Electrical Characteristics:

1. Volts: As directed.
2. Phase: Three.
3. Hertz: 60.
4. Full-Load Amperes: As directed.
5. Minimum Circuit Ampacity: As directed.
6. Maximum Overcurrent Protection: As directed.

2.9 SOURCE QUALITY CONTROL

A. Fabricate and label deaerator tanks according to ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

B. Factory install and test piping that connects pumps to tanks according to ASME B31.1, Power Piping or ASME B31.9, "Building Services Piping as directed.

C. Factory Tests: Test performance and submit test results on packaged deaerator units, according to ASME PTC 12.3, before shipping to Project.

D. Witness Testing:

1. Allow Owner access to witness source quality-control testing.
2. Notify Architect or Owner 15 days in advance of testing.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Coordinate size and location of bases. Cast anchor-bolt inserts into concrete bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

B. Equipment Mounting:

1. Install deaerators on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed
2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

C. Install deaerators to permit access for service and maintenance.

D. Where installing piping adjacent to machine, allow space for service and maintenance.

E. Support piping independent of equipment.

F. Install base-mounted pumps on concrete base with grouted base frame.

G. Install all parts and materials not factory installed.

H. Assemble and install deaerators trim, components, and accessories that are not factory installed.

I. Install control and electrical devices furnished with deaerators that are not factory mounted.

J. Install control and power wiring to field-mounted control and electrical devices furnished with deaerators that are not factory installed.

K. Perform cleaning procedures according to manufacturer's written instructions after completion of hydrostatic testing and before performing other field tests. Following cleaning procedures, deaerator shall be washed and flushed until water leaving deaerator is clear.

L. Protect deaerators from corrosion.

1. Before filling with water, protect by dry storage method recommended by manufacturer.
2. After filled with water, protect by wet storage method recommended by manufacturer.

M. Chemical Treatment: Quality of water in deaerators shall be maintained by a professional water treatment organization that shall provide on-site supervision to maintain the required water quality during periods of storage, operating, standby, and test conditions. See applicable water treatment Section as directed, for additional requirements.

3.2 PIPING CONNECTIONS

A. Steam and condensate piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect steam and condensate piping to tank tappings with shutoff valves and unions or flanges at each connection.

C. Connect condensate drains, pump-discharge piping, vents, overflow drains, makeup water, steam supply, and cooling water piping.

1. Extend overflow drains to floor or sanitary drains.
2. Extend vent piping to outside and terminate with manufacturer-approved cap furnished with deaerator.
3. Install piping from safety valves and drip-pan elbows. Extend piping from safety valves and terminate to vent outdoors. Extend piping from drip-pan elbow drain to nearest floor or sanitary drain.
4. Install piping from equipment drain connection to nearest floor or sanitary drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

D. Hot equipment drains connected to sanitary drainage system shall be cooled before discharging into the system if required to comply with more stringent of governing code requirements and requirements indicated.

1. Provide a temperature-controlled, non-potable, domestic cold water source to cool hot equipment drains to deliver a discharge temperature as directed.

E. Connect chemical treatment piping to each deaerator chemical treatment connection with check valve and isolation valve.

F. Where installing piping adjacent to deaerators, allow space for service and maintenance.

3.3 ELECTRICAL POWER CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.4 CONTROLS CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between deaerators and other equipment to interlock operation as required to provide a complete and functioning system.

C. Connect control wiring between deaerator control interface and DDC system for remote monitoring and control of deaerators. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC".

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Inspect field-assembled components and equipment installation, including piping and electrical connections, for compliance with requirements.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3. Verify bearing lubrication.
4. Verify proper motor rotation.
5. Test Reports: Prepare a written report to record the following:

    a. Test procedures used.
    b. Test results that comply with requirements.
    c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

B. Deaerator will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Set makeup water-level controls.
3. Set operating controls.
4. Verify safety controls.
5. Verify lubrication.
6. Verify proper motor rotation.
7. Start pumps according to manufacturer's written instructions.

B. Report: Prepare a written report to record the following:

1. Procedures used.
2. Initial findings.
3. Final results.
4. Corrective action taken to achieve compliance with requirements indicated.
5. Date of testing.
6. Name and contact information for person performing testing.

3.7 ADJUSTING AND CLEANING

A. Adjust initial temperature and pressure set points.

B. Set field-adjustable switches and circuit-breaker trip ranges.

C. Clean strainers.

3.8 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain deaerators.

B. Video training sessions, and provide electronic copy of video to Owner.

END OF SECTION 235316

SECTION 235413 - ELECTRIC-RESISTANCE FURNACES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Electric furnaces and accessories complete with controls.
2. Air filters.
3. Humidifiers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings:

1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace the following components of furnaces that fail in materials or workmanship within specified warranty period:

1. Warranty Period, Commencing on Date of Substantial Completion:

a. Furnace Heat Exchanger: As directed.
b. Integrated Ignition and Blower Control Circuit Board: Five years.
c. Draft-Inducer Motor: Five years.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 ASSEMBLY DESCRIPTION

A. Factory assembled, piped, wired, and tested.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a qualified testing agency, and marked for intended location and application.

2.3 FURNACES

A. Cabinet: Steel, with duct liner downstream from cooling coil.

1. Duct Liner: Fiberglass, minimum 1/2 inch (13 mm) or 3/4 inch (19 mm) thick as directed, complying with ASTM C1071 and having a coated surface exposed to airstream complying with NFPA 90A or NFPA 90B and with NAIMA's "Fibrous Glass Duct Liner Standard."

    a. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

2. Factory paint external cabinets in manufacturer's standard color.

B. Fan: Centrifugal, factory balanced, resilient mounted, direct drive.

1. Fan Motors: Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Special Motor Features: Single speed, premium efficiency, as defined in Section 230513 "Common Motor Requirements for HVAC Equipment," and with internal thermal protection and permanent lubrication.
3. Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.
4. Special Motor Features: Electronically controlled motor (ECM) controlled by integrated furnace/blower control.

C. Electric-Resistant Heating Elements: Helix-wound, nickel-chromium wire-heating elements in ceramic insulators mounted on steel supports.

D. Heating-Element Control: Sequencer relay with relay for each element; switches elements on and off, with delay between each increment; initiates, stops, or changes fan speed.

E. Summer Fan Switch: Connected to permit independent on-off switch of unit fan.

F. Capacities and Characteristics:

1. Airflow Configuration: As directed.
2. Electric Heating Element:

a. Capacity: As directed.
b. Number of Steps: As directed.
c. Volts: As directed.
d. Phase: As directed.
e. Hertz: As directed.
f. Full-Load Amperes: As directed.
g. Minimum Circuit Ampacity: As directed.
h. Maximum Overcurrent Protection: As directed.

3. Fan:

a. Airflow: As directed.
b. External Static Pressure: As directed.
c. Motor:

1) Size: As directed.
2) Speed: As directed.

d. Volts: As directed.
e. Phase: As directed.
f. Hertz: As directed.
g. Full-Load Amperes: As directed.
h. Minimum Circuit Ampacity: As directed.
i. Maximum Overcurrent Protection: As directed.

4. Furnace Electrical Connection:

a. Volts: As directed.
b. Phase: As directed.
c. Hertz: As directed.
d. Full-Load Amperes: As directed.
e. Minimum Circuit Ampacity: As directed.
f. Maximum Overcurrent Protection: As directed.

2.4 THERMOSTATS AND HUMIDISTATS

A. Controls shall comply with requirements in ASHRAE/IES 90.1, "Controls."

B. Solid-State Thermostat: Programmable, microprocessor-based unit as directed with automatic or manual switching as directed from heating to cooling, preferential rate control, seven-day programmability with minimum of four temperature presets per day, vacation mode, and battery backup protection against power failure for program settings.

C. Single-Stage, Heating-Cooling Thermostat: Adjustable, heating-cooling, wall-mounted unit with fan on-automatic selector.

D. Two-Stage, Heating-Cooling Thermostat: Adjustable, heating-cooling, wall-mounted unit with fan on-automatic selector.

E. Single or Two-Stage, Heating-Only Thermostat as directed: Wall-mounted unit with fan on-automatic selector.

F. Solid-State, Combination Thermostat and Humidistat: Wall-mounted, Freestanding or Wireless as directed, programmable, microprocessor-based unit with automatic switching from heating to cooling and humidifying to dehumidifying, preferential rate control, seven-day programmability with minimum of four temperature presets per day, vacation mode, and battery backup protection against power failure for program settings.

G. Humidistat: Adjustable, wall or duct-mounted unit.

H. Control Wiring: Balanced twisted-pair cabling complying with requirements for Category 5e in Section 260523 "Control Voltage Cables for Electrical Equipment" or complying with requirements for Category 5e in Section 271513 "Communications Copper Horizontal Cabling" as directed.

I. Control Wiring: Balanced twisted pair cabling.
   1. Description: As directed, No. 24 AWG, 100 ohm, four pair.
   2. Cable Jacket Color: Blue.

2.5 AIR FILTERS

A. Washable Filters: 1-inch- (25-mm-) thick urethane pad.

B. Disposable Filters: 1-inch- (25-mm-) thick fiberglass media with ASHRAE 52.2 MERV rating of 6 or higher, in sheet metal frame.

C. Charged Media Air Filters: Sheet metal housing arranged to be ducted in return-air duct connection to furnace; generates electrostatic charge; MERV 10 rating.

D. HEPA Air-Filter Units: Sheet metal housing with fan arranged to be ducted to return-air duct connection to furnace, with activated carbon prefilter, carbon VOC, and high-efficiency particulate air (HEPA) disposable filter. HEPA shall be as follows:

   1. Standard: UL 586.
   2. Rating: ASHRAE 52.2, 99.97 percent efficiency to 0.30-micrometer particle size.

2.6 HUMIDIFIERS

A. Minimum capacity rating indicated according to AHRI 610.

B. Media-wheel bypass type with bypass damper and motor-driven media wheel in reservoir with float-valve level control; arranged for mounting on return duct or plenum with bypass connection to supply duct.

C. Wetted-pad, continuous-drain, bypass type with bypass damper and water-flow control orifice; arranged for mounting on return duct or plenum with bypass connection to supply duct.

D. Fan-powered, wetted-pad, continuous-drain type with water-flow control orifice and motor; arranged for mounting on duct or plenum.

E. Pumped, fan-powered, wetted-pad type with reservoir-level control and pump and fan motors; arranged for mounting on duct or plenum.

F. Comply with applicable requirements in ASHRAE 62.1.

G. Capacities and Characteristics:

1. Type: As directed.
2. Water Connection Size: As directed.
3. Drain Connection Size: As directed.
4. Volts: As directed.
5. Phase: As directed.
6. Hertz: As directed.
7. Minimum Circuit Ampacity: As directed.
8. Maximum Overcurrent Protection: As directed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Suspended Units: Suspend from structure using threaded rods, spring hangers, and building attachments. Secure rods to unit hanger attachments. Adjust hangers so unit is level and plumb.

B. Base-Mounted Units: Secure units to substrate. Provide optional bottom closure base if required by installation conditions.

C. Controls: Install thermostats and humidistats at mounting height of 60 inches (1500 mm) above floor.

D. Wiring Method: Install control wiring in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal control wiring except in unfinished spaces.

3.2 CONNECTIONS

A. Install piping adjacent to equipment to allow service and maintenance.

B. Water piping installation requirements are specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties. Connect water piping with union and ball valve.

C. Connect ducts to furnace with flexible connector. Comply with requirements in Section 233300 "Air Duct Accessories."

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Perform electrical test and visual and mechanical inspection.
2. Leak Test: After installation, charge systems with refrigerant and oil and test for leaks. Repair leaks replace lost refrigerant and oil, and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation, product capability, and compliance with requirements.
4. Verify that fan wheel is rotating in the correct direction and is not vibrating or binding.
5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.

END OF SECTION 235413

SECTION 235416.13 - GAS-FIRED FURNACES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Gas-fired, noncondensing or condensing furnaces and accessories complete with controls as directed.
2. Air filters.
3. Humidifiers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

C. Shop Drawings:

1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.4 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace the following components of furnaces that fail in materials or workmanship within specified warranty period:

1. Warranty Period, Commencing on Date of Substantial Completion:

a. Furnace Heat Exchanger: As directed.
b. Integrated Ignition and Blower Control Circuit Board: Five years.
c. Draft-Inducer Motor: Five years.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a qualified testing agency, and marked for intended location and application.

B. General Requirements for Noncondensing Gas-Fired Furnaces: Factory assembled, piped, wired, and tested; complying with ANSI Z21.47/CSA 2.3 and NFPA 54.

2.2 GAS-FIRED FURNACES, NONCONDENSING

A. Cabinet: Steel or Galvanized steel as directed.

1. Cabinet interior around heat exchanger shall be factory-installed insulation.
2. Lift-out panels shall expose burners and all other items requiring access for maintenance.
3. Factory paint external cabinets in manufacturer's standard color.
4. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. Fan: Centrifugal, factory balanced, resilient mounted, as directed.

1. Fan Motors: Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Special Motor Features: Single speed, premium efficiency, as defined in Section 230513 "Common Motor Requirements for HVAC Equipment," and with internal thermal protection and permanent lubrication.
3. Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.
4. Special Motor Features: Electronically controlled motor (ECM) controlled by integrated furnace/blower control.

C. Type of Gas: Natural or Propane as directed.

D. Heat Exchanger: Aluminized or Stainless steel as directed.

E. Burner:

1. Gas Valve: 100 percent safety two-stage or modulating main gas valve as directed, main shutoff valve, pressure regulator, safety pilot with electronic flame sensor, limit control, transformer, and combination ignition/fan timer control board.
2. Ignition: Electric pilot ignition, with hot-surface igniter or electric spark ignition.

F. Gas-Burner Safety Controls:

1. Electronic Flame Sensor: Prevents gas valve from opening until pilot flame is proven; stops gas flow on ignition failure.
2. Flame Rollout Switch: Installed on burner box; prevents burner operation.
3. Limit Control: Fixed stop at maximum permissible setting; de-energizes burner on excessive bonnet temperature; automatic reset.

G. Combustion-Air Inducer: Centrifugal fan with thermally protected motor and sleeve bearings prepurges heat exchanger and vents combustion products; pressure switch prevents furnace operation if combustion-air inlet or flue outlet is blocked.

H. Furnace Controls: Solid-state board integrates ignition, heat, cooling, and fan speeds; and adjustable fan-on and fan-off timing; terminals for connection to accessories.

I. Vent Materials: Comply with requirements in Section 235123 "Gas Vents" for Type B metal vents.

J. Capacities and Characteristics:

1. Airflow Configuration: As directed.
2. Gas:

    a. Type: Natural or Propane as directed.
    b. Venting Type: Power venter or with combustion-air intake as directed.
    c. Minimum Efficiency AFUE: Percent As directed.
    d. Minimum Thermal Efficiency: Percent As directed.
    e. Minimum Combustion Efficiency: Percent As directed.
    f. Input: As directed.
    g. Heat Output: As directed.
    h. Gas Connection Size: As directed.
    i. Draft-Inducer Motor:

        1) Size: As directed.
        2) Speed: As directed.

    j. Combustion-Air Inlet Size: As directed.
    k. Combustion-Air Inlet Material: As directed.
    l. Heat-Exchanger Condensate Drain Size: As directed.
    m. Vent Size: As directed.

3. Fan:

    a. Airflow: As directed.
    b. External Static Pressure: As directed.
    c. Motor:

        1) Size: As directed.
        2) Speed: As directed.

    d. Volts: As directed.
    e. Phase: As directed.
    f. Hertz: As directed.
    g. Full-Load Amperes: As directed.
    h. Minimum Circuit Ampacity: As directed.
    i. Maximum Overcurrent Protection: As directed.

4. Furnace Electrical Connection:

a. Volts: As directed.
b. Phase: As directed.
c. Hertz: As directed.
d. Full-Load Amperes: As directed.
e. Minimum Circuit Ampacity: As directed.
f. Maximum Overcurrent Protection: As directed.

2.3 GAS-FIRED FURNACES, CONDENSING

A. Cabinet: Steel or Galvanized steel as directed.

1. Cabinet interior around heat exchanger shall be factory-installed insulation.
2. Lift-out panels shall expose burners and all other items requiring access for maintenance.
3. Factory paint external cabinets in manufacturer's standard color.
4. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. Fan: Centrifugal, factory balanced, resilient mounted, direct drive.

1. Fan Motors: Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Special Motor Features: Single speed, premium efficiency, as defined in Section 230513 "Common Motor Requirements for HVAC Equipment," and with internal thermal protection and permanent lubrication.
3. Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.
4. Special Motor Features: Electronically controlled motor (ECM) controlled by integrated furnace/blower control.

C. Type of Gas: Natural or Propane as directed.

D. Heat Exchanger:

1. Primary: Aluminized or Stainless steel as directed.
2. Secondary: Polyethylene-coated or Stainless steel as directed.

E. Burner:

1. Gas Valve: 100 percent safety two-stage or modulating main gas valve, main shutoff valve, pressure regulator, safety pilot with electronic flame sensor, limit control, transformer, and combination ignition/fan timer control board as directed.
2. Ignition: Electric pilot ignition, with hot-surface igniter or electric spark ignition.

F. Gas-Burner Safety Controls:

1. Electronic Flame Sensor: Prevents gas valve from opening until pilot flame is proven; stops gas flow on ignition failure.
2. Flame Rollout Switch: Installed on burner box; prevents burner operation.
3. Limit Control: Fixed stop at maximum permissible setting; de-energizes burner on excessive bonnet temperature; automatic reset.

G. Combustion-Air Inducer: Centrifugal fan with thermally protected motor and sleeve bearings prepurges heat exchanger and vents combustion products; pressure switch prevents furnace operation if combustion-air inlet or flue outlet is blocked.

H. Furnace Controls: Solid-state board integrates ignition, heat, cooling, and fan speeds; adjustable fan-on and fan-off timing; terminals for connection to accessories; diagnostic light with viewport.

I. Accessories:

1. Combination Combustion-Air Intake and Vent: PVC plastic fitting to combine combustion-air inlet and vent through outside wall or roof as directed.
2. CPVC Plastic Vent Materials:

    a. CPVC Plastic Pipe: Schedule 40, complying with ASTM F441/F441M.
    b. CPVC Plastic Fittings: Schedule 40, complying with ASTM F438, socket type.
    c. CPVC Solvent Cement: ASTM F493.

3. PVC Plastic Vent Materials:

    a. PVC Plastic Pipe: Schedule 40, complying with ASTM D1785.
    b. PVC Plastic Fittings: Schedule 40, complying with ASTM D2466, socket type.
    c. PVC Solvent Cement: ASTM D2564.

J. Capacities and Characteristics:

1. Airflow Configuration: As directed.
2. Gas:

    a. Type: Natural or Propane as directed.
    b. Venting Type: Power venter or Power venter with combustion-air intake as directed.
    c. Minimum Efficiency AFUE: Percent As directed.
    d. Minimum Thermal Efficiency: Percent As directed.
    e. Minimum Combustion Efficiency: Percent As directed.
    f. Input: As directed.
    g. Heat Output: As directed.
    h. Gas Connection Size: As directed.
    i. Draft-Inducer Motor:

        1) Size: As directed.
        2) Speed: As directed.

    j. Combustion-Air Inlet Size: As directed.
    k. Combustion-Air Inlet Material: CPVC or PVC As directed.
    l. Heat-Exchanger Condensate Drain Size: As directed.
    m. Vent Size: As directed.
    n. Vent Material: CPVC or PVC as directed.

3. Fan:

a. Airflow: As directed.
b. External Static Pressure: As directed.
c. Motor:

1) Size: As directed.
2) Speed: As directed.

d. Volts: As directed.
e. Phase: As directed.
f. Hertz: As directed.
g. Full-Load Amperes: As directed.
h. Minimum Circuit Ampacity: As directed.
i. Maximum Overcurrent Protection: As directed.

4. Furnace Electrical Connection:

a. Volts: As directed.
b. Phase: As directed.
c. Hertz: As directed.
d. Full-Load Amperes: As directed.
e. Minimum Circuit Ampacity: As directed.
f. Maximum Overcurrent Protection: As directed.

2.4 THERMOSTATS AND HUMIDISTATS

A. Controls shall comply with requirements in ASHRAE/IES 90.1, "Controls."

B. Solid-State Thermostat: As directed Wall-mounted, Freestanding or Wireless, programmable, microprocessor-based unit with automatic or manual switching from heating to cooling, preferential rate control, seven-day programmability with minimum of four temperature presets per day, vacation mode, and battery backup protection against power failure for program settings.

C. Single-Stage, Heating-Cooling Thermostat: Adjustable, heating-cooling, wall-mounted unit with fan on-automatic selector.

D. Two-Stage, Heating-Cooling Thermostat: Adjustable, heating-cooling, wall-mounted unit with fan on-automatic selector.

E. Single or Two-Stage, Heating-Only Thermostat As directed: Wall-mounted unit with fan on-automatic selector.

F. Solid-State, Combination Thermostat and Humidistat: As directed Wall-mounted, Freestanding or Wireless, programmable, microprocessor-based unit with automatic switching from heating to cooling and humidifying to dehumidifying, preferential rate control, seven-day programmability with minimum of four temperature presets per day, vacation mode, and battery backup protection against power failure for program settings.

G. Humidistat: Adjustable, wall or duct-mounted unit As directed.

H. Control Wiring: Balanced twisted-pair cabling complying with requirements for Category 5e in Section 260523 "Control-Voltage Electrical Power Cables or Section 271513 Communications Copper Horizontal Cabling as directed.
   1. Description: As directed, No. 24 AWG, 100 ohm, four pair.
   2. Cable Jacket Color: Blue.

2.5 AIR FILTERS

A. Washable Filters: 1-inch- (25-mm-) thick urethane pad.

B. Disposable Filters: 1-inch- (25-mm-) thick fiberglass media with ASHRAE 52.2 MERV rating of 6 or higher, in sheet metal frame.

C. Charged Media Air Filters: Sheet metal housing arranged to be ducted in return-air duct connection to furnace; generates electrostatic charge; MERV 10 rating.

D. HEPA Air Filter Units: Sheet metal housing with fan arranged to be ducted to return-air duct connection to furnace, with activated carbon prefilter, carbon VOC, and high-efficiency particulate air (HEPA) disposable filter. HEPA shall be as follows:

   1. Standard: UL 586.
   2. Rating: ASHRAE 52.2, 99.97 percent efficiency to 0.30-micrometer particle size.

2.6 HUMIDIFIERS

A. Minimum capacity rating indicated according to AHRI 610.

B. Media-wheel bypass type with bypass damper and motor-driven media wheel in reservoir with float-valve level control; arranged for mounting on return duct or plenum with bypass connection to supply duct.

C. Wetted-pad, continuous-drain, bypass type with bypass damper and water-flow control orifice; arranged for mounting on return duct or plenum with bypass connection to supply duct.

D. Fan-powered, wetted-pad, continuous-drain type with water-flow control orifice and motor; arranged for mounting on duct or plenum.

E. Pumped, fan-powered, wetted-pad type with reservoir-level control and pump and fan motors; arranged for mounting on duct or plenum.

F. Comply with applicable requirements in ASHRAE 62.1.

G. Capacities and Characteristics:

   1. Type: As directed.
   2. Water Connection Size: As directed.
   3. Drain Connection Size: As directed.
   4. Volts: As directed.
   5. Phase: As directed.
   6. Hertz: As directed.

7. Minimum Circuit Ampacity: As directed.
8. Maximum Overcurrent Protection: As directed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install gas-fired furnaces and associated fuel and vent features and systems according to NFPA 54.

B. Suspended Units: Suspend from structure using threaded rods, spring hangers, and building attachments. Secure rods to unit hanger attachments. Adjust hangers so unit is level and plumb.

C. Base-Mounted Units: Secure units to substrate. Provide optional bottom closure base if required by installation conditions.

D. Controls: Install thermostats and humidistats at mounting height of 60 inches (1500 mm) above floor.

E. Wiring Method: Install control wiring in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal control wiring except in unfinished spaces.

3.2 CONNECTIONS

A. Gas piping installation requirements are specified in Section 231123 "Facility Natural-Gas Piping" or Section 231126 "Facility Liquefied-Petroleum Gas Piping" as directed. Drawings indicate general arrangement of piping, fittings, and specialties. Connect gas piping with union or flange and appliance connector valve.

B. Install piping adjacent to equipment to allow service and maintenance.

C. Water piping installation requirements are specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties. Connect water piping with union and ball valve.

D. Vent Connection, Noncondensing, Gas-Fired Furnaces: Connect Type B vents to furnace vent connection and extend outdoors. Type B vents and their installation requirements are specified in Section 235123 "Gas Vents."

E. Vent and Outside-Air Connection, Condensing, Gas-Fired Furnaces: Connect plastic piping vent material to furnace connections and extend outdoors. Terminate vent outdoors with a cap and in an arrangement that will protect against entry of birds, insects, and dirt.

1. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
2. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
3. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

a. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements.
b. CPVC Piping: Join according to ASTM D2846/D2846M, Appendix.

c. PVC Pressure Piping: Join schedule number ASTM D1785 PVC pipe and PVC socket fittings according to ASTM D2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D2855.

4. Slope pipe vent back to furnace or to outside terminal.

F. Connect ducts to furnace with flexible connector. Comply with requirements in Section 233300 "Air Duct Accessories."

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Perform electrical test and visual and mechanical inspection.
2. Leak Test: After installation, charge systems with refrigerant and test for leaks. Repair leaks, replace lost refrigerant, and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation, product capability, and compliance with requirements.
4. Verify that fan wheel is rotating in the correct direction and is not vibrating or binding.
5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.

END OF SECTION 235416.13

SECTION 235416.16 - OIL-FIRED FURNACES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Oil-fired furnaces and accessories complete with controls.
2. Air filters.
3. Humidifiers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings:

1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.4 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace the following components of furnaces that fail in materials or workmanship within specified warranty period:

1. Warranty Period, Commencing on Date of Substantial Completion:

a. Furnace Heat Exchanger: As directed.
b. Integrated Ignition and Blower Control Circuit Board: Five years.
c. Draft-Inducer Motor: Five years.
d. High-Efficiency Oil Furnace Burner: Three years.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 ASSEMBLY DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a qualified testing agency, and marked for intended location and application.

B. Manufactured Units: Factory assembled, piped, wired, and tested; complying with UL 727 and with NFPA 31.

2.3 FURNACES

A. Cabinet: Steel or Galvanized steel as directed.

1. Cabinet interior around heat exchanger shall be factory-installed insulation.
2. Lift-out panels shall expose burners and all other items requiring access for maintenance.
3. Factory paint external cabinets in manufacturer's standard color.
4. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. Fan: Centrifugal, factory balanced, resilient mounted, as directed.

1. Fan Motors: Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Special Motor Features: Single speed, premium efficiency, as defined in Section 230513 "Common Motor Requirements for HVAC Equipment," and with internal thermal protection and permanent lubrication.
3. Special Motor Features: Multi-tapped, multispeed with internal thermal protection and permanent lubrication.

C. Heat Exchanger: Welded steel with ceramic-fiber liner or refractory insert at the burner in the combustion chamber as directed. Minimum 2-inch- (50-mm-) diameter access ports in heat exchanger to permit access for cleaning.

D. Burner: High-pressure atomizing type, with rubber-mounted, adjustable, combustion-air blower; integrated fuel pump; hinged, flame-inspection port; cadmium-sulfide flame sensor; electrodes; ignition transformer; and oil nozzle.

1. Time-Delay Relay: Limits time for establishing main flame.
2. Flame Sensor: Monitors flame and stops burner on flame failure.
3. Limit Control: Fixed stop at maximum permissible setting; de-energizes burner on excessive bonnet temperature; automatic reset.

E. Barometric Draft Regulator: Match furnace; for mounting in flue.

F. Furnace Controls: Solid-state board integrates ignition, heat, cooling, and fan speeds; and adjustable fan-on and fan-off timing; terminals for connection to accessories.

G. Vent Materials: Comply with requirements in Section 235123 "Gas Vents" for Type B metal vents.

H. Capacities and Characteristics:

1. Airflow Configuration: As directed.
2. Minimum Efficiency AFUE: Percent As directed.
3. Minimum Thermal Efficiency: Percent As directed.
4. Oil:

a. Input: As directed.
b. Heat Output: As directed.
c. Burner Motor:

1) Size: As directed.
2) Speed: As directed.

d. Vent Size: As directed.

5. Fan:

a. Airflow: As directed.
b. External Static Pressure: As directed.
c. Motor:

1) Size: As directed.
2) Speed: As directed.

d. Volts: As directed.
e. Phase: As directed.
f. Hertz: As directed.
g. Full-Load Amperes: As directed.
h. Minimum Circuit Ampacity: As directed.
i. Maximum Overcurrent Protection: As directed.

6. Furnace Electrical Connection:

a. Volts: As directed.
b. Phase: As directed.
c. Hertz: As directed.
d. Full-Load Amperes: As directed.
e. Minimum Circuit Ampacity: As directed.
f. Maximum Overcurrent Protection: As directed.

2.4 THERMOSTATS AND HUMIDISTATS

A. Controls shall comply with requirements in ASHRAE/IES 90.1, "Controls."

B. Solid-State Thermostat: As directed, programmable, microprocessor-based unit with automatic or manual switching from heating to cooling, preferential rate control, seven-day

programmability with minimum of four temperature presets per day, vacation mode, and battery backup protection against power failure for program settings.

C. Single-Stage, Heating-Cooling Thermostat: Adjustable, heating-cooling, wall-mounted unit with fan on-automatic selector.

D. Two-Stage, Heating-Cooling Thermostat: Adjustable, heating-cooling, wall-mounted unit with fan on-automatic selector.

E. Single or Two-Stage, Heating-Only Thermostat as directed: Wall-mounted unit with fan on-automatic selector.

F. Solid-State, Combination Thermostat and Humidistat: Wall-mounted, Freestanding or Wireless, programmable, microprocessor-based unit with automatic switching from heating to cooling and humidifying to dehumidifying, preferential rate control, seven-day programmability with minimum of four temperature presets per day, vacation mode, and battery backup protection against power failure for program settings.

G. Humidistat: Adjustable, wall or duct-mounted unit or directed.

H. Control Wiring: Unshielded twisted-pair cabling.

1. No. 24 AWG, 100 ohm, four pair.
2. Cable Jacket Color: Blue.

2.5 AIR FILTERS

A. Washable Filters: 1-inch- (25-mm-) thick urethane pad.

B. Disposable Filters: 1-inch- (25-mm-) thick fiberglass media with ASHRAE 52.2 MERV rating of 6 or higher, in sheet metal frame.

C. Charged Media Air Filters: Sheet metal housing arranged to be ducted in return-air duct connection to furnace; generates electrostatic charge; MERV 10 rating.

D. HEPA Air Filter Units: Sheet metal housing with fan arranged to be ducted to return-air duct connection to furnace, with activated carbon prefilter, carbon VOC, and high-efficiency particulate air (HEPA) disposable filter. HEPA shall be as follows:

1. Standard: UL 586.
2. Rating: ASHRAE 52.2, 99.97 percent efficiency to 0.30-micrometer particle size.

2.6 HUMIDIFIERS

A. Minimum capacity rating indicated according to AHRI 610.

B. Media-wheel bypass type with bypass damper and motor-driven media wheel in reservoir with float-valve level control; arranged for mounting on return duct or plenum with bypass connection to supply duct.

C. Wetted-pad, continuous-drain, bypass type with bypass damper and water-flow control orifice; arranged for mounting on return duct or plenum with bypass connection to supply duct.

D. Fan-powered, wetted-pad, continuous-drain type with water-flow control orifice and motor; arranged for mounting on duct or plenum.

E. Pumped, fan-powered, wetted-pad type with reservoir-level control and pump and fan motors; arranged for mounting on duct or plenum.

F. Comply with applicable requirements in ASHRAE 62.1.

G. Capacities and Characteristics:

1. Type: As directed.
2. Water Connection Size: As directed.
3. Drain Connection Size: As directed.
4. Volts: As directed.
5. Phase: As directed.
6. Hertz: As directed.
7. Minimum Circuit Ampacity: As directed.
8. Maximum Overcurrent Protection: As directed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install oil-fired furnaces and associated fuel and vent piping according to NFPA 31.

B. Suspended Units: Suspend from structure using threaded rods, spring hangers, and building attachments. Secure rods to unit hanger attachments. Adjust hangers so unit is level and plumb.

C. Base-Mounted Units: Secure units to substrate. Provide optional bottom closure base if required by installation conditions.

D. Controls: Install thermostats and humidistats at mounting height of 60 inches (1500 mm) above floor.

E. Wiring Method: Install control wiring in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal control wiring except in unfinished spaces.

3.2 CONNECTIONS

A. Oil piping installation requirements are specified in Section 231113 "Facility Fuel-Oil Piping." Drawings indicate general arrangement of piping, fittings, and specialties. Connect oil piping with union or flange and ball or gate valve as directed.

B. Install piping adjacent to equipment to allow service and maintenance.

C. Water piping installation requirements are specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties. Connect water piping with union and ball valve.

D. Vent Connections: Connect Type L vents to furnace vent connection and extend outdoors. Type L vents and their installation requirements are specified in Section 235123 "Gas Vents."

E. Connect ducts to furnace with flexible connector. Comply with requirements in Section 233300 "Air Duct Accessories."

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Perform electrical test and visual and mechanical inspection.
2. Leak Test: After installation, charge systems with refrigerant and oil and test for leaks. Repair leaks replace lost refrigerant and oil, and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation, product capability, and compliance with requirements.
4. Verify that fan wheel is rotating in the correct direction and is not vibrating or binding.
5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.

END OF SECTION 235416.16

SECTION 235513.16 - GAS-FIRED DUCT HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes gas-fired duct heaters.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of gas-fired duct heater.

1. Include rated capacities, operating characteristics, and accessories.

B. Shop Drawings: For gas-fired duct heaters; signed and sealed by a qualified professional engineer. Include plans, elevations, sections, and attachment details.

1. Prepare by or under the supervision of a qualified professional engineer detailing fabrication and assembly of gas-fired duct heaters, as well as procedures and diagrams.
2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4. Include diagrams for signal and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, elevations, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Structural members to which equipment will be attached.
2. Items penetrating roof and the following:

a. Duct, vent, and gas piping rough-ins and connections.

B. Seismic Qualification Certificates: For gas-fired duct heaters, accessories, and components, from manufacturer.

C. Field quality-control reports.

D. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace heat exchanger of gas-fired duct heater that fails in materials or workmanship within specified warranty period.

1. Warranty Period: Two or Five years from date of Substantial Completion as directed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Gas-fired duct heaters shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. Seismic Fabrication Requirements: Fabricate and reinforce suspension attachments of gas-fired duct heaters, accessories mountings, and components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC" when gas-fired duct heater is anchored to building structure.
2. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
3. Insert requirements for Component Amplification Factor and Component Response Modification Factor.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Capacities and Characteristics:

1. Heat Exchanger: Aluminized or Stainless steel as directed.
2. Burner Material: Aluminized steel with stainless-steel inserts or Stainless steel as directed.
3. Venting: Gravity or Power vented.
4. Venting: Indoor, separated combustion, power vented.

a. Concentric, Terminal Vent Assembly: Combined combustion-air inlet and power-vent outlet with wall or roof caps. Include adapter assembly for connection to inlet and outlet pipes and flashing for wall or roof penetration.

5. Flue Outlet: As directed in diameter.
6. Gas Input: As directed.
7. Gas Output: As directed.
8. Gas Control Valve: As directed.
9. Annual Fuel Utilization Efficiency: 80 percent.
10. Minimum Airflow: As directed.
11. External Static Pressure: As directed.

2.3 MANUFACTURED UNITS

A. Description: Factory assembled, piped, and wired; and complying with ANSI Z83.8/CSA 2.6.

B. Fuel Type: Design burner for natural or propane gas having characteristics same as those of gas available at Project site as directed.

C. Indoor External Housing: Steel cabinet with integral support inserts and removable bottom arranged to serve as drain pan.

1. External Casings and Cabinets: Baked enamel or Powder coating over corrosion-resistant-treated surface as directed.

D. Outdoor External Housing: Weatherproof steel cabinet with integral support inserts and removable bottom arranged to serve as drain pan.

1. External Casings and Cabinets: Baked enamel or Powder coating over corrosion-resistant-treated surface as directed.

E. Internal Casing: Aluminized steel, arranged to contain airflow, with duct flanges at inlet and outlet.

F. Power Venter: Integral, motorized centrifugal fan interlocked with gas valve.

G. Controls: Regulated redundant gas valve containing pilot solenoid valve, electric gas valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.

1. Ignition: Standing pilot or Electronically controlled electric spark with flame sensor as directed.
2. Fan Thermal Switch: Operates fan on heat-exchanger temperature.
3. Vent Flow Verification: Flame rollout switch or Differential pressure switch to verify open vent as directed.
4. Control transformer.
5. High Limit: Thermal switch or fuse to stop burner.
6. Thermostat: Devices and wiring are specified in Section 230923.27 "Temperature Instruments."

7. Thermostat: Single-stage, wall-mounted type with 50 to 90 deg F (10 to 32 deg C) operating range and fan on switch.
8. Thermostat: Two-stage, wall-mounted type with 50 to 90 deg F (10 to 32 deg C) operating range and fan on switch.
9. Thermostat: Single-stage type with duct-mounted sensor and 50 to 90 deg F (10 to 32 deg C) operating range.
10. Thermostat: Two-stage type with duct-mounted sensor and 50 to 90 deg F (10 to 32 deg C) operating range.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install and connect gas-fired duct heaters and associated fuel and vent features and systems according to NFPA 54 or CSA B149.1 as directed, applicable local codes and regulations, and manufacturer's written instructions.

B. Suspended Units: Suspend from substrate using threaded rods, spring hangers, and building attachments. Secure rods to unit hanger attachments. Adjust hangers so unit is level and plumb.

1. Spring hangers are specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
2. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for spring hangers and seismic restraints.
3. Restrain the unit to resist code-required horizontal acceleration.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to gas-fired duct heaters, allow space for service and maintenance.

C. Gas Piping: Comply with Section 231123 "Facility Natural-Gas Piping" or Section 231126 "Facility Liquefied-Petroleum Gas Piping" connect gas piping to gas train inlet; provide union with enough clearance for burner removal and service as directed.

D. Vent Connections: Comply with Section 235123 "Gas Vents."

E. Duct Connections: Comply with Section 233113 "Metal Ducts" or Section 233116 "Nonmetal Ducts" as directed.

F. Electrical Connections: Comply with applicable requirements in electrical Sections.

1. Install electrical devices furnished with heaters but not specified to be factory mounted.

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
2. Verify bearing lubrication.
3. Verify proper motor rotation.
4. Test Reports: Prepare a written report to record the following:

    a. Test procedures used.
    b. Test results that comply with requirements.
    c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

C. Gas-fired duct heater will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.4 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Adjust burner and other unit components for optimum heating performance and efficiency.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain gas-fired duct heaters.

END OF SECTION 235513.16

SECTION 235523.13 - LOW-INTENSITY, GAS-FIRED, RADIANT HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes low-intensity, gas-fired, forced-draft or draft-induced radiant heaters as directed.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings:

1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Manufacturer's Special Warranty: Manufacturer agrees to repair or replace components of radiant heaters that fail in materials or workmanship within specified warranty period.

1. Warranty Period: All warranty periods listed below are from date of Substantial Completion.

a. Burner Assembly: Years as directed.
b. Combustion and Emitter Tubes: Years as directed.
c. Heater Controls: One Year(s) as directed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. CSA certified, with CSA Seal and certification number clearly visible on units indicating compliance with ANSI Z83.20/CSA 2.34.

B. UL listed and labeled, with UL label clearly visible on units indicating compliance with ANSI Z83.20/CSA 2.34.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 FORCED-DRAFT HEATERS

A. Description: Factory-assembled, indoor or outdoor, overhead-mounted, electrically controlled, low-intensity, infrared radiant heating units using gas combustion. Heater to have all necessary factory-installed wiring and piping required prior to field installation and startup as directed.

B. Fuel Type: Design burner for natural or propane gas having characteristics same as those of gas available at Project site as directed.

C. Burner Assembly:

1. Combustion-Air Inlet: Non-ducted, unvented.
2. Combustion-Air Inlet: Ducted horizontal to outdoors through sidewall with vent caps.
3. Combustion-Air Inlet: Ducted vertical to outdoors through roof with vent caps.
4. Ignition System: As directed, with flame rod sensing capabilities and self-diagnostic control module.

D. Combustion Chamber: 4-inch- (100-mm-) diameter, 12 or 16-gage, as directed, tubing with high-emissivity, high-temperature, corrosion-resistant external finish.

E. Emitter Tube: 4-inch- (100-mm-) diameter, 12 or 16-gage, as directed, tubing with high-emissivity, high-temperature, corrosion-resistant external finish. Emitter tubing shall be equipped with baffles to maximize heating efficiency.

1. Tubing Connections: As directed.
2. 90 or 180-degree-bend emitter steel tubing with high-emissivity, high-temperature, corrosion-resistant external finish as directed.

F. Reflector: As directed with end caps. Shape to control radiation from tubing for uniform intensity at floor level with 100 percent cutoff above centerline of tubing. Reflectors or entire heater shall accommodate rotational adjustment from horizontal to a minimum 30-degree tilt from vertical.

G. Capacities and Characteristics:

1. Gas Input: As directed.
2. Gas Output: As directed.

3. Fuel-Supply Connection: As directed.
4. Power Requirements:

    a. Volts: As directed.
    b. Phase: Single or Three as directed.
    c. Hertz: 60.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed.
    f. Maximum Overcurrent Protection: As directed.

2.3 DRAFT-INDUCED HEATERS

A. Description: Factory-assembled, indoor or outdoor, overhead-mounted, electrically controlled, low-intensity, infrared radiant heating units using gas combustion. Heater to have all necessary factory-installed wiring and piping required prior to field installation and startup as directed.

B. Fuel Type: Design burner for natural or propane gas having characteristics same as those of gas available at Project site as directed.

C. Burner Assembly:

1. Combustion-Air Inlet: Non-ducted, unvented.
2. Combustion-Air Inlet: Ducted horizontal to outdoors through sidewall with vent caps.
3. Combustion-Air Inlet: Ducted vertical to outdoors through roof with vent caps.
4. Ignition System: As directed, with flame rod sensing capabilities and self-diagnostic control module.

D. Combustion Chamber: 4-inch- (100-mm-) diameter, 12 or 16-gage, as directed, tubing with high-emissivity, high-temperature, corrosion-resistant external finish.

E. Emitter Tube: 4-inch- (100-mm-) or 3-inch- (76-mm-) diameter as directed, 12 or 16-gage, as directed, tubing with high-emissivity, high-temperature, corrosion-resistant external finish. Emitter tubing shall be equipped with baffles to maximize heating efficiency.

1. Tubing Connections: As directed.
2. 90 or 180-degree-bend emitter steel tubing with high-emissivity, high-temperature, corrosion-resistant external finish as directed.

F. Vacuum Exhaust Fan: Dynamically balanced, direct-driven, isolated from emitter tubing exhaust system by high-temperature flexible vibration isolation connector. Fan and connector to have a minimum temperature rating of 450 deg F (232 deg C).

1. Motors: General requirements for motors are specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Balancing Dampers: Plate type, mounted in cast, double-flange fitting with vacuum test plug.
3. Filter: Cartridge type for mounting on burner housing.
4. Vent Termination: Vertical through roof or Horizontal though side-wall with vent caps as directed.

G. Reflector: As directed, with end caps. Shape to control radiation from tubing for uniform intensity at floor level with 100 percent cutoff above centerline of tubing. Reflectors or entire heater shall accommodate rotational adjustment from horizontal to a minimum 30-degree tilt from vertical.

H. Capacities and Characteristics:

1. Gas Input: As directed.
2. Gas Output: As directed.
3. Fuel-Supply Connection: As directed.
4. Power Requirements:

    a. Volts: As directed.
    b. Phase: Single or Three As directed.
    c. Hertz: 60.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed.
    f. Maximum Overcurrent Protection: As directed.

5. Vacuum Exhaust Fan Motor Size: As directed.

    a. Volts: As directed.
    b. Phase: Single or Three as directed.
    c. Hertz: 60.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed.
    f. Maximum Overcurrent Protection: As directed.

2.4 CONTROLS AND SAFETIES

A. Gas Control Valve: Single or Two-stage, regulated redundant 24-V ac gas valve that contains pilot solenoid valve, electric gas valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body as directed.

B. Failure Safeguards: 100 percent shutoff of gas flow in the event of flame or power failure.

C. Prepurge several seconds of air control system prior to burner ignition as directed.

D. Safety lockout of burner after three consecutive ignition failures or flame is not reestablished within trial ignition period as directed.

E. Blocked Vent Safety: Differential pressure switch in burner safety circuit to stop burner operation with high discharge or suction pressure.

F. Control Panel Interlock: Stops burner if panel is open.

G. Indicator Lights: "Airflow-on" and "burner-on" indicator lights.

H. Thermostat: Devices and wiring are specified in Section 230923.27 "Temperature Instruments."

I. Thermostat: Single-stage, wall-mounted type with 50 to 90 deg F (10 to 32 deg C) operating range and fan on switch.

1. Control Transformer: Integrally mounted.

J. Thermostat: Two-stage, wall-mounted type with 50 to 90 deg F (10 to 32 deg C) operating range and fan on switch.

1. Control Transformer: Integrally mounted.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment Installation: Install gas-fired, radiant heaters and associated gas features and systems according to NFPA 54 or CSA B149.1.

B. Suspended Units: Suspend from substrate using chain hanger kits and building attachments or Mount to substrate using manufacturer's rigid mounting kits or custom fabricated brackets as directed.

1. Restrain the unit to resist seismic acceleration. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
2. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

C. Maintain manufacturers' recommended clearances for combustibles.

D. Gas Piping: Comply with Section 231123 "Facility Natural-Gas Piping" or Section 231126 "Facility Liquefied-Petroleum Gas Piping" as directed, connect gas piping to gas train inlet; provide union with enough clearance for burner removal and service.

1. Gas Connections: Connect gas piping to radiant heaters according to NFPA 54 or CSA B149.1 as directed.

E. Where installing piping adjacent to gas-fired, radiant heaters, allow space for service and maintenance.

F. Vent Connections: Comply with Section 233113 "Metal Ducts" and with Section 235123 "Gas Vents."

G. Electrical Connections: Comply with applicable requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

1. Install electrical devices furnished with heaters but not specified to be factory mounted.

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
2. Verify bearing lubrication.
3. Verify proper motor rotation.
4. Test Reports: Prepare a written report to record the following:

    a. Test procedures used.
    b. Test results that comply with requirements.
    c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

B. Gas-fired, radiant heaters will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.3 ADJUSTING

A. Adjust initial-temperature set points.

B. Adjust burner and other unit components for optimum heating performance and efficiency.

END OF SECTION 235523.13

SECTION 235523.16 - HIGH-INTENSITY, GAS-FIRED, RADIANT HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. High-intensity, infrared, gas-fired, radiant heaters.
2. Gas-fired, outdoor, infrared patio heaters.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings:

1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Manufacturer's Special Warranty: Manufacturer agrees to repair or replace components of radiant heaters that fail in materials or workmanship within specified warranty period.

1. Warranty Period: All warranty periods listed below are from date of Substantial Completion.

a. Ceramic Tiles: As directed.
b. Heater Components: As directed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with ANSI Z83.19A/CSA 2.35A or ANSI Z83.26/CSA 2.37 as directed.

1. CSA certified, with CSA Seal and certification number clearly visible on units.
2. UL listed and labeled, with UL label clearly visible on units.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 HIGH-INTENSITY, INFRARED, GAS-FIRED, RADIANT HEATERS

A. Factory-assembled, indoor or outdoor, overhead-mounted, electrically controlled, high-intensity, infrared, radiant heating units using gas combustion. Heater to have all necessary factory-installed wiring and piping required prior to field installation and startup as directed.

B. Fuel Type: Design burner for natural or propane gas having characteristics same as those of gas available at Project site as directed.

C. Burner Assembly: Modular, aluminized steel with powder-coat or similar finish or stainless-steel plenum chamber secured with stainless-steel retainers as directed.

D. Emitter: Perforated ceramic tiles.

E. Reflector: One-sided, bright-polished aluminum.

F. Ignition:

1. Manual Pilot: Self-energizing with no external power connection.
2. Direct Spark: 24/25 or 115/120-V ac, solid-state ignition module with spark electrode and flame sensor as directed.

G. Accessories:

1. Parabolic reflector or Reflector extensions as directed.
2. Wire grid or expanded metal secondary emitter for increased efficiency.
3. Protective screen and heat-deflector shield.
4. Stainless-steel flexible connector with manual valve for gas supply.
5. Hanger chain with "S" hooks.
6. Preassembled chain suspension kit.
7. Rigid mounting kits.
8. Clearance warning plaque.
9. Two-stage operation.

H. Capacities and Characteristics:

1. Gas Input: As directed.
2. Gas Output: As directed.

3. Electrical Characteristics:

    a. Volts: As directed.
    b. Phase: Single.
    c. Hertz: 60.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed.
    f. Maximum Overcurrent Protection: As directed.

2.3 GAS-FIRED, OUTDOOR, INFRARED PATIO HEATERS

A. Factory-assembled, indoor or outdoor, overhead-mounted, electrically controlled, high-intensity, infrared, radiant heating units using gas combustion. Heater to have all necessary factory-installed wiring and piping required prior to field installation and startup as directed.

B. Fuel Type: Design burner for natural or propane gas having characteristics same as those of gas available at Project site as directed.

C. Burner Assembly: As directed Modular, aluminized steel with powder-coat, similar finish or stainless-steel plenum chamber secured with stainless-steel retainers.

D. Emitter: Perforated ceramic tiles.

E. Reflector: Polished stainless steel.

F. Ignition: Direct spark, 24/25 or 115/120-V ac, solid-state ignition module with spark electrode and flame sensor as directed.

G. Accessories:

    1. Wire grid or expanded metal secondary emitter for increased efficiency.
    2. Protective screen and heat-deflector shield.
    3. Stainless-steel flexible connector with manual valve for gas supply.
    4. Hanger chain with "S" hooks.
    5. Preassembled chain suspension kit.
    6. Rigid mounting kits.
    7. Clearance warning plaque.

H. Capacities and Characteristics:

    1. Gas Input: As directed.
    2. Gas Output: As directed.
    3. Electrical Characteristics:

        a. Volts: 24/25 or 115/120 as directed.
        b. Phase: Single.
        c. Hertz: 60.
        d. Full-Load Amperes: As directed.
        e. Minimum Circuit Ampacity: As directed.
        f. Maximum Overcurrent Protection: As directed.

2.4 CONTROLS AND SAFETIES

A. Failure Safeguards: 100 percent main gas shutoff on pilot or pilot or power failure as directed.

B. Thermostat: Devices and wiring are specified in Section 230923.27 "Temperature Instruments."

C. Thermostat: Single-stage, wall-mounted type with 50 to 90 deg F (10 to 32 deg C) operating range and fan on switch.

1. Control Transformer: Integrally mounted.

D. Thermostat: Two-stage, wall-mounted type with 50 to 90 deg F (10 to 32 deg C) operating range and fan on switch.

1. Control Transformer: Integrally mounted.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment Installation: Install gas-fired, radiant heaters and associated gas features and systems according to NFPA 54 or CSA B149.1 as directed.

B. Suspended Units: Suspend from substrate using chain hanger kits and building attachments or Mount to substrate using rigid mounting kits or brackets, supplied by manufacturer or manufactured as directed.

1. Restrain the unit to resist seismic acceleration. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
2. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

C. Maintain manufacturers' recommended clearances for combustibles.

D. Gas Piping: Comply with Section 231123 "Facility Natural-Gas Piping" or Section 231126 "Facility Liquefied-Petroleum Gas Piping" connect gas piping to gas train inlet; provide union with enough clearance for burner removal and service as directed.

1. Gas Connections: Connect gas piping to radiant heaters according to NFPA 54 or CSA B149.1.

E. Where installing piping adjacent to gas-fired, radiant heaters, allow space for service and maintenance.

F. Electrical Connections: Comply with applicable requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

1. Install electrical devices furnished with heaters but not specified to be factory mounted.

G. Adjust initial-temperature set points.

H. Adjust burner and other unit components for optimum heating performance and efficiency.

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
2. Verify bearing lubrication.
3. Verify proper motor rotation.
4. Test Reports: Prepare a written report to record the following:

    a. Test procedures used.
    b. Test results that comply with requirements.
    c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

B. Gas-fired, radiant heaters will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 235523.16

SECTION 235533.13 - OIL-FIRED UNIT HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes oil-fired unit heaters.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of oil-fired unit heater.

1. Include rated capacities, operating characteristics, and accessories.

B. Shop Drawings: For oil-fired unit heaters; signed and sealed by a qualified professional engineer. Include plans, elevations, sections, and attachment details.

1. Prepare by or under the supervision of a qualified professional engineer detailing fabrication and assembly of oil-fired unit heaters, as well as procedures and diagrams.
2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, elevations, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Structural members to which equipment will be attached.
2. Items penetrating roof and the following:

a. Vent and oil piping rough-ins and connections.

B. Seismic Qualification Certificates: For oil-fired unit heaters, accessories, and components, from manufacturer.

C. Field quality-control reports.

D. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace heat exchanger of oil-fired unit heater that fails in materials or workmanship within specified warranty period.

1. Warranty Period: Two or Five years from date of Substantial Completion as directed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Oil-fired unit heaters shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. Seismic Fabrication Requirements: Fabricate and reinforce suspension attachments of oil-fired unit heaters, accessories mountings, and components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC" when oil-fired unit heater is anchored to building structure.
2. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Capacities and Characteristics:

1. Oil Input: As directed.
2. Heat Output: As directed.
3. Annual Fuel Utilization Efficiency: 80 percent.
4. Minimum Airflow: As directed.
5. External Static Pressure: As directed.
6. Motor Enclosure: Totally enclosed, fan cooled.
7. Electrical Characteristics:

a. Motor Size: As directed.

b. Motor Speed: As directed.
c. Volts: As directed.
d. Phase: Single or Poly as directed.
e. Hertz: 60.
f. Full-Load Amperes: As directed.
g. Minimum Circuit Ampacity: As directed.
h. Maximum Overcurrent Protection: As directed.

2.3 MANUFACTURED UNITS

A. Description: Factory assembled, piped, and wired, and complying with UL 731.

B. Housing: Steel, with inserts for suspension mounting rods.

1. External Casings and Cabinets: Baked enamel or Powder coating over corrosion-resistant-treated surface as directed.
2. Discharge Louvers: Independently adjustable, horizontal or vertical blades as directed.
3. Discharge Nozzle: Discharge at 25 to 65 degrees (0.44 to 1.13 radians) or 50 to 90 degrees (0.87 to 1.57 radians) from horizontal as directed.

C. Accessories:

1. Oil Booster Pump: 30-gph (108-L/h) or 70-gph (252-L/h) capacity; motor and two-stage fuel unit with pressure-regulating valve and strainer.
2. Oil safety valve.
3. Outdoor Combustion-Air Adapter: Sealed to housing and fitted with quick access cover or door and fitting for terminating outdoor-air duct.

D. Heat Exchanger: Minimum 0.09-inch (2.2-mm) steel.

E. Burners: Flame-retention, pressure-atomizing, forced-draft, gun type; with integral fuel pump and electronic spark ignition and flame safety.

1. Safety Device: Oil-pressure switch.

F. Propeller Unit Fan:

1. Aluminum blades dynamically balanced and resiliently mounted.
2. Steel fan-blade guard.

G. Centrifugal Unit Fan:

1. Steel, centrifugal fan dynamically balanced and resiliently mounted.
2. Belt driven with adjustable-pitch motor sheave.

H. Motors:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Enclosure Materials: Rolled steel.

3. Motor Bearings: As directed.
4. Unusual Service Conditions:

    a. Ambient Temperature: As directed.
    b. Altitude: Above sea level as directed.
    c. High humidity.

5. Efficiency: Premium efficient.
6. NEMA Design: As directed.
7. Service Factor: As directed.

I. Controls: Factory piped and prewired to electrical junction box mounted on unit, including the following:

1. Control Transformer: Integrally mounted, 120- to 24-V ac.
2. Cad-cell safety system.
3. Manual reset safety.
4. Automatic Fan Thermal Switch: Fan operates with heat-exchanger temperature more than 135 deg F (58 deg C).
5. Thermostat: Devices and wiring are specified in Section 230923.27 "Temperature Instruments."
6. Wall or Unit-Mounted Thermostat as directed:

    a. Single or Two stage as directed.
    b. Fan on-off-automatic switch.
    c. 24-V ac.
    d. 50 to 90 deg F (10 to 32 deg C) operating range.

J. Electrical Connection: Factory wire motors and controls for a single electrical connection.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install and connect oil-fired unit heaters and associated fuel and vent piping according to NFPA 31 or CSA B139 as directed, applicable local codes and regulations, and manufacturer's written instructions.

3.2 EQUIPMENT MOUNTING

A. Suspended Units: Suspend from substrate using threaded rods, spring hangers, and building attachments. Secure rods to unit hanger attachments. Adjust hangers so unit is level and plumb.

1. Threaded Rods, Spring Hangers, and Building Attachments: Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" and Section 230548 "Vibration and Seismic Controls for HVAC."

2. Threaded Rods, Spring Hangers, Building Attachments, and Seismic Restraints: Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment." and Section 230548 "Vibration and Seismic Controls for HVAC"
3. Anchor the unit to resist code-required horizontal acceleration.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to oil-fired unit heater, allow space for service and maintenance.

C. Fuel Oil Piping: Comply with Section 231113 "Facility Fuel-Oil Piping." Connect to fuel oil supply and return piping with shutoff valve and union at each connection.

D. Vent Connections: Comply with Section 235123 "Gas Vents."

E. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

F. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
2. Verify bearing lubrication.
3. Verify proper motor rotation.
4. Test Reports: Prepare a written report to record the following:

    a. Test procedures used.
    b. Test results that comply with requirements.
    c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

C. Oil-fired unit heater will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Adjust burner and other unit components for optimum heating performance and efficiency.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain oil-fired unit heaters.

END OF SECTION 235533.13

SECTION 235533.16 - GAS-FIRED UNIT HEATERS

1.1 SUMMARY

A. Section includes gas-fired unit heaters.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of gas-fired unit heater.

1. Include rated capacities, operating characteristics, and accessories.

B. Shop Drawings: For gas-fired unit heaters; signed and sealed by a qualified professional engineer. Include plans, elevations, sections, and attachment details.

1. Prepare by or under the supervision of a qualified professional engineer detailing fabrication and assembly of gas-fired unit heaters, as well as procedures and diagrams.
2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, elevations, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Structural members to which equipment will be attached.
2. Items penetrating roof and the following:

a. Vent and gas piping rough-ins and connections.

B. Seismic Qualification Certificates: For gas-fired unit heaters, accessories, and components, from manufacturer.

C. Field quality-control reports.

D. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace heat exchanger of gas-fired unit heater that fails in materials or workmanship within specified warranty period.

1. Warranty Period: Two or Five years as directed from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Gas-fired unit heaters shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. Seismic Fabrication Requirements: Fabricate and reinforce suspension attachments of gas-fired unit heaters, accessories mountings, and components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC" Section 15074 "Vibration and Seismic Controls for HVAC" when gas-fired unit heater is anchored to building structure.
2. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Capacities and Characteristics:

1. Gas Input: As directed.
2. Gas Output: As directed.
3. Annual Gas Utilization Efficiency: 80 percent.
4. Minimum Airflow: As directed.
5. External Static Pressure: As directed.
6. Motor Enclosure: Totally enclosed, fan cooled.
7. Electrical Characteristics:

a. Motor Size: As directed.
b. Motor Speed: Rpm as directed.
c. Volts: As directed.
d. Phase: Single or Poly as directed.
e. Hertz: 60.

f. Full-Load Amperes: As directed.
g. Minimum Circuit Ampacity: As directed.
h. Maximum Overcurrent Protection: As directed.

2.3 MANUFACTURED UNITS

A. Description: Factory assembled, piped, and wired, and complying with ANSI Z83.8/CSA 2.6.

B. Gas Type: Design burner for natural or propane gas as directed having characteristics same as those of gas available at Project site.

C. Type of Venting: Vented as directed.

D. Housing: Steel, with integral draft hood and inserts for suspension mounting rods.

1. External Casings and Cabinets: Baked enamel or Powder coating as directed over corrosion-resistant-treated surface.
2. Discharge Louvers: Independently adjustable, horizontal or vertical blades as directed.
3. Discharge Nozzle: Discharge at 25 to 65 degrees (0.44 to 1.13 radians) or 50 to 90 degrees (0.87 to 1.57 radians) from horizontal as directed.

E. Accessories:

1. Four-point suspension kit.
2. Power Venter: Centrifugal aluminized-steel fan, with stainless-steel shaft; 120-V ac motor.
3. Concentric, Terminal Vent Assembly: Combined combustion-air inlet and power-vent outlet with wall or roof caps. Include adapter assembly for connection to inlet and outlet pipes, and flashing for wall or roof penetration.

F. Heat Exchanger: Aluminized or Stainless steel as directed.

G. Burner Material: Aluminized steel with stainless-steel inserts or Stainless steel as directed.

H. Propeller Unit Fan:

1. As directed, Formed-steel or Aluminum propeller blades riveted to heavy-gage steel spider bolted to cast-iron hub, dynamically balanced, and resiliently mounted.
2. Fan-Blade Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.

I. Centrifugal Unit Fan:

1. Steel, centrifugal fan dynamically balanced and resiliently mounted.
2. Belt-Driven Drive Assembly:

a. Resiliently mounted to housing, with the following features:

1) Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
2) Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.

3) Pulleys: Cast-iron, adjustable-pitch motor pulley.

J. Motors:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Enclosure Materials: Rolled steel.
3. Motor Bearings: As directed.
4. Unusual Service Conditions:

    a. Ambient Temperature: As directed.
    b. Altitude: Above sea level as directed.
    c. High humidity.

5. Efficiency: Premium efficient.
6. NEMA Design: As directed.
7. Service Factor: As directed.

K. Controls: Regulated redundant gas valve containing pilot solenoid valve, electric gas valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.

1. Gas Control Valve: As directed.
2. Ignition: Standing pilot or Electronically controlled electric spark with flame sensor as directed.
3. Fan Thermal Switch: Operates fan on heat-exchanger temperature.
4. Vent Flow Verification: Flame rollout switch or Differential pressure switch to verify open vent as directed.
5. Control transformer.
6. High Limit: Thermal switch or fuse to stop burner.
7. Thermostat: Devices and wiring are specified in Section 230923.27 "Temperature Instruments."
8. Wall or Unit-Mounted Thermostat as directed:

    a. Single or Two stage as directed.
    b. Fan on-off-automatic switch.
    c. 24-V ac.
    d. 50 to 90 deg F (10 to 32 deg C) operating range.

L. Electrical Connection: Factory wire motors and controls for a single electrical connection.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install and connect gas-fired unit heaters and associated gas and vent features and systems according to NFPA 54 or CSA B149.1 as directed, applicable local codes and regulations, and manufacturer's written instructions.

3.2 EQUIPMENT MOUNTING

A. Suspended Units: Suspend from substrate using threaded rods, spring hangers, and building attachments. Secure rods to unit hanger attachments. Adjust hangers so unit is level and plumb.

B. Substrate-Mounted Units: Provide supports connected to substrate. Secure units to supports.

1. Spring hangers and seismic restraints as directed.
2. Threaded Rods, Spring Hangers, and Building Attachments: Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" and Section 230548 "Vibration and Seismic Controls for HVAC."
3. Threaded Rods, Spring Hangers, Building Attachments, and Seismic Restraints: Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment." and Section 230548 "Vibration and Seismic Controls for HVAC."
4. Anchor the unit to resist code-required horizontal acceleration.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to gas-fired unit heater, allow space for service and maintenance.

C. Gas Piping: Comply with Section 231123 "Facility Natural-Gas Piping" or Section 231126 "Facility Liquefied-Petroleum Gas Piping" as directed. Connect gas piping to gas train inlet; provide union with enough clearance for burner removal and service.

D. Vent Connections: Comply with Section 235123 "Gas Vents."

E. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

F. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
2. Verify bearing lubrication.
3. Verify proper motor rotation.
4. Test Reports: Prepare a written report to record the following:

a. Test procedures used.
b. Test results that comply with requirements.
c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

C. Gas-fired unit heater will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Adjust burner and other unit components for optimum heating performance and efficiency.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain gas-fired unit heaters.

END OF SECTION 235533.16

SECTION 235613.13 - HEATING, FLAT-PLATE, SOLAR COLLECTORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Liquid-type, medium-temperature, glazed, heating, flat-plate, solar collectors, accessories, and mountings.

1.2 DEFINITIONS

A. FSEC: Florida Solar Energy Center.

B. SRCC: Solar Rating and Certification Corporation.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For solar collectors.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1.4 QUALITY ASSURANCE

A. Collector Certification: Certified by FSEC and SRCC.

B. Manufacturer and collector model shall be listed in "Directory of SRCC Certified Solar Collector Ratings."

1.5 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace solar collectors that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hail Resistance: Able to withstand 1-inch- (25-mm-) diameter hail.

2.2 MANUFACTURERS

2.3 COLLECTORS

A. Enclosure: Extruded aluminum.

1. Finish: As directed.

B. Back Sheet: Aluminum sheet or galvanized sheet steel.

C. Insulation: As directed.

1. Minimum Thermal Resistance (R-value): R-7.5 on the back and R-5 on the sidewalls.

D. Absorber Plate: Copper fins and tubes or aluminum fins and copper tubes or copper sheet as directed.

E. Header and Absorber Tubes: Copper, NPS 3/4 (DN 65).

F. Glazing:

1. Glazing Materials: Single-sheet, low-iron, tempered glass with textured finish on outside surface.
2. Gaskets and Grommets: UV-resistant EPDM gaskets with molded corners and extruded silicone grommets.
3. Continuous secondary silicone seal between the glass and enclosure.

G. Mounting Frame:

1. Fabricated to withstand wind loads of up to 130 mph (210 km/h) with no separation of the collector from the frame or the frame from the structure.
2. Material: Stainless steel or Extruded aluminum as directed.
3. Profile: As directed
4. Fasteners: Stainless steel.

H. Collector Certification: Certified by FSEC and SRCC.

2.4 CONTROLS

A. Comply with requirements in Section 230993.11 "Sequence of Operations for HVAC DDC."

2.5 CAPACITIES AND CHARACTERISTICS

A. Area:

1. Gross: As directed.
2. Net Aperture: As directed.

B. Dry Weight: As directed.

C. Fluid Type: Water.

D. Fluid Capacity: As directed.

E. Test Pressure: As directed.

F. Maximum Operating Temperature: As directed.

G. SRCC Certified Performance Rating:

1. Clear Day at 2000 Btu/sq. ft. per Day (23 MJ/sq. m per Day): As directed.
2. Mildly Cloudy Day at 1500 Btu/sq. ft. per Day (17 MJ/sq. m per Day): As directed.
3. Cloudy Day at 1000 Btu/sq. ft. per Day (11 MJ/sq. m per Day): As directed.

PART 3 - EXECUTION

3.1 SOLAR-COLLECTOR INSTALLATION

A. Comply with manufacturer's written instructions for collector mounting and installation.

B. Install the collector according to ASHRAE's "Active Solar Heating Systems Installation Manual."

C. Install low-voltage wiring from the sensor to the energy-management panel.

D. Mount the collector frame support feet to the structural support steel using stainless-steel bolts. Attach each pair of legs using two bolts for each.

E. Place high-temperature-resistant covers over the header to prevent contaminants from entering the headers.

F. Coat the controller's sensor with a layer of thermal paste and insert into the collector sensor port to full depth. Apply a silicone sealant around the entire perimeter of the sensor where it enters the collector. Completely cover the opening with insulation to prevent water ingress. Only use high-temperature-rated (minimum 395 deg F (202 deg C) sensors and cabling.

G. After connecting the inlet and outlet of the collectors to the system, purge the system of all air.

H. Install collectors with not less than minimum space for access and service as recommended by solar-collector manufacturer.

3.2 CONNECTIONS

A. Comply with requirements for piping specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties. "Section 15179 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to solar collectors, allow space for service and maintenance.

C. Install flexible connections on piping between collectors installed in series.

D. Install ball valve and union at inlet and outlet of solar collectors. Comply with requirements in Section 230523.12 "Ball Valves for HVAC Piping" for materials and installation requirements for ball valves and unions.

E. Connect solar collectors to lightning protection system. Comply with requirements in Section 264113 "Lightning Protection for Structures."

3.3 ADJUSTING

A. Adjust tilt angle per design requirement and adjust the collector balance valve to provide the design flow.

END OF SECTION 235613.13

SECTION 235613.19 - HEATING, SOLAR, VACUUM-TUBE COLLECTORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes liquid-type, heating, solar, vacuum-tube collectors.

1.2 DEFINITIONS

A. FSEC: Florida Solar Energy Center.

B. SRCC: Solar Rating and Certification Corporation.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For solar collectors.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of heating, solar, vacuum-tube collectors.
4. Include diagrams for control wiring.

1.4 QUALITY ASSURANCE

A. Collector Certification: Certified by FSEC and SRCC.

B. Manufacturer and collector model shall be listed in SRCC's "Directory of SRCC Certified Solar Collector Ratings."

1.5 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace solar collectors that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hail Resistance: Able to withstand 1-inch- (25-mm-) diameter hail.

2.2 MANUFACTURERS

2.3 COLLECTORS

A. Enclosure: Extruded aluminum.

1. Finish: As directed.

B. Header:

1. Tubing: Aluminum-covered copper.
2. Header Assembly: Brazed with BAg45CnZn brazing material.
3. Test Pressure: Each header factory tested to 145 psig (1000 kPa).

C. Heat Pipes: Oxygen-free copper, with a minimum wall thickness of 0.027 inch (0.685 mm), Grade C10200.

D. Vacuum Tubes: Twin tubes or double wall, tempered Borosilicate glass.

1. Outer Tube: Clear, with wall thickness not less than 0.07 inch (1.8 mm) and outside diameter of 2.28 inches (57.9 mm).
2. Inside Wall Coating: Selective coating to act as the absorber.
3. Interstitial Space: Evacuated and the bottom coated with silver barium.
4. Seal: Vacuum tubes sealed to the header with UV-stabilized, high-temperature vulcanized (HTV), silicone rubber seals and rings.

E. Absorber Coating: Minimum absorptance of 0.92 percent and maximum emissivity of 8 percent.

F. Mounting Frame:

1. Fabricated to withstand wind loads of up to 130 mph (210 km/h) with no separation of the collector from the frame or the frame from the structure.
2. Material: Stainless steel or Extruded aluminum as directed.
3. Profile: As directed.
4. Fasteners: Stainless steel.

G. Flow Interruption: Panel design shall allow uninterrupted heated-fluid flow during damage and repair of absorber element.

2.4 CONTROLS

A. Comply with requirements in Section 230993.11 "Sequence of Operations for HVAC DDC."

2.5 CAPACITIES AND CHARACTERISTICS

A. Area:

1. Gross: As directed.
2. Net Aperture: As directed.

B. Dry Weight: As directed.

C. Fluid Type: Treated purified water or Evaporative fluid as directed.

D. Fluid Capacity: As directed.

E. Test Pressure: As directed.

F. Maximum Operating Temperature: As directed.

G. SRCC Certified Thermal Performance Rating:

1. Clear Day at 2000 Btu/sq. ft. (23 MJ/sq. m) per Day: As directed.
2. Mildly Cloudy Day at 1500 Btu/sq. ft. (17 MJ/sq. m) per Day: As directed.
3. Cloudy Day at 1000 Btu/sq. ft. (11 MJ/sq. m) per Day: As directed.

PART 3 - EXECUTION

3.1 SOLAR COLLECTOR INSTALLATION

A. Comply with manufacturer's written instructions for collector mounting and installation.

B. Install the collector according to ASHRAE's "Active Solar Heating Systems Installation Manual."

C. Install low-voltage wiring from the sensor to the energy-management panel.

D. Mount the collector frame support feet to the structural support steel using stainless-steel bolts. Attach each pair of legs using two bolts for each.

E. Place high-temperature-resistant covers over the header to prevent contaminants from entering the headers.

F. Coat the controller's sensor with a layer of thermal paste and insert into the collector sensor port to full depth. Apply a silicone sealant around the entire perimeter of the sensor where it enters the collector. Completely cover the opening with insulation to prevent water ingress. Only use high-temperature-rated, minimum 395 deg F (202 deg C), sensors and cabling.

G. After connecting the inlet and outlet of the collectors to the system, purge the system of all air.

H. Install collectors with not less than minimum space for access and service as recommended by solar collector manufacturer.

I. Once piping is installed and confirmed leak free and the air is purged, install the heat pipes and vacuum tubes.

3.2 CONNECTIONS

A. Comply with requirements for piping specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties. "Section 15179 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to solar collectors, allow space for service and maintenance.

C. Install flexible connections on piping between collectors installed in series.

D. Install ball valve and union at inlet and outlet of solar collectors. Comply with requirements in Section 230523.12 "Ball Valves for HVAC Piping"for materials and installation requirements for ball valves and unions.

E. Connect solar collectors to lightning protection system. Comply with requirements in Section 264113 "Lightning Protection for Structures."

3.3 ADJUSTING

A. Adjust tilt angle per design requirement and adjust the collector balance valve to provide the design flow.

END OF SECTION 235613.19

SECTION 235700 - HEAT EXCHANGERS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes shell-and-tube and plate heat exchangers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Design Calculations: Calculate requirements for selecting seismic restraints and for designing bases.
2. Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.

C. Delegated-Design Submittal: Details and design calculations for seismic restraints for heat exchangers.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Equipment room, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Tube-removal space.
2. Structural members to which heat exchangers will be attached.

B. Seismic Qualification Data: Certificates, for heat exchanger, accessories, and components, from manufacturer.

C. Source quality-control reports.

D. Field quality-control reports.

E. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of domestic-water heat exchangers that fail in materials or workmanship within specified warranty period.

1. Warranty Periods: From date of Substantial Completion.

a. Shell-and-Tube, Domestic-Water Heat Exchangers:

1) Tube Coil: One year.
2) Other Components: One year.

b. Plate, Domestic-Water Heat Exchangers:

1) Brazed-Plate Type: One year.
2) Plate-and-Frame Type: One year.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design seismic restraints for heat exchangers.

B. Seismic Performance: Heat exchangers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor is 1.5 - 1.0, as directed.

2.2 SHELL-AND-TUBE HEAT EXCHANGERS

A. Description: Packaged assembly of tank, heat-exchanger coils, and specialties.

B. Construction: Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1.

C. Configuration: U-tube with removable bundle.

D. Shell Materials: Steel.

E. Head:

1. Materials: Cast iron.
2. Flanged and bolted to shell.

F. Tube:

1. Seamless copper tubes.
2. Tube diameter is determined by manufacturer based on service.

G. Tubesheet Materials: Steel.

H. Baffles: Steel.

I. Piping Connections:

1. NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
2. NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.

J. Support Saddles:

1. Fabricated of material similar to shell.
2. Fabricate foot mount with provision for anchoring to support.
3. Fabricate attachment of saddle supports to pressure vessel with reinforcement strong enough to resist heat-exchanger movement during seismic event when heat-exchanger saddles are anchored to building structure.

K. Capacities and Characteristics:

1. General:

   a. Shell Diameter: As directed.
   b. Heat-Exchanger Length: As directed.
   c. Heat-Exchanger Surface Area: As directed.
   d. Number of Passes: As directed.
   e. Heat Exchanged: As directed.
   f. Operating Weight: As directed.

2. Shell Side:

   a. Fluid: Water or Steam, as directed.
   b. Working Pressure: As directed, psig (kPa).
   c. Supply Pressure: As directed, psig (kPa).
   d. Steam Flow Rate: As directed, lb/h (kg/h).
   e. Water Flow Rate: As directed, gpm (L/s).
   f. Pressure Drop: As directed, psig (kPa).
   g. Inlet Temperature: As directed, deg F (deg C).
   h. Outlet Temperature: As directed, deg F (deg C).
   i. Fouling Factor: As directed.

j. Inlet Size: As directed, NPS (DN).
k. Outlet Size: As directed, NPS (DN).

3. Tube Side:

a. Fluid: Water or Steam, as directed.
b. Working Pressure: As directed, psig (kPa).
c. Supply Pressure: As directed, psig (kPa).
d. Steam Flow Rate: As directed, lb/h (kg/h).
e. Water Flow Rate: As directed, gpm (L/s).
f. Pressure Drop: As directed, psig (kPa).
g. Inlet Temperature: As directed, deg F (deg C).
h. Outlet Temperature: As directed, deg F (deg C).
i. Fouling Factor: As directed.
j. Inlet Size: As directed, NPS (DN).
k. Outlet Size: As directed NPS (DN).

2.3 GASKETED-PLATE HEAT EXCHANGERS

A. Configuration: Freestanding assembly consisting of frame support, top and bottom carrying and guide bars, fixed and movable end plates, tie rods, individually removable plates, and one-piece gaskets.

B. Construction: Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1.

C. Frame:

1. Capacity to accommodate 20 percent additional plates.
2. Painted carbon steel with provisions for anchoring to support.

D. Top and Bottom Carrying and Guide Bars: Painted carbon steel, aluminum, or stainless steel.

1. Fabricate attachment of heat-exchanger carrying and guide bars with reinforcement strong enough to resist heat-exchanger movement during seismic event when heat-exchanger carrying and guide bars are anchored to building structure.

E. End-Plate Material: Painted carbon steel.

F. Tie Rods and Nuts: Steel or stainless steel.

G. Plate Material: 0.024 inch (0.6 mm) thick before stamping; Type 304 stainless steel.

H. Gasket Materials: Nitrile rubber.

I. Piping Connections:

1. NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
2. NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.

J. Enclose plates in solid aluminum removable shroud.

K. Capacities and Characteristics:

1. General:

a. Heat-Exchanger Surface Area: As directed, sq. ft. (sq. m).
b. Number of Plates: As directed.
c. Number of Passes: One.
d. Heat Exchanged: As directed, Btu/h (kW).
e. Operating Weight: As directed, lb (kg).

2. Hot Side:

a. Fluid: Water or Steam, as directed.
b. Working Pressure: As directed, psig (kPa).
c. Supply Pressure: As directed, psig (kPa).
d. Steam Flow Rate: As directed, lb/h (kg/h).
e. Water Flow Rate: As directed, gpm (L/s).
f. Pressure Drop: As directed, psig (kPa).
g. Inlet Temperature: As directed, deg F (deg C).
h. Outlet Temperature: As directed, deg F (deg C).
i. Fouling Factor: As directed.
j. Inlet Size: As directed, NPS (DN).
k. Outlet Size: As directed, NPS (DN).

3. Cold Side:

a. Fluid: Water or Steam, as directed.
b. Working Pressure: As directed, psig (kPa).
c. Supply Pressure: As directed, psig (kPa).
d. Steam Flow Rate: As directed, lb/h (kg/h).
e. Water Flow Rate: As directed, gpm (L/s).
f. Pressure Drop: As directed, psig (kPa).
g. Inlet Temperature: As directed, deg F (deg C).
h. Outlet Temperature: As directed, deg F (deg C).
i. Fouling Factor: As directed.
j. Inlet Size: As directed, NPS (DN).
k. Outlet Size: As directed, NPS (DN).

2.4 BRAZED-PLATE HEAT EXCHANGERS

A. Configuration: Brazed assembly consisting of embossed or pressed stainless-steel plates brazed together and two end plates, one with threaded nozzles and one with pattern-embossed plates.

B. Construction: Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1.

C. End-Plate Material: Type 316 stainless steel.

D. Threaded Nozzles: Type 316 stainless steel.

E. Plate Material: Type 316 stainless steel.

F. Brazing Material: Copper.

G. Capacities and Characteristics:

1. General:

a. Heat-Exchanger Surface Area: As directed, sq. ft. (sq. m).
b. Heat Exchanged: As directed, Btu/h (kW).
c. Operating Weight: As directed lb (kg).

2. Hot Side:

a. Fluid: Water or Steam, as directed.
b. Working Pressure: As directed, psig (kPa).
c. Supply Pressure: As directed, psig (kPa).
d. Steam Flow Rate: As directed, lb/h (kg/h).
e. Water Flow Rate: As directed, gpm (L/s).
f. Pressure Drop: As directed, psig (kPa).
g. Inlet Temperature: As directed, deg F (deg C).
h. Outlet Temperature: As directed, deg F (deg C).
i. Fouling Factor: As directed.
j. Inlet Size: As directed, NPS (DN).
k. Outlet Size: As directed, NPS (DN).

3. Cold Side:

a. Fluid: Water or Steam, as directed.
b. Working Pressure: As directed, psig (kPa).
c. Supply Pressure: As directed, psig (kPa).
d. Steam Flow Rate: As directed, lb/h (kg/h).
e. Water Flow Rate: As directed, gpm (L/s).
f. Pressure Drop: As directed, psig (kPa).
g. Inlet Temperature: As directed, deg F (deg C).
h. Outlet Temperature: As directed, deg F (deg C).
i. Fouling Factor: As directed.
j. Inlet Size: As directed, NPS (DN).
k. Outlet Size: As directed, NPS (DN).

2.5 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect heat exchangers according to ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1. Affix ASME label.

B. Hydrostatically test heat exchangers to minimum of one and one-half times pressure rating before shipment.

C. Heat exchangers will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment Mounting:

1. Install heat exchangers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." Or Section 033053 "Miscellaneous Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

B. Install shell-and-tube heat exchangers on saddle supports.

C. Install gasketed-plate heat exchanger on custom-designed wall supports anchored to structure as indicated on Drawings.

D. Install metal shroud over installed gasketed-plate heat exchanger according to manufacturer's written instructions.

E. Install brazed-plate heat exchanger on custom-designed wall supports anchored to structure as indicated on Drawings.

F. Comply with requirements for piping specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

G. Comply with requirements for steam and condensate piping specified in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties."

H. Maintain manufacturer's recommended clearances for tube removal, service, and maintenance.

I. Install piping adjacent to heat exchangers to allow space for service and maintenance of heat exchangers. Arrange piping for easy removal of heat exchangers.

J. Install shutoff valves at heat-exchanger inlet and outlet connections.

K. Install relief valves on heat-exchanger heated-fluid connection and install pipe relief valves, full size of valve connection, to floor drain.

L. Install vacuum breaker at heat-exchanger steam inlet connection.

M. Install hose end valve to drain shell.

N. Install thermometer on heat-exchanger and inlet and outlet piping and install thermometer on heating-fluid inlet and outlet piping. Comply with requirements for thermometers specified in Section 230519 "Meters and Gages for HVAC Piping."

O. Install pressure gages on heat-exchanger and heating-fluid piping. Comply with requirements for pressure gages specified in Section 230519 "Meters and Gages for HVAC Piping."

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Heat exchanger will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.3 CLEANING

A. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

END OF SECTION 235700

SECTION 236200 - PACKAGED COMPRESSOR AND CONDENSER UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes packaged, air-cooled, refrigerant compressor and condenser units.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: For compressor and condenser units. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: For power, signal, and control wiring.

1.3 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Fabricate and label refrigeration system according to ASHRAE 15, "Safety Standard for Refrigeration Systems."

C. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6, "Heating, Ventilating, and Air-Conditioning."

1.4 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of compressor and condenser units that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Compressor failure.
b. Condenser coil leak.

2. Warranty Period: Five - Ten years from date of Substantial Completion, as directed.
3. Warranty Period (Compressor Only): Five, Seven or Ten, as directed, years from date of Substantial Completion.
4. Warranty Period (Components Other Than Compressor): Five - Ten years from date of Substantial Completion, as directed.

5. Warranty Period (Condenser Coil Only): Five years from date of Substantial Completion, as completion.

PART 2 - PRODUCTS

2.1 COMPRESSOR AND CONDENSER UNITS, AIR COOLED, 1 TO 5 TONS (3.5 TO 17.6 kW)

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following or available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Description: Factory assembled and tested; consisting of compressor, condenser coil, fan, motors, refrigerant reservoir, and operating controls.

C. Compressor: Scroll, hermetically sealed, with rubber vibration isolators.

1. Motor: Single or two speed and includes thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
2. Two-Speed Compressor: Include manual-reset, high-pressure switch and automatic-reset, low-pressure switch.
3. Accumulator: Suction tube.

D. Refrigerant: R-22, R-407C or R-410A, as directed.

E. Refrigerant: R-407C or R-410A.

F. Condenser Coil: Seamless copper-tube, aluminum-fin coil; circuited for integral liquid subcooler, with removable drain pan and brass service valves with service ports.

G. Condenser Fan: Direct-drive, aluminum propeller fan; with permanently lubricated, totally enclosed fan motor with thermal-overload protection and ball bearings.

H. Accessories:

1. Coastal Filter: Mesh screen to protect condenser coil from salt damage.
2. Crankcase heater.
3. Cycle Protector: Automatic-reset timer to prevent rapid compressor cycling.
4. Electronic programmable thermostat or Low-voltage thermostat and subbase to control compressor and condenser unit and evaporator fan.
5. Evaporator Freeze Thermostat: Temperature-actuated switch that stops unit when evaporator reaches freezing temperature.
6. Filter-dryer.
7. High-Pressure Switch: Automatic-reset switch cycles compressor off on high refrigerant pressure.
8. Liquid-line solenoid.
9. Low-Ambient Controller: Cycles condenser fan to permit operation down to 30 deg F (minus 1 deg C), 0 deg F (minus 18 deg C) with time-delay relay to bypass low-pressure switch.

10. Low-Ambient Controller: Controls condenser fan speed to permit operation down to minus 20 deg F (minus 29 deg C) with time-delay relay to bypass low-pressure switch.
11. Low-Pressure Switch: Automatic-reset switch cycles compressor off on low refrigerant pressure.
12. PE mounting base.
13. Precharged and insulated suction and liquid tubing.
14. Sound Hood: Wraps around sound attenuation cover for compressor.
15. Thermostatic expansion valve.
16. Time-Delay Relay: Continues operation of evaporator fan after compressor shuts off.
17. Reversing valve.

I. Unit Casing: Galvanized steel, finished with baked enamel; with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Mount service valves, fittings, and gage ports on exterior of casing.

J. Capacities and Characteristics:

1. Compressor and Condenser Unit:

    a. Full-Load Cooling Capacity: As directed, MBh (kW).
    b. Energy-Efficiency Ratio (EER): As directed.
    c. Seasonal Energy-Efficiency Ratio (SEER): As directed.
    d. Coefficient of Performance (COP): As directed.
    e. Compressor Suction Temperature: As directed, deg F (deg C).
    f. Capacity Steps: As directed.

2. Refrigerant Connections:

    a. Liquid Pipe Size: As directed, NPS (DN).
    b. Suction Pipe Size: As directed, NPS (DN).

3. Compressor:

    a. Rated-Load Amperes: As directed.
    b. Locked-Rotor Amperes: As directed.
    c. Power Input: As directed.

4. Air-Cooled Condenser:

    a. Ambient-Air Temperature: As directed, deg F (deg C).
    b. Airflow: As directed, cfm (L/s).
    c. Number of Condenser Fans: As directed.
    d. Condenser Fan Motor Size: As directed.

5. Electrical Characteristics:

    a. Kilowatt Input: As directed.
    b. Volts: As directed.
    c. Phase: As directed.
    d. Hertz: As directed.

e. Maximum Circuit Ampacity: As directed.
f. Maximum Instantaneous Current Flow during Startup: As directed.
g. Maximum Overcurrent Protection: As directed.

2.2 COMPRESSOR AND CONDENSER UNITS, AIR COOLED, 6 TO 120 TONS (21 TO 422 kW)

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following or available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Description: Factory assembled and tested, air cooled; consisting of casing, compressors, condenser coils, condenser fans and motors, and unit controls.

C. Compressor: Hermetic scroll compressor designed for service with crankcase sight glass, crankcase heater, and backseating service access valves on suction and discharge ports.

1. Capacity Control: On-off compressor cycling or Hot-gas bypass.

D. Compressor: Hermetic or semihermetic rotary screw compressor designed for service with crankcase sight glass, crankcase heater, and backseating service access valves on suction and discharge ports.

1. Capacity Control: As directed.

E. Refrigerant: R-22, R-407C, R-410A or R-134a, as directed.

F. Refrigerant: R-407C, R-410A, or R-134a.

G. Condenser Coil: Seamless copper-tube, aluminum-fin coil, including subcooling circuit and backseating liquid-line service access valve. Factory pressure test coils, then dehydrate by drawing a vacuum and fill with a holding charge of nitrogen or refrigerant.

H. Condenser Fan: Propeller-type vertical discharge; either directly or belt driven. Include the following:

1. Permanently lubricated, ball-bearing totally enclosed motors.
2. Separate motor for each fan.
3. Dynamically and statically balanced fan assemblies.

I. Operating and safety controls include the following:

1. Manual-reset, high-pressure cutout switches.
2. Automatic-reset, low-pressure cutout switches.
3. Low-oil-pressure cutout switch.
4. Compressor-winding thermostat cutout switch.
5. Three-leg, compressor-overload protection.
6. Control transformer.
7. Magnetic contactors for compressor and condenser fan motors.
8. Timer to prevent excessive compressor cycling.

J. Accessories:

1. Electronic programmable thermostat or Low-voltage thermostat and subbase to control compressor and condenser unit and evaporator fan.
2. Low-Ambient Controller: Cycles condenser fan to permit operation down to 0 deg F (minus 18 deg C) with time-delay relay to bypass low-pressure switch.
3. Low-Ambient Controller: Controls condenser fan speed to permit operation down to minus 20 deg F (minus 29 deg C) with time-delay relay to bypass low-pressure switch.
4. Gage Panel: Package with refrigerant circuit suction and discharge gages.
5. Hot-gas bypass kit.
6. Part-winding-start timing relay, circuit breakers, and contactors.
7. Reversing valve.

K. Unit Casings: Designed for outdoor installation with weather protection for components and controls and with removable panels for required access to compressors, controls, condenser fans, motors, and drives. Additional features include the following:

1. Steel, galvanized or zinc coated, for exposed casing surfaces; treated and finished with manufacturer's standard paint coating.
2. Perimeter base rail with forklift slots and lifting holes to facilitate rigging.
3. Gasketed control panel door.
4. Nonfused disconnect switch, factory mounted and wired, for single external electrical power connection.
5. Condenser coil hail guard or grille.

L. Capacities and Characteristics:

1. Compressor and Condenser Unit:

    a. Full-Load Cooling Capacity: As directed, MBh (kW).
    b. Energy-Efficiency Ratio (EER): As directed.
    c. Seasonal Energy-Efficiency Ratio (SEER): As directed.
    d. Coefficient of Performance (COP): As directed.
    e. Compressor Suction Temperature: As directed, deg F (deg C).
    f. Capacity Steps: As directed.

2. Refrigerant Connections:

    a. Liquid Pipe Size: As directed, NPS (DN).
    b. Suction Pipe Size: As directed, NPS (DN).

3. Compressors:

    a. Number of Compressors: As directed.
    b. Rated-Load Amperes: As directed.
    c. Locked-Rotor Amperes: As directed.
    d. Power Input: As directed.

4. Air-Cooled Condenser:

    a. Ambient-Air Temperature: As directed deg F (deg C).

b. Airflow: As directed cfm (L/s).
c. Number of Condenser Fans: As directed
d. Condenser Fan Motor Size: As directed.

5. Electrical Characteristics:

a. Kilowatt Input: As directed.
b. Volts: As directed.
c. Phase: As directed.
d. Hertz: As directed.
e. Maximum Circuit Amperes: As directed.
f. Maximum Instantaneous Current Flow during Startup: As directed.
g. Maximum Overcurrent Protection: As directed.

2.3 SOURCE QUALITY CONTROL

A. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IESNA 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings," Section 6, "Heating, Ventilating, and Air-Conditioning."

B. Testing Requirements: Factory test sound-power-level ratings according to ARI 270 - ARI 370.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install unit level and plumb, firmly anchored in locations indicated.

B. Install roof-mounting units on equipment supports specified in Section 077200 "Roof Accessories."

C. Equipment Mounting:

1. Install compressor and condenser units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." Or Section 033053 "Miscellaneous Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

D. Maintain manufacturer's recommended clearances for service and maintenance.

E. Loose Components: Install electrical components, devices, and accessories that are not factory mounted.

3.2 CONNECTIONS

A. Comply with requirements for piping in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

C. Connect precharged refrigerant tubing to unit's quick-connect fittings. Install tubing so it does not interfere with access to unit. Install furnished accessories.

D. Connect refrigerant piping to air-cooled compressor and condenser units; maintain required access to unit. Install furnished field-mounted accessories. Refrigerant piping and specialties are specified in Section 232300 "Refrigerant Piping."

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.
2. Leak Test: After installation, charge system with refrigerant and oil and test for leaks. Repair leaks replace lost refrigerant and oil, and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor operation and unit operation, product capability, and compliance with requirements.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
5. Verify proper airflow over coils.

C. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.

END OF SECTION 236200

SECTION 236313 - AIR-COOLED REFRIGERANT CONDENSERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes packaged, air-cooled refrigerant condensers for outdoor or indoor installation.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: For air-cooled refrigerant condensers. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 MANUFACTURED UNITS

A. Description: Factory assembled and tested; consisting of casing, condenser coils, condenser fans and motors, and unit controls.

B. Refrigerant: R-22, R-407C or R-410A, as directed.

C. Refrigerant: R-407C or R-410A.

D. Condenser Coil: Factory tested at 425 psig (2930 kPa).

1. Tube: As directed.
2. Coil Fin: Aluminum or Steel.
3. Coating: As directed.
4. Circuit: To match compressors with liquid subcooling coil.

E. Condenser Fans and Drives: Propeller fans with aluminum or galvanized-steel, galvanized-steel or stainless-steel fan blades, as directed, for vertical or horizontal air discharge; directly driven with permanently lubricated or grease-lubricated ball-bearing motors with integral current- and thermal-overload protection.

1. Weather-proof motors with rain shield and shaft slinger.
2. Extend grease lines to outside of casing.

F. Condenser Fans and Drives: Forward-curved centrifugal fans for vertical or horizontal air discharge.

1. Fan on steel shaft with self-aligning ball bearings.
2. V-belt drive with minimum of two belts; variable pitch drive pulley.
3. Motor mounted on adjustable slide base.

G. Operating and Safety Controls: Include condenser fan motor thermal and overload cutouts; 115-V control transformer, if required; magnetic contactors for condenser fan motors and a non-fused factory-mounted and -wired disconnect switch for single external electrical power connection.

1. Fan Cycling Control: Head pressure switches or Ambient thermostats.

H. Casings: Galvanized or zinc-coated steel treated and finished with manufacturer's standard paint coating, Aluminum or Stainless steel, as directed, designed for outdoor installation with weather protection for components and controls, and with the following:

1. Removable panels for access to controls, condenser fans, motors, and drives.
2. Plated or Stainless steel fan guards.
3. Lifting eyes.
4. Removable legs, Height as directed.

2.3 CAPACITIES AND CHARACTERISTICS

A. Heat-Rejection Capacity: As directed, MBh (kW).

B. Condensing Temperature:

1. Saturated Discharge Temperature: As directed, deg F (deg C).
2. Saturated Suction Temperature: As directed, deg F (deg C).
3. Subcooling Temperature: As directed, deg F (deg C).

C. Ambient-Air Temperature: As directed, deg F (deg C).

D. Refrigerant Pipe Connections:

1. Number of Connections: As directed.
2. Liquid Pipe Size: As directed, NPS (DN).
3. Suction Pipe Size: As directed, NPS (DN).

E. Coils:

1. Arrangement: As directed.
2. Number of Rows: As directed.
3. Fin Spacing: 12 fins/inch (2 mm), as directed.
4. Total Face Area: As directed, sq. ft. (sq. m).

F. Fans:

1. Number of Condenser Fans: As directed.
2. Diameter: As directed (mm).
3. RPM: As directed.
4. Total Airflow: As directed cfm (L/s).
5. Condenser Fan Motor Size: As directed.

G. Electrical Characteristics:

1. Kilowatts: As directed.
2. Volts: As directed.
3. Phase: As directed.
4. Hertz: As directed.
5. Maximum Circuit Ampacity: As directed.
6. Maximum Instantaneous Current Flow during Startup: As directed.
7. Maximum Overcurrent Protection: As directed.

2.4 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Enclosure Type: Totally enclosed, fan cooled.
2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
3. Mount unit-mounted disconnect switches on exterior or interior of unit.

2.5 SOURCE QUALITY CONTROL

A. Testing Requirements: Factory test sound-power-level ratings according to ARI 270.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install unit level and plumb, firmly anchored in locations indicated; maintain manufacturer's recommended clearances.

B. Equipment Mounting:

1. Install air-cooled condenser refrigerant condensers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." Or Section 033053 "Miscellaneous Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

C. Maintain manufacturer's recommended clearances for service and maintenance.

D. Loose Components: Install electrical components, devices, and accessories that are not factory mounted.

3.2 CONNECTIONS

A. Piping installation requirements are specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Refrigerant Piping: Connect piping to unit with pressure relief, service valve, filter-dryer, and moisture indicator on each refrigerant-circuit liquid line. Refrigerant piping and specialties are specified in Section 232300 "Refrigerant Piping."

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Perform electrical test and visual and mechanical inspection.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Complete manufacturer's starting checklist.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
5. Verify proper airflow over coils.

C. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.

D. Air-cooled refrigerant condensers will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION 236313

SECTION 236333 - EVAPORATIVE REFRIGERANT CONDENSERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes factory-assembled and -tested, forced or induced draft evaporative refrigerant condensers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: For evaporative refrigerant condensers.

1. Include plans, elevations, sections, and mounting or attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

D. Delegated-Design Submittal: For evaporative refrigerant condensers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
2. Wind and Seismic Restraint Details: Detail fabrication and attachment of restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.
3. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include handrails, ladders, and equipment mounting frame.
4. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, elevations, and other details, drawn to scale, using input from Installers of the items involved.

B. Seismic Qualification Data: Certificates for evaporative refrigerant condensers, accessories, and components, from manufacturer.

C. Field quality-control reports.

D. Sample warranties.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.

B. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures.

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of evaporative refrigerant condensers that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five year(s) from date of Substantial Completion, as directed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASME Compliance: Fabricate and label heat-exchanger coils to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

C. Comply with NFPA 70.

D. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15.
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1.

E. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

F. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design evaporative refrigerant condenser support structure and seismic restraints and wind restraints.

G. Structural Performance: Evaporative refrigerant condenser support structure shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Dead Loads: As directed.
2. Live Loads: As directed.
3. Roof Loads: As directed.
4. Snow Loads: As directed.
5. Seismic Loads: As directed.
6. Wind Loads: As directed.
7. Deflection Limits: Design system to withstand design loads without deflections greater than the following:

    a. As directed.

H. Wind-Restraint Performance:

1. Basic Wind Speed: As directed.
2. Building Classification Category: I, II, III, IV or as directed.
3. Minimum 10 lb/sq. ft. (48.8 kg/sq. m) multiplied by the maximum area of the mechanical component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

I. Seismic Performance: Evaporative refrigerant condenser shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 - 1.0.

2.2 FORCED-DRAFT EVAPORATIVE REFRIGERANT CONDENSERS

A. Casing and Frame:

1. Casing and Frame Material: As directed.
2. Frame Material: As directed.
3. Fasteners: Galvanized or Stainless steel.
4. Joints and Seams: Sealed watertight.
5. Welded Connections: Continuous and watertight.

B. Collection Basin: Configure evaporative refrigerant condenser for installation with a field-constructed collection basin.

C. Collection Basin:

1. Material: FRP with UV inhibitors, Galvanized steel, ASTM A653/A653M, G210 (Z600) coating or Galvanized steel, ASTM A653/A653M, G235 (Z700) coating, as directed.
2. Strainer: Removable stainless steel strainer with openings smaller than nozzle orifices.

3. Overflow and drain connections.
4. Makeup water connection.

D. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.

E. Electric Basin Heater:

1. Stainless Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
2. Heater Control Panel: Mounted on the side of each evaporative refrigerant condenser cell.
3. Enclosure: NEMA 250, Type 3R, Type 4 or Type 4X, as directed.
4. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor evaporative refrigerant condenser water level and de-energize the heater when the water reaches low-level set point.
5. Control-circuit transformer with primary and secondary side fuses.
6. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
7. Single-point, field-power connection to a fused disconnect switch, non-fused disconnect switch or circuit breaker, as directed and heater branch circuiting complying with NFPA 70.
8. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except make connections to each electric basin heater with liquid tight conduit.

F. Water Distribution Piping: Main header and lateral branch piping designed for even distribution over heat exchanger coil throughout the flow range, without the need for balancing valves and for connecting individual, removable, non-clogging spray nozzles.

1. Pipe Material: Fiberglass, PVC or Galvanized steel, as directed.
2. Spray Nozzle Material: Plastic, Polypropylene or PVC, as directed.
3. Piping Supports: Corrosion-resistant hangers and supports designed to resist movement during operation and shipment.

G. Recirculating Piping: PVC, with connections for separately provided, remote spray pump.

H. Spray Pump: Close-coupled, end-suction, single-stage, bronze-fitted centrifugal pump; with suction strainer, flow balancing valve, and mechanical seal suitable for outdoor service.

1. General Requirements for Spray Pump Motor: Comply with NEMA designation and temperature-rating requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment" and not indicated below.
2. Motor Enclosure: As directed.
3. Energy Efficiency: Comply with ASHRAE/IES 90.1 or NEMA Premium Efficient.
4. Service Factor: 1.0 - 1.15, as directed.

I. Heat-Exchanger Coils:

1. Tube and Tube Sheet Materials: Copper tube with stainless steel sheet.
2. Heat-Exchanger Arrangement: Serpentine tubes, Serpentine tubes with removable cover plate on inlet and outlet headers or Straight tubes with removable header cover plate on

both ends of heat exchanger for straight-through access to each tube, as directed; and sloped for complete drainage of fluid by gravity.

3. ASME Compliance: Designed, manufactured, and tested according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, and bearing ASME "U" stamp; and sloped for complete drainage of fluid by gravity.
4. Field Piping Connections: Vent, supply, and return suitable for mating to ASME B16.5, Class 150 flange.

J. Removable Drift Eliminator:

1. Material: FRP or PVC; with maximum flame-spread index of 5 – 25, as directed, according to ASTM E84.
2. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
3. Configuration: Multipass, designed and tested to reduce water carryover to achieve performance indicated.

K. Removable Air-Intake Screens: Galvanized steel wire mesh.

L. Centrifugal Fan: Double-width, double-inlet fan with forward-curved blades, statically and dynamically balanced at the factory after assembly.

1. Number of Fans: Each evaporative refrigerant condenser cell shall have a single fan or multiple fans connected to a common shaft.
2. Fan Wheel and Housing Materials: Galvanized steel.
3. Fan Shaft: Steel, coated to resist corrosion.
4. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens complying with OSHA regulations.
5. Fan Shaft Bearings: Self-aligning, grease-lubricated ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C). Bearings designed for an L-10 life of 40,000 - 50,000 hours.
6. Grease Fittings for Bearings: Extended lubrication lines to an easily accessible location.

M. Belt Drive:

1. Service Factor: 1.5 based on motor nameplate horsepower.
2. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
3. Belt: Multiple V-belt design with a matched set of cogged belts.
4. Belt: One-piece, multigrooved, solid-back belt.
5. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
6. Belt-Drive Guard: Comply with OSHA regulations.

N. Fan Motor:

1. General Requirements for Fan Motors: Comply with NEMA designation and temperature-rating requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment" and not indicated below.
2. Motor Enclosure: As directed.
3. Energy Efficiency: Comply with ASHRAE/IES 90.1 or NEMA Premium Efficient.

4. Service Factor: 1.15.
5. Insulation: Class F or Class H.
6. Variable-Speed Motors: Inverter-duty rated according to NEMA MG-1.
7. Dual-Fan Motors: Two single-speed motors, one sized for full-load operating conditions and one sized for part-load operating conditions, with two sets of drives and belts.
8. Severe-duty rating with the following features:

    a. Rotor and stator protected with corrosion-inhibiting epoxy resin.
    b. Double-shielded, vacuum-degassed bearings lubricated with premium moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C).
    c. Internal heater automatically energized when motor is de-energized.

9. Motor Base: Adjustable, or other suitable provision for adjusting belt tension.
10. Discharge Dampers: Positive-closure, automatic, isolation dampers with electric actuators.

    a. Provide field power and controls to open dampers when pump is energized, and close dampers when pump is de-energized.

O. Capacity-Control Dampers: Galvanized-steel or Stainless steel dampers, with linkages, electric operator, controller, limit switches, transformer, and weatherproof enclosure.

P. Vibration Switch: For each fan drive.

1. Enclosure: NEMA 250, Type 4 or Type 4X.
2. Vibration Detection: Sensor with a field-adjustable acceleration sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Evaporative refrigerant condenser manufacturer shall recommend switch set point for proper operation and protection.
3. Provide switch with manual-reset button for field connection to a DDC system for HVAC and hardwired connection to fan motor electrical circuit.
4. Switch shall, on sensing excessive vibration, signal an alarm through the DDC system for HVAC and shut down the fan.

Q. Controls: Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."

R. Control Package: Factory installed and wired, and functionally tested at factory before shipment.

1. NEMA 250, Type 3R, Type 4 or Type 4X enclosure with removable internally mounted backplate.
2. Control-circuit transformer with primary and secondary side fuses.
3. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
4. Microprocessor-based controller for automatic control of fan and spray pump based on evaporative refrigerant condenser leaving-water temperature with control features to improve operating efficiency based on outdoor ambient wet-bulb temperature by using adaptive logic.

5. Fan motor sequencer for multiple-cell, two-speed, and two-motor applications with automatic lead-stage rotation.
6. Collection basin, electric/electronic level controller, complying with requirements in "Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve" Paragraph above.
7. Electric basin heaters with temperature-control and low-water-level safety switch for each cell, complying with requirements in "Electric Basin Heater" Paragraph above.
8. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph above.
9. Controls and wiring for two-motor, single-fan drives shall be same as that for two-speed, two-winding motors.
10. Power and controls to open discharge hood dampers when pump is energized and close dampers when pump is de-energized.
11. Single-point, field-power connection to a fused disconnect switch, nonfused disconnect switch, circuit breaker for each evaporative refrigerant condenser cell, as directed.

    a. Branch power circuit to each motor and electric basin heater and to controls with a disconnect switch or circuit breaker.
    b. NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor. Provide variable-frequency controller with manual bypass and line reactors for each variable-speed motor indicated.

12. Factory-installed wiring outside of enclosures shall be in metal raceway, except make connections to each motor and electric basin heater with liquid tight conduit.
13. Visual indication of status and alarm with momentary test push button for each motor.
14. Audible alarm and silence switch.
15. Visual indication of elapsed run time graduated in hours for each motor.
16. Evaporative refrigerant condenser shall have hardware to enable DDC system for HVAC to remotely monitor and display the following:

    a. Operational status of each motor.
    b. Position of dampers.
    c. Evaporative refrigerant condenser leaving-fluid temperature.
    d. Fan vibration alarm.
    e. Collection basin high, low or high- and low, water-level alarms, as directed.

S. Personnel Access Components:

1. Doors: Large enough for personnel to access evaporative refrigerant condenser internal components from both evaporative refrigerant condenser end walls. Doors shall be operable from both sides of the door.
2. External Ladders with Safety Cages: Aluminum, galvanized- or stainless steel, fixed ladders with ladder extensions to access external platforms and top of evaporative refrigerant condenser from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.
3. External Platforms with Handrails: Aluminum, FRP, or galvanized-steel bar grating at evaporative refrigerant condenser access doors when evaporative refrigerant condensers are elevated and not accessible from grade.

4. Handrail: Aluminum, galvanized steel, or stainless steel complete with kneerail and toeboard at platforms and around top of evaporative refrigerant condenser. Comply with 29 CFR 1910.23.
5. Internal Platforms: Aluminum, FRP, or galvanized-steel bar grating.

    a. Spanning the collection basin from one end of evaporative refrigerant condenser to the other and positioned to form a path between the access doors. Platform shall be elevated, so that all parts are above the high-water level of the collection basin.

T. Capacities and Characteristics:

1. Number of Cells: As directed.
2. Maximum Drift Loss: 0.005 percent of design water flow, as directed.
3. Heat-Exchanger Coil(s):

    a. Refrigerant Type: R-407C, R-410A or HFC-134a.
    b. Minimum Heat Rejection: As directed, Btu/h (kW).
    c. Condensing Temperature: As directed, deg F (deg C).
    d. Entering-Air Wet-Bulb Temperature: As directed, deg F (deg C).

4. Fan Location: Bottom or Side.
5. Fan Motor:

    a. Type: As directed.
    b. Horsepower/Cell: As directed.
    c. Full-Load Ampacity: As directed.
    d. Minimum Circuit Ampacity: As directed.
    e. Maximum Overcurrent Protection Device: As directed.
    f. Electrical Characteristics: 208, 240, 480 V, as directed ac, three phase, 60 Hz.

6. Spray Pump and Motor:

    a. Water Flow/Cell: As directed, gpm (L/s).
    b. Horsepower/Cell: As directed.
    c. Full-Load Ampacity: As directed.
    d. Minimum Circuit Ampacity: As directed.
    e. Maximum Overcurrent Protection Device: As directed.
    f. Electrical Characteristics: 120, 208, 240, 277, 480, V ac, single or three phase, 60 Hz, as directed.

7. Sound Pressure Level: As directed at distance in feet (m) when measured according to CTI ATC 128.
8. Basin Heater:

    a. Basin Water Temperature: 40 deg F (5 deg C), as directed.
    b. Outdoor Ambient Temperature: 0 deg F (Minus 18 deg C) or Minus 20 deg F (Minus 29 deg C).
    c. Capacity/Cell: As directed, kW.
    d. Full-Load Ampacity: As directed, A.
    e. Minimum Circuit Ampacity: As directed, A.
    f. Maximum Overcurrent Protection Device: As directed, A.

g. Electrical Characteristics: 208, 240, 480V ac, three phase, 60 Hz, as directed.
h. Capacity/Cell: As directed, MBtu/h (kW).
i. Entering-Fluid Temperature: As directed, deg F (deg C).
j. Fluid Flow Rate: As directed, gpm (L/s).
k. Fluid Pressure Drop: As directed, psig (kPa).
l. Capacity/Cell: As directed. MBtu/h (kW).
m. Steam Flow: As directed, lb/h (L/s).
n. Steam Pressure: As directed, psig (kPa).

2.3 INDUCED-DRAFT EVAPORATIVE REFRIGERANT CONDENSERS

A. Casing and Frame:

1. Casing and Frame Material: As directed.
2. Frame Material: As directed.
3. Fasteners: Galvanized or Stainless steel.
4. Joints and Seams: Sealed watertight.
5. Welded Connections: Continuous and watertight.

B. Collection Basin: Configure evaporative refrigerant condenser for installation with a field-constructed collection basin.

C. Collection Basin:

1. Material: Galvanized steel, ASTM A653/A653M, G210 (Z600) coating or Galvanized steel, ASTM A653/A653M, G235 (Z700) coating.
2. Overflow and drain connections.
3. Makeup water connection.

D. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.

E. Electric Basin Heater:

1. Stainless Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
2. Heater Control Panel: Mounted on the side of each evaporative refrigerant condenser cell.
3. Enclosure: NEMA 250, Type 3R, Type 4 or Type 4X, as directed.
4. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor evaporative refrigerant condenser water level and de-energize the heater when the water reaches low-level set point.
5. Control-circuit transformer with primary and secondary side fuses.
6. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
7. Single-point, field-power connection to a fused disconnect switch or non-fused disconnect switch or circuit breaker, as directed, and heater branch circuiting, complying with NFPA 70.
8. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except make connections to each electric basin heater with liquid tight conduit.

F. Pressurized Water Distribution Piping: Main header and lateral branch piping designed for even distribution over heat-exchanger coil throughout the flow range without the need for balancing valves and for connecting individual, removable, non-clogging spray nozzles.

1. Pipe Material: Fiberglass, PVC or Galvanized steel, as directed.
2. Spray Nozzle Material: Plastic, Polypropylene or PVC, as directed.
3. Piping Supports: Corrosion-resistant hangers and supports to resist movement during operation and shipment.

G. Recirculating Piping: PVC, with connections for separately provided, remote spray pump.

H. Spray Pump: Close-coupled, end-suction, single-stage, bronze-fitted centrifugal pump; with suction strainer, flow balancing valve, and mechanical seal suitable for outdoor service.

1. General Requirements for Spray Pump Motor: Comply with NEMA designation and temperature-rating requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment" and not indicated below.
2. Motor Enclosure: As directed.
3. Energy Efficiency: Comply with ASHRAE/IES 90.1 or NEMA Premium Efficient.
4. Service Factor: 1.0 - 1.15.

I. Heat-Exchanger Coils:

1. Tube and Tube Sheet Materials: Copper tube with stainless steel sheet.
2. Heat-Exchanger Arrangement: Serpentine tubes, Serpentine tubes with removable cover plate on inlet and outlet headers or Straight tubes with removable header cover plate on both ends of heat exchanger for straight-through access to each tube; and sloped for complete drainage of fluid by gravity.
3. ASME Compliance: Designed, manufactured, and tested according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, and bearing ASME "U" stamp; and sloped for complete drainage of fluid by gravity.
4. Field Piping Connections: Vent, supply, and return suitable for mating to ASME B16.5, Class 150 flange.

J. Removable Drift Eliminator:

1. Material: FRP or PVC with maximum flame-spread index of 5 - 25 according to ASTM E84.
2. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
3. Configuration: Multipass, designed and tested to reduce water carryover to achieve performance indicated.

K. Air-Intake Louvers:

1. Material: FRP, PVC or Matching casing, as directed.
2. UV Treatment: Treat louvers with inhibitors to protect against damage caused by UV radiation.
3. Louver Blades: Arranged to uniformly direct air into evaporative refrigerant condenser, to minimize air resistance, and to prevent water from splashing out during all modes of operation including operation with fans off.

L. Axial Fan: Balanced at the factory after assembly.

1. Blade Material: Aluminum, FRP or Galvanized steel, as directed.
2. Hub Material: Aluminum, FRP, Galvanized steel, as directed.
3. Blade Pitch: Field adjustable.
4. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens, complying with OSHA regulations.
5. Fan Shaft Bearings: Self-aligning, grease-lubricated ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C). Bearings designed for an L-10 life of 40,000 - 50,000 hours.
6. Grease Fittings for Bearings: Extended lubrication lines to an easily accessible location.

M. Belt Drive:

1. Service Factor: 1.5 based on motor nameplate horsepower.
2. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
3. Belt: Multiple V-belt design with a matched set of cogged belts.
4. Belt: One-piece, multigrooved, solid-back belt.
5. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
6. Belt-Drive Guard: Comply with OSHA regulations.

N. Fan Motor:

1. General Requirements for Fan Motors: Comply with NEMA designation and temperature-rating requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment" and not indicated below.
2. Motor Enclosure: As directed.
3. Energy Efficiency: Comply with ASHRAE/IES 90.1 or NEMA Premium Efficient.
4. Service Factor: 1.15.
5. Insulation: Class F or Class H.
6. Variable-Speed Motors: Inverter-duty rated according to NEMA MG-1.
7. Severe-duty rating with the following features:

    a. Rotor and stator protected with corrosion-inhibiting epoxy resin.
    b. Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C).
    c. Internal heater automatically energized when motor is de-energized.

8. Motor Base: Adjustable, or other suitable provision for adjusting belt tension.

O. Fan Discharge Stack: Material shall match casing, manufacturer's standard or velocity recovery design.

1. Stack Extension: Fabricated to extend above fan deck unless otherwise indicated.
2. Stack Termination: Wire-mesh, galvanized-steel screens, complying with OSHA regulations.

P. Vibration Switch: For each fan drive.

1. Enclosure: NEMA 250, Type 4 or Type 4X.
2. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Evaporative refrigerant condenser manufacturer shall recommend switch set point for proper operation and protection.
3. Provide switch with manual-reset button for field connection to a DDC system for HVAC and hardwired connection to fan motor electrical circuit.
4. Switch shall, on sensing excessive vibration, signal an alarm through the DDC system for HVAC and shut down the fan.

Q. Controls: Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."

R. Control Package: Factory installed and wired, and functionally tested at factory before shipment.

1. NEMA 250, Type 3R, Type 4, Type 4X or as directed, enclosure with removable internally mount backplate.
2. Control-circuit transformer with primary and secondary side fuses.
3. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
4. Microprocessor-based controller for automatic control of fan and spray pump based on evaporative refrigerant condenser leaving-water temperature, with control features to improve operating efficiency based on outdoor ambient wet-bulb temperature by using adaptive logic.
5. Fan motor sequencer for multiple-cell and two-speed applications with automatic lead-stage rotation.
6. Electric basin heaters with temperature-control and low-water-level safety switch for each cell, complying with requirements in "Electric Basin Heater" Paragraph above.
7. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph above.
8. Single-point, field-power connection to a fused disconnect switch, nonfused disconnect switch, circuit breaker or for each evaporative refrigerant condenser cell, as directed.

    a. Branch power circuit to each motor and electric basin heater and to controls with a disconnect switch or circuit breaker.
    b. NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor. Provide variable-frequency controller with manual bypass and line reactors for each variable-speed motor indicated.

9. Factory-installed wiring outside of enclosures shall be in metal raceway, except make connections to each motor and electric basin heater with liquidtight conduit.
10. Visual indication of status and alarm with momentary test push button for each motor.
11. Audible alarm and silence switch.
12. Visual indication of elapsed run time, graduated in hours for each motor.
13. Evaporative refrigerant condenser shall have hardware to enable DDC system for HVAC to remotely monitor and display the following:

    a. Operational status of each motor.

b. Evaporative refrigerant condenser leaving-fluid temperature.
c. Fan vibration alarm.
d. Collection basin high, low or high and low water-level alarms, as directed.

S. Personnel Access Components:

1. Doors: Large enough for personnel to access evaporative refrigerant condenser internal components from both evaporative refrigerant condenser end walls. Doors shall be operable from both sides of the door.
2. External Ladders with Safety Cages: Aluminum, galvanized- or stainless steel, fixed ladders with ladder extensions to access external platforms and top of evaporative refrigerant condenser from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.
3. External Platforms with Handrails: Aluminum, FRP, or galvanized-steel bar grating at evaporative refrigerant condenser access doors when evaporative refrigerant condensers are elevated and not accessible from grade.
4. Handrail: Aluminum, galvanized steel, or stainless steel, complete with kneerail and toeboard at platforms, and around top of evaporative refrigerant condenser. Comply with 29 CFR 1910.23.
5. Internal Platforms: Aluminum, FRP, or galvanized-steel bar grating.

    a. Spanning the collection basin from one end of evaporative refrigerant condenser to the other and positioned to form a path between the access doors. Platform shall be elevated, so that all parts are above the high-water level of the collection basin.
    b. Elevated internal platforms with handrails accessible from fixed vertical ladders to access the fan drive assembly when out of reach from collection basin platform.

T. Capacities and Characteristics:

1. Number of Cells: As directed.
2. Maximum Drift Loss: 0.005 percent of design water flow, as directed.
3. Heat-Exchanger Coil:

    a. Refrigerant Type: R-407C, R-410A or HFC-134a, as directed.
    b. Minimum Heat Rejection: As directed, Btu/h (kW).
    c. Condensing Temperature: As directed, deg F (deg C).
    d. Entering-Air Wet-Bulb Temperature: As directed deg F (deg C).

4. Fan Motor:

    a. Type: Single speed, Two speed, single winding, Two speed, two winding or Variable speed, as directed.
    b. Horsepower/Cell: As directed, hp.
    c. Full-Load Ampacity: As directed, A.
    d. Minimum Circuit Ampacity: As directed, A.
    e. Maximum Overcurrent Protection Device: As directed, A.
    f. Electrical Characteristics: 208, 240 or 480 V ac, three phase, 60 Hz, as directed.

5. Spray Pump and Motor:

    a. Water Flow/Cell: As directed, gpm (L/s).

b. Horsepower/Cell: As directed, hp.
c. Full-Load Ampacity: As directed A.
d. Minimum Circuit Ampacity: As directed, A.
e. Maximum Overcurrent Protection Device: As directed, A.
f. Electrical Characteristics: 120, 208, 240, 277 or 480 V ac; single or three phase, 60 Hz, as directed.

6. Sound Pressure Level: As directed, when measured according to CTI ATC 128.
7. Basin Heater:

a. Basin Water Temperature: 40 deg F (5 deg C).
b. Outdoor Ambient Temperature: 0 deg F (Minus 18 deg C) or Minus 20 deg F (Minus 29 deg C).
c. Capacity/Cell: As directed. kW.
d. Full-Load Ampacity: As directed, A.
e. Minimum Circuit Ampacity: As directed, A.
f. Maximum Overcurrent Protection Device: As directed, A.
g. Electrical Characteristics: 208, 240, 480 V ac, three phase, 60 Hz, as directed.
h. Capacity/Cell: As directed, MBtu/h (kW).
i. Entering-Fluid Temperature: As directed, deg F (deg C).
j. Fluid Flow Rate: As directed, gpm (L/s).
k. Fluid Pressure Drop: As directed, psig (kPa).
l. Capacity/Cell: As directed, MBtu/h (kW).
m. Steam Flow: As directed, lb/h (L/s).
n. Steam Pressure: As directed, psig (kPa).

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment Mounting:

1. Install evaporative refrigerant condensers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." Or Section 033053 "Miscellaneous Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

B. Maintain manufacturer's recommended clearances for service and maintenance.

C. Loose Equipment: Install electrical components, devices, and accessories that are not factory mounted.

D. Adjust water-level control for proper operating level.

3.2 PIPING CONNECTIONS

A. Install piping adjacent to evaporative refrigerant condensers to allow service and maintenance.

B. Install flexible pipe connectors at final connection of evaporative refrigerant condensers mounted on vibration isolators.

C. Run overflow, drain, and bleed lines to sanitary sewage system.

D. Domestic Water Piping: Comply with requirements in Section 221116 "Domestic Water Piping." Connect to water-level control with shutoff valve and union or flange at each connection.

E. Refrigerant Piping: Comply with requirements in Section 232300 "Refrigerant Piping." Connect to evaporative refrigerant condenser coil with isolation valves at each connection.

F. Ducts: Comply with requirements in Section 233113 "Metal Ducts." Connect ducts to evaporative refrigerant condenser inlet and outlet, full size of outlet, with flexible duct connection.

3.3 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.
3. Locate nameplate where easily visible.

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between control devices.

C. Connect control wiring according to Section 260523 "Control Voltage Electrical Power Cables."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Leak Test: After installation, fill water coils with water, and test coils and connections for leaks. Repair leaks and retest until no leaks exist.
2. Charge refrigerant coils with refrigerant and test for leaks. Repair leaks and retest until no leaks exist.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Evaporative refrigerant condenser will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.

B. Obtain performance tables from manufacturer.

C. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing of evaporative refrigerant condensers.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train or train Owner's maintenance personnel to adjust, operate, and maintain evaporative refrigerant condensers.

END OF SECTION 236333

SECTION 236413.13 - DIRECT-FIRED ABSORPTION WATER CHILLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Packaged, water-cooled, direct-fired absorption water chillers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings:

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Insulated Surface Diagrams: Indicating cold and hot surfaces requiring field-applied insulation with surface area tabulated for each.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, or BIM model, drawn to scale and coordinated with all building trades.

B. Seismic Qualification Data: Certificates, for chillers, accessories, and components, from manufacturer.

C. Source quality-control reports.

D. Startup service reports.

E. Test and inspection startup reports.

F. Field quality-control reports.

G. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.

B. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of chillers that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Year(s) from date of Substantial Completion, as directed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. AHRI Rating: Rate chiller performance in accordance with requirements in AHRI 560.

B. ASHRAE Compliance:

1. ASHRAE 15 and ASHRAE 34 for safety code for mechanical refrigeration.
2. ASHRAE/IES 90.1.

C. ASME Compliance: Fabricate and label chiller pressure vessels to comply with applicable portions of ASME Boiler and Pressure Vessel Code.

D. Comply with NFPA 70.

E. UL Compliance:

1. Comply with requirements of UL and UL Canada and include label by qualified testing agency showing compliance.
2. UL 726, "Oil-Fired Boiler Assemblies.", UL 795, "Commercial-Industrial Gas Heating Equipment.", UL 726, "Oil-Fired Boiler Assemblies"; and UL 795, "Commercial-Industrial Gas Heating Equipment.", as directed.

F. Seismic Performance: Direct-fired absorption water chillers shall withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7, as directed.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

G. Condenser-Liquid Temperature Performance:

1. Startup Condenser-Liquid Temperature: Provide chiller capable of starting with entering condenser-liquid temperature of 60 deg F (16 deg C) and providing stable operation until system temperature is elevated to manufacturer's recommended minimum operating entering condenser-liquid temperature.
2. Minimum Operating Condenser-Liquid Temperature: Provide chiller capable of continuous operation over entire capacity range indicated with entering condenser-liquid temperature of 70 deg F (21 deg C).
3. Make factory modifications to standard chiller design if necessary to comply with performance indicated.

H. Site Altitude: Provide chiller suitable for altitude at which it is installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.

I. Performance Tolerance: Comply with the following in lieu of AHRI 560:

1. Allowable Capacity Tolerance: Zero percent, as directed
2. Allowable IPLV/NPLV Performance Tolerance: Zero percent, as directed

2.3 CAPACITIES AND CHARACTERISTICS

A. Capacity: As directed, tons (kW).

B. Full-Load Efficiency (COP): As directed.

C. Part-Load Efficiency (IPLV) or (NPLV): As directed

D. Evaporator:

1. Pressure Rating: 150 psig (1035 kPa) or 300 psig (2070 kPa), as directed.
2. Number of Passes: Two, Three or Four, as directed.
3. Liquid Type: Water.
4. Design Liquid Flow Rate: As directed, gpm (L/s).
5. Minimum Liquid Flow Rate: As directed, gpm (L/s).
6. Entering-Liquid Temperature: As directed, deg F (deg C).
7. Leaving-Liquid Temperature: As directed, deg F (deg C).
8. Liquid Pressure Drop: As directed, feet of head (kPa).
9. Liquid Velocity: As directed, fps (m/s).

10. Fouling Factor: 0.0001 sq. ft. x h x deg F/Btu (0.000018 sq. m x deg C/W), 0.00025 sq. ft. x h x deg F/Btu (0.000045 sq. m x deg C/W) or 0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W), as directed.

E. Absorber/Condenser:

1. Pressure Rating: 150 psig (1035 kPa) or 300 psig (2070 kPa), as directed.
2. Number of Passes: One, Two or Three, as directed.
3. Liquid Type: Water.
4. Design Liquid Flow Rate: As directed, gpm (L/s).
5. Entering-Liquid Temperature: As directed, deg F (deg C).
6. Leaving-Liquid Temperature: As directed, deg F (deg C).
7. Liquid Pressure Drop: As directed, feet of head (kPa).
8. Liquid Velocity: As directed, fps (m/s).
9. Fouling Factor: 0.00025 sq. ft. x h x deg F/Btu (0.000045 sq. m x deg C/W), 0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W) or 0.001 sq. ft. x h x deg F/Btu (0.00022 sq. m x deg C/W), as directed.

F. Dedicated Hot-Water Heat Exchanger:

1. Capacity: As directed, MBtu/h (kW).
2. Pressure Rating: 150 psig (1035 kPa) or 300 psig (2070 kPa), as directed.
3. Number of Passes: One, Two, Three or Four, as directed.
4. Liquid Type: Water.
5. Design Liquid Flow Rate: As directed, gpm (L/s).
6. Entering-Liquid Temperature: As directed, deg F (deg C).
7. Leaving-Liquid Temperature: As directed, deg F (deg C).
8. Liquid Pressure Drop: As directed, feet of head (kPa).
9. Liquid Velocity: As directed, fps (m/s).
10. Fouling Factor: 0.0001 sq. ft. x h x deg F/Btu (0.000018 sq. m x deg C/W), 0.00025 sq. ft. x h x deg F/Btu (0.000045 sq. m x deg C/W) or 0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W), as directed.

G. Burner Blower:

1. Motor Horsepower: As directed.
2. RPM: As directed.

H. Pump Horsepower:

1. Purge: As directed.
2. Refrigerant: As directed.
3. Solution: As directed.

I. Chiller Control Electrical Requirements:

1. Power Input: As directed.
2. Minimum Circuit Ampacity: As directed, A.

3. Maximum Overcurrent Protection Device: As directed, A.
4. Characteristics: 120 V ac, single phase, 60 Hz, as directed.

J. Chiller Electrical Requirements:

1. Power Input: As directed.
2. Minimum Circuit Ampacity: As directed.
3. Maximum Overcurrent Protection Device: As directed.
4. Characteristics: 208, 240 or 480 V ac, three phase, 60 Hz, as directed.

K. Natural-Gas Heating Value: As directed, Btu/cu. ft. (kJ/L).

L. Natural Gas Input, Full-Fire: As directed, cfh (mL/s).

M. Fuel-Oil Heating Value: As directed, Btu/gal. (MJ/L).

N. Fuel-Oil Input, Full Fire: As directed, gph (mL/s).

O. Sound Power Level Rating: 80 – 85 dBA sound power level when measured in accordance with AHRI 575. Provide factory-installed sound attenuation treatment if necessary to achieve performance indicated.

2.4 MANUFACTURED UNIT

A. Description: Factory-assembled and -tested, hermetic-design chiller, complete with absorber, evaporator, condenser, generator, solution heat exchanger, controls, absorbent solution pump with motor, refrigerant pump with motor, purge unit with motor, burner assembly, motor controllers, rupture disk, interconnecting unit piping and wiring, indicated accessories, and mounting frame.

1. Disassemble chiller into major assemblies, as required for installation, after factory testing and before packaging for shipment.

B. Absorbent and Refrigerant:

1. Absorbent: Lithium bromide solution with corrosion inhibitor.
2. Refrigerant: Deionized or distilled water.
3. Performance Enhancer: Heat and mass transfer enhancer to improve performance.

C. Seismic Fabrication Requirements: Fabricate mounting base and attachment to chiller, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC" when mounting base is anchored to building structure.

2.5 PUMPS

A. Hermetically sealed, self-lubricating, and fitted with self-adjusting, spring-loaded, wear-compensating, tapered carbon bearings.

B. Pump motor assembly shall be designed to operate for not less than 50,000 hours between inspections.

C. Pump motors shall be cooled and bearings lubricated, by fluid being pumped.

D. Provide isolation valves at pump suction and discharge.

E. Provide separate pumps for absorbent solution and refrigerant.

1. Provide chiller manufacturer's recommended absorbent solution and refrigerant flow-control method, to comply with operating requirements indicated.

F. Purge System: Unit mounted and factory wired, equipped with controls and pump to automatically remove noncondensable vapors.

1. Purge Pump Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

a. Enclosure: Open dripproof or totally enclosed.

2.6 HEAT-EXCHANGER SHELLS

A. Configuration: Two shells; one shell consists of absorber/evaporator, low-stage generator/condenser; and one shell consists of high-stage generator. Where indicated, equip chiller with dedicated hot-water heat exchanger.

B. Construction: Fabricated from continuously welded carbon-steel sheet or plate, or from seamless pipe.

C. Design Pressure and Temperature Rating: Comply with applicable requirements in ASME Boiler and Pressure Vessel Code.

D. End Tube Sheets: Carbon-steel plates continuously welded to each end of shell; drilled and reamed to accommodate tubes, with positive seal between liquid in tubes and refrigerant in shell.

E. Intermediate Tube Sheets: Carbon-steel plates installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid tube contact resulting in abrasion and wear.

F. Generator/Condenser Shell Pressure Relief Device: Manufacturer's standard rupture disk complying with requirements in ASHRAE 15 and ASHRAE 34, and in applicable portions of ASME Boiler and Pressure Vessel Code.

2.7 ABSORBER

A. Nozzle or Dispersion Trays: Designed to evenly distribute absorbent solution over tubes; constructed of brass, stainless steel, or another material that will not corrode.

B. Tubes:

1. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end without damage to tube sheets and other tubes.
2. Material: Copper or copper-nickel alloy.
3. Minimum Wall Thickness: Manufacturer's choice, 0.025 inch (0.6 mm), 0.028 inch (0.7 mm) or 0.035 inch (0.9 mm), as directed.
4. External Finish: Manufacturer's standard.
5. Internal Finish: Enhanced or smooth.

C. Water Boxes:

1. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from each end without disturbing refrigerant in shell.
2. Standard or Marine-type water box with piping connections.

    a. Water boxes and marine-type water-box covers with lifting lugs or eyebolts.
    b. Hinged water boxes.
    c. Hinged marine-type water-box covers.

3. Standard water box without piping connections.

    a. Water boxes with lifting lugs or eyebolts.
    b. Hinged water boxes.

4. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange, Welded, ASME B16.5, raised-face flange, grooved for mechanical-joint coupling or Grooved with mechanical-joint coupling and flange adapter, as directed.
5. Thermistor or RTD temperature sensor factory installed in each nozzle.
6. Fit each water box with 3/4-inch (19-mm) or 1-inch (25-mm)drain connection at low point and vent connection at high point, each with threaded plug.

D. Additional Corrosion Protection:

1. Electrolytic corrosion-inhibitor anode.
2. Coat wetted surfaces with corrosion-resistant finish.
3. Using same material as tubes, clad surfaces of end tube sheets in contact with liquid. Coat other wetted surfaces, including water boxes, with corrosion-resistant finish.

E. Absorber/Condenser Crossover Piping: Factory-furnished and -installed piping connecting liquid connection of absorber discharge to inlet connection of condenser.

2.8 EVAPORATOR

A. Nozzle or Dispersion Trays: Designed to evenly distribute refrigerant over tubes; constructed of brass, stainless steel, or another material that will not corrode when exposed to absorbent.

B. Refrigerant Holding Pan: Steel or stainless steel.

C. Tubes:

1. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end without damage to tube sheets, other tubes, and integrity of tube-tube sheet connections.
2. Material: Copper or copper-nickel alloy.
3. Minimum Wall Thickness: Manufacturer's choice, 0.025 inch (0.6 mm), 0.028 inch (0.7 mm) or 0.035 inch (0.9 mm), as directed.
4. External Finish: Manufacturer's standard.
5. Internal Finish: Enhanced or smooth.

D. Water Boxes:

1. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
2. Standard or Marine-type water box with piping connections.

    a. Water boxes and marine-type water-box covers with lifting lugs or eyebolts.
    b. Hinged water boxes.
    c. Hinged marine-type water-box covers.

3. Standard water box without piping connections.

    a. Water boxes with lifting lugs or eyebolts.
    b. Hinged water boxes.
    c. Hinged marine water-box covers.

4. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange, Welded, ASME B16.5, raised-face flange, grooved for mechanical-joint coupling or Grooved with mechanical-joint coupling and flange adapter, as directed.
5. Thermistor or RTD temperature sensor factory installed in each nozzle.
6. Fit each water box with 3/4-inch (19-mm) or 1-inch (25-mm) drain connection at low point and vent connection at high point, each with threaded plug.

2.9 CONDENSER

A. Refrigerant Holding Pan: Steel or stainless steel.

B. Tubes:

1. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end without damage to tube sheets and other tubes.
2. Material: Copper or copper-nickel alloy.
3. Minimum Wall Thickness: Manufacturer's choice, 0.025 inch (0.6 mm), 0.028 inch (0.7 mm) or 0.035 inch (0.9 mm), as directed.
4. External Finish: Manufacturer's standard.
5. Internal Finish: Enhanced or smooth.

C. Water Boxes:

1. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
2. Standard or Marine-type water box with piping connections.
    a. Water boxes and marine-type water-box covers with lifting lugs or eyebolts.
    b. Hinged water boxes.
    c. Hinged marine-type water-box covers.
3. Standard water box without piping connections.
    a. Water boxes with lifting lugs or eyebolts.
    b. Hinged water boxes.
    c. Hinged marine water-box covers.
4. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange, Welded, ASME B16.5, raised-face flange, grooved for mechanical-joint coupling or Grooved with mechanical-joint coupling and flange adapter, as directed.
5. Thermistor or RTD temperature sensor factory installed in each nozzle.
6. Fit each water box with 3/4-inch (19-mm) or 1-inch (25-mm) drain connection at low point and vent connection at high point, each with threaded plug.

D. Additional Corrosion Protection:

1. Electrolytic corrosion-inhibitor anode.
2. Coat wetted surfaces with corrosion-resistant finish.
3. Using same material as tubes, clad surfaces of end tube sheets in contact with liquid. Coat other wetted surfaces, including water boxes, with corrosion-resistant finish.

2.10 FIRST-STAGE GENERATOR

A. Tubes:

1. Replaceable, straight, or U tubes expanded into tube sheets.
2. Material: Manufacturer's standard or steel, as directed.
3. Minimum Wall Thickness: Manufacturer's choice.
4. External Finish: Manufacturer's standard.
5. Internal Finish: Manufacturer's choice; enhanced or smooth.

B. Water Boxes:

1. Carbon-steel construction; arranged to allow visual inspection and cleaning of tubes from each end without disturbing refrigerant in shell.
2. Standard water box.
3. Water boxes with lifting lugs or eyebolts.
4. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange, Welded, ASME B16.5, raised-face flange, grooved for mechanical-joint coupling or Grooved with mechanical-joint coupling and flange adapter.
5. Thermistor or RTD temperature sensor factory installed in each nozzle.
6. Fit each water box with 3/4-inch (19-mm) or 1-inch (25-mm) drain connection at low point and vent connection at high point, each with threaded plug.

2.11 SECOND-STAGE GENERATOR

A. Tubes:

1. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from each end without damage to tube sheets and other tubes.
2. Material: Copper or copper-nickel alloy.
3. Minimum Wall Thickness: Manufacturer's choice, 0.025 inch (0.6 mm), 0.028 inch (0.7 mm) or 0.035 inch (0.9 mm).
4. External Finish: Manufacturer's standard.
5. Internal Finish: Manufacturer's standard.

B. Water Boxes:

1. Carbon-steel construction; arranged to allow visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
2. Standard type.
3. Water boxes with lifting lugs or eyebolts.
4. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange, Welded, ASME B16.5, raised-face flange, grooved for mechanical-joint coupling or Grooved with mechanical-joint coupling and flange adapter.
5. Thermistor or RTD temperature sensor factory installed in each nozzle.
6. Fit each water box with 3/4-inch (19-mm) or 1-inch (25-mm) drain connection at low point and vent connection at high point, each with threaded plug.

2.12 DEDICATED HOT-WATER HEAT EXCHANGER

A. Tubes:

1. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from each end without damage to tube sheets and other tubes.
2. Material: Copper or copper-nickel alloy.
3. Minimum Wall Thickness: Manufacturer's choice.
4. External Finish: Manufacturer's standard.
5. Internal Finish: Manufacturer's standard.

B. Water Boxes:

1. Carbon-steel construction; arranged to allow visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
2. Standard type.
3. Water boxes with lifting lugs or eyebolts.
4. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange, Welded, ASME B16.5, raised-face flange, Grooved for mechanical-joint coupling or Grooved with mechanical-joint coupling and flange adapter, as directed.
5. Thermistor or RTD temperature sensor factory installed in each nozzle.
6. Fit each water box with 3/4-inch (19-mm) or 1-inch (25-mm) drain connection at low point and vent connection at high point, each with threaded plug.

2.13 SOLUTION HEAT EXCHANGER

A. Description: Shell-and-tube or brazed-plate heat exchanger, integral to chiller, to increase cycle efficiency by preheating diluted solution on its way to generator while precooling concentrated solution returning from generator.

2.14 BURNER ASSEMBLY

A. Burner: Welded construction with multivane, stainless steel, flame-retention diffuser suitable for natural gas, propane and No. 2 fuel oil. Mount burner on hinged access door to permit access to combustion chamber.

B. Combustion-Air Blower: Centrifugal fan integral to burner, directly driven by motor; with adjustable damper assembly and locking quadrant to set air-fuel ratio.

1. Motors: Comply with requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

C. Fuel-Oil Supply: Control devices and modulating control sequence suitable to comply with requirements of ASME CSD-1, FM Global or UL.

1. Fuel-Oil Pump: Two-stage, gear-type oil pump capable of producing 300-psig (2070-kPa) discharge pressure and 15-in. Hg (50.7-kPa) vacuum.
2. Fuel-Oil Piping Specialties:

a. Suction-line, manual, gate valve.
b. Removable-mesh oil strainer.
c. 0- to 30-in. Hg (0- to 101.3-kPa) vacuum; 0- to 30-psig (0- to 207-kPa) vacuum-pressure gauge.
d. 0- to 300-psig (0- to 2070-kPa) oil-nozzle pressure gauge.
e. Nozzle-line, solenoid-safety-shutoff oil valve.

D. Fuel-Oil Pilot: Intermittent or Interrupted electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff solenoid with cadmium sulfide, UV scanner or Optical flame-safety control.

E. Gas Train: Control devices and modulating control sequence to comply with requirements of ASME CSD-1, FM Global or UL.

F. Gas Pilot: Intermittent or Interrupted electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.

G. Equip burner assembly to limit nitrogen oxide emissions to 20 – 30 ppm.

2.15 ELECTRICAL

A. Factory installed and wired, and functionally tested at factory before shipment.

B. Single-point, field-power connection to fused disconnect switch, nonfused disconnect switch or circuit breaker, as directed. Provide electrical devices with minimum withstand rating as required by electrical power distribution system, but not less than 42,000 - 65,000 A.

1. Branch power circuit to each motor, dedicated electrical load, and to controls with disconnect switch or circuit breaker.

a. NEMA KS 1, heavy-duty fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection in accordance with IEC 60947-4-1.
b. NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit-trip set point.

2. NEMA ICS 2, Class A, full-voltage, non-reversing motor controller, with hand-off-auto switch, and overcurrent protection for each motor.
3. Control-circuit transformer with primary and secondary side fuses.

C. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Include spare wiring terminal block for connection to external controls or equipment.

D. Wiring Outside of Enclosures: Factory installed in metal raceway except make terminal connections with not more than 24-inch (610-mm) length of liquidtight or flexible metallic conduit. Coordinate conduit requirements with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

2.16 CONTROLS

A. Provide chiller control panel separate from burner control panel.

B. Burner Control Panel: Factory or field mounted. Maintains safe operating conditions, burner safety limits, burner operation, and interface with chiller controls; include following components:

1. On-off switch.
2. Flame safeguard.
3. Contacts for remote monitoring of flame failure.
4. Contacts for proof of combustion-air flow.
5. Exhaust gas temperature limit switch.
6. Control-circuit transformer.
7. Burner motor controls.
8. Fuel-oil pump controls, if chiller is equipped with fuel-oil pump.
9. Visual indication of on/off status of ignition, blower, and main fuel.
10. Alarm bell.

C. Control: Standalone and microprocessor based, with programs and configuration settings stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.

D. Enclosure: Unit mounted, NEMA 250, Type 1, Type 3R, Type 4 or Type 4x, with hinged or lockable cover.

E. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. Display following information in either imperial or metric units selectable through interface:

1. Date and time.
2. Operating or alarm status.
3. Cumulative operating hours.
4. Outdoor-air temperature if required for chilled-water temperature reset.
5. Operating set points for temperature and pressure.
6. Entering and leaving temperatures of chilled and condenser water.
7. Refrigerant temperature.
8. Solution concentration and temperature.
9. Indication of solution and purge-pump operation.
10. Generator shell pressure.

11. Number of starts.
12. Number of purge cycles.
13. Entering and leaving hot-water temperatures.
14. Burner firing rate displayed in percent.

F. Control Functions:

1. Manual or automatic startup and shutdown time schedule.
2. Automatic cycle to prevent crystallization.
3. Entering and leaving chilled-water temperatures and control set points. Reset chilled-water temperature set point based on return-water, outdoor-air or space temperature, as directed.
4. Entering and leaving hot-water temperatures and control set points. Reset hot-water temperature based on return-water, outdoor-air or space temperature, as directed
5. Condenser-liquid temperature.
6. Measure and record cooling provided and heating energy consumed within programmable time periods, minimum monthly.
7. Measure and record heating provided and heating energy consumed within programmable time periods, minimum monthly.

G. Capacity Control: Automatically controls burner firing rate to maintain chilled-water temperature set point for cooling loads and heating-water temperature set point for heating loads ranging from 30 to 100 percent.

H. Safety Shutdowns: To automatically shut down chiller and require manual reset before restart. Display message following each safety shutdown.

1. Crystallization.
2. Low refrigerant temperature.
3. Loss of chilled- or condenser-water flow.
4. Low leaving chilled-water temperature, 2 deg F (1 deg C) below set point.
5. First-stage generator low-solution level.
6. First-stage generator high temperature or pressure.
7. Burner alarm or control malfunction.
8. Power failure.
9. Solution pump overloads.
10. External auxiliary safety shutdown.
11. High solution concentration.
12. Incomplete dilution cycle.

I. Warning Conditions: Provide controls to keep chiller operational, but inhibit burner firing rate to prevent safety shutdown. Provide control panel with warning alarm contacts and display message when any of following operating conditions are detected:

1. Low refrigerant temperature.
2. High generator temperature or pressure.
3. High or low entering condenser-water temperature.
4. Solution temperature sensor failure.

5. Low chilled-water flow.
6. Purge-pump current overload.

J. Cycling Shutdowns: Permit automatic restart when preprogrammed limits are reached. Display message following each cycle shutdown.

1. Cooling Mode:

a. Loss of condenser-water flow.
b. Low leaving chilled-water temperature.
c. Power failure.

2. Heating Mode:

a. Loss of hot-water flow.
b. High leaving hot-water temperature.
c. Power failure.

K. Trending: Capability to trend analog data up to five parameters simultaneously over adjustable period and frequency of polling.

L. Security Access: Provide electronic security access to controls through identification and password with at least three levels of security: view only; view and operate; and view, operate, and service.

M. Control Authority: At least four conditions: off, local manual control at chiller, local automatic control at chiller, and automatic control through remote source.

N. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting printer or electronic monitoring device.

O. BAS Interface: Factory-installed hardware and software to enable BAS to monitor, control, and display chiller status and alarms.

1. Hardwired Points:

a. Monitoring: On-off status, common trouble alarm.
b. Control: On-off operation, chilled-water, discharge temperature set-point adjustment or hot-water, discharge temperature set-point adjustment.

2. Provide ASHRAE 135 (BACnet), LonTalk or Modbus, as directed for communication interface with BAS to enable BAS operator to control and monitor chiller from remote operator workstation. Provide for control features and monitoring points displayed locally at chiller control panel to be available through BAS.

2.17 FINISH

A. Paint chiller, using manufacturer's standard procedures, except comply with the following minimum requirements:

1. Provide at least one coat of primer with total dry film thickness of at least 2 mils (0.05 mm).
2. Provide at least two coats of alkyd-modified, vinyl enamel, epoxy or polyurethane, as directed to finish with total dry film thickness of at least 4 mils (0.10 mm).
3. Paint surfaces that are to be insulated before applying insulation.
4. Paint installed insulation to match adjacent uninsulated surfaces.
5. Color of finish coat to be manufacturer's standard or as directed.

B. Furnish Owner with quart container of paint used in application of topcoat to use in touchup applications after Project closeout.

2.18 ACCESSORIES

A. Sight Glasses: Equip unit with sight glasses for visual inspection of absorbent solution and refrigerant levels. Provide at least one sight glass in absorber and evaporator sections.

B. Flow Switches:

1. Furnish chiller manufacturer-supplied flow switch for each condenser or evaporator and condenser and verify field-mounting location before installation.
2. Paddle Flow Switches:

    a. Vane operated to actuate double-pole, double-throw switch with one pole field wired to chiller control panel and other pole field wired to BAS.
    b. Contacts: Platinum alloy, silver alloy, or gold-plated switch contacts with 10 A rating at 120 V ac.
    c. Pressure rating equal to pressure rating of heat exchanger.
    d. Construct body and wetted parts of Type 316 stainless steel.
    e. House switch in NEMA 250, Type 4 enclosure constructed of die-cast aluminum.
    f. Vane length to suit installation.

3. Pressure Differential Switches:

    a. Construction: Wetted parts of body and trim constructed of Type 316 stainless steel.
    b. Performance: Switch suitable to withstand, without damage, full-pressure rating of heat exchanger applied to either port and exhibit no set point shift due to variation in working pressure.
    c. Set Point: Screw type, field adjustable.
    d. Electrical Connections: Internally mounted, screw-type terminal blocks.
    e. Switch Enclosure: NEMA 250, Type 4.

f. Switch Action: Double-pole, double-throw switch with one pole field wired to chiller control panel and other pole field wired to BAS.

C. Vibration Isolation:

1. Chiller-manufacturer-furnished, neoprene-pad vibration isolation for each chiller.

a. Two layers of 0.375-inch- (10-mm-) thick, ribbed- or waffle-pattern neoprene pads separated by 16-gauge, stainless steel plate.
b. Fabricate pads from 40- to 50-durometer neoprene.
c. Provide stainless steel square bearing plate to load pad uniformly between 20 and 40 psi (138 and 276 kPa) with 0.12- to 0.16-inch (3- to 4-mm) deflection.

2.19 SOURCE QUALITY CONTROL

A. Perform functional run tests of chillers before shipping.

B. Factory test and inspect absorber, generator, evaporator, and condenser in accordance with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Pressure test tube-side of heat exchangers, including water boxes, to 1.5 times rated pressure. Vacuum and pressure test shells for leaks.

C. Burner Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion requirements indicated.

D. Allow Owner access to place where chillers are being tested. Notify Architect 14 days in advance of testing.

E. Prepare and submit test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

PART 3 - EXECUTION

3.1 INSTALLATION OF CHILLER

A. Examine chillers before installation. Reject chillers that are physically damaged.

B. Install chillers on support structure indicated.

C. Equipment Mounting:

1. Install chillers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." Or Section 033053 "Miscellaneous Cast-in-Place Concrete."

2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

D. Maintain manufacturer's recommended clearances for service and maintenance.

E. Charge chiller with absorbent and refrigerant if not factory charged.

F. Install separate devices furnished by manufacturer and not factory installed.

G. Insulate hot and cold chiller surfaces that are recommended by chiller manufacturer to be insulated, and are not factory insulated. Comply with requirements in Section 230716 "HVAC Equipment Insulation."

3.2 PIPING CONNECTIONS

A. Comply with requirements for hydronic piping in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Comply with requirements for gas piping in Section 231123 "Facility Natural-Gas Piping" or Section 231126 "Facility Liquefied-Petroleum Gas Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

C. Connect fuel gas piping full size to gas-train inlet with shutoff valve and union.

D. Extend burner fuel train vent to suitable outdoor location, away from operable windows and air intakes.

E. Install gas-fired boilers in accordance with NFPA 54.

F. Comply with requirements for fuel-oil piping in Section 231113 "Facility Fuel-Oil Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

G. Connect oil piping full size to burner inlet with shutoff valve and union.

H. Install oil-fired chillers in accordance with NFPA 31.

I. Where installing piping adjacent to chiller, allow space for service and maintenance.

J. Hot-Water Heat-Exchanger Connections: Connect to heat-exchanger inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with shutoff valve and pressure gauge. Connect to heat-exchanger outlet with shutoff valve, check valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with shutoff valve and pressure gauge, flow meter, and drain connection with valve. Make connections to chiller with flange or mechanical coupling.

K. Evaporator-Liquid Connections: Connect to evaporator inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with shutoff valve and pressure gauge. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with shutoff valve and pressure gauge, flow meter, and drain connection with valve. Make connections to chiller with flange or mechanical coupling.

L. Absorber/Condenser-Liquid Connections: Connect to inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with shutoff valve and pressure gauge. Connect to outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with shutoff valve and pressure gauge, flow meter, and drain connection with valve. Make connections to chiller with flange or mechanical coupling.

1. If not factory furnished or installed, provide pipe connecting liquid connection of absorber discharge and condenser inlet.

M. Refrigerant Pressure Relief Device Connections: Extend vent piping or separate vent piping for each chiller without valves or restrictions to outdoor location. Comply with ASHRAE 15 and ASHRAE 34. Connect to chiller pressure relief device with flexible connector and dirt leg with drain valve.

N. Extend purge vent piping or separate purge vent piping for each chiller to outdoor location. Comply with ASHRAE 15 and ASHRAE 34.

O. Connect each chiller drain connection with union and drain pipe, and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection.

P. Comply with requirements for chimney system in Section 235133 "Insulated Sectional Chimneys" and Section 235116 "Fabricated Breechings and Accessories." Drawings indicate general arrangement of pipe, fittings, and specialties. Connect chimney system to chiller burner outlet and extend to outdoor location.

Q. Connect fuel-fired burner assembly and blower and associated damper for combustion air.

3.3 ELECTRICAL CONNECTIONS

A. Install electrical devices furnished with chiller but not factory mounted.

B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

D. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

E. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between control devices.

C. Connect control wiring in accordance with Section 260523 "Control Voltage Electrical Power Cables."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Absorption water chillers will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. Engage factory-authorized service representative to perform or Perform startup service.

1. Complete installation and startup checks in accordance with manufacturer's written instructions.
2. Verify that absorbent and refrigerant charge is sufficient and chiller has been leak tested.

3. Verify that pumps are installed and functional.
4. Verify that thermometers and gauges are installed.
5. Verify that refrigerant pressure relief device is vented to outdoors.
6. Verify proper motor rotation.
7. Operate chiller for run-in period.
8. Verify proper fuel supply. Adjust air-fuel ratio and combustion.
9. Verify proper combustion-air source.
10. Verify proper exhaust emissions.
11. Verify static deflection of vibration isolators including deflection during chiller startup and shutdown.
12. Verify and record performance of liquid flow and low-temperature interlocks for evaporator and condenser.
13. Verify and record performance of chiller protection devices.
14. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
15. Burner Test: Adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas.

B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assembly, installation, and connection.

C. Prepare test and inspection startup reports.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train or train Owner's maintenance personnel to adjust, operate, and maintain chillers. Video record training sessions.

END OF SECTION 236413.13

SECTION 236413.16 - INDIRECT-FIRED ABSORPTION WATER CHILLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Packaged, water-cooled, single- and double-effect absorption water chillers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings:

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Insulated Surface Diagrams: Indicating cold and hot surfaces requiring field-applied insulation with area tabulated for each.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, or BIM model, drawn to scale and coordinated with all building trades.

B. Seismic Qualification Data: Certificates, for chillers, accessories, and components, from manufacturer.

C. Source quality-control reports.

D. Startup service reports.

E. Test and inspection startup reports.

F. Field quality-control reports.

G. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.

B. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of chillers that fail in materials or workmanship within specified warranty period.

1. Warranty Period: As directed One, Two, Three, Four or Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. AHRI Rating: Rate chiller performance in accordance with requirements in AHRI 560.

B. ASHRAE Compliance:

1. ASHRAE 15 and ASHRAE 34 for safety code for mechanical refrigeration.
2. ASHRAE/IES 90.1.

C. ASME Compliance: Fabricate and label chiller pressure vessels to comply with applicable portions of ASME Boiler and Pressure Vessel Code.

D. Comply with NFPA 70.

E. UL Compliance:

1. Comply with requirements of UL and UL Canada and include label by a qualified testing agency showing compliance.

F. Seismic Performance: Indirect-fired absorption water chillers shall withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

G. Condenser-Liquid Temperature Performance:

1. Startup Condenser-Liquid Temperature: Provide chiller capable of starting with entering condenser-liquid temperature of 64 deg F (17.7 deg C) or 45 deg F (7.2 deg C) as directed and providing stable operation until system temperature is elevated to minimum operating entering condenser-liquid temperature.
2. Minimum Operating Condenser-Liquid Temperature: Provide chiller capable of continuous operation over entire capacity range indicated with an entering condenser-liquid temperature of 65 deg F (18 deg C), 60 deg F (16 deg C) or 55 deg F (13 deg C) as directed.
3. Make factory modifications to standard chiller design if necessary to comply with performance indicated.

H. Site Altitude: Provide chiller suitable for altitude at which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.

I. Performance Tolerance: Comply with following in lieu of AHRI 560:

1. Allowable Capacity Tolerance: Zero percent.
2. Allowable IPLV/NPLV Performance Tolerance: Zero percent.

2.3 CAPACITIES AND CHARACTERISTICS

A. Capacity: As directed tons (kW).

B. Full-Load Efficiency (COP): As directed.

C. Part-Load Efficiency (IPLV) or (NPLV): As directed.

D. Evaporator:

1. Pressure Rating: 150 psig (1035 kPa) or 300 psig (2070 kPa) As directed.
2. Number of Passes: One, Two or Three as directed.
3. Liquid Type: Water.
4. Design Liquid Flow Rate: As directed gpm (L/s).
5. Minimum Liquid Flow Rate: As directed gpm (L/s).
6. Entering-Liquid Temperature: As directed deg F (deg C).
7. Leaving-Liquid Temperature: As directed deg F (deg C).
8. Liquid Pressure Drop: As directed feet of head (kPa).
9. Liquid Velocity: As directed fps (m/s).
10. Fouling Factor: 0.0001 sq. ft. x h x deg F/Btu (0.000018 sq. m x deg C/W), 0.00025 sq. ft. x h x deg F/Btu (0.000045 sq. m x deg C/W) or 0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W) as directed.

E. Absorber/Condenser:

1. Pressure Rating: 150 psig (1035) or 300 psig (2070) as directed.
2. Number of Passes: One, Two or Three as directed.
3. Liquid Type: Water.
4. Design Liquid Flow Rate: As directed gpm (L/s).
5. Entering-Liquid Temperature: As directed deg F (deg C).
6. Leaving-Liquid Temperature: As directed deg F (deg C).
7. Liquid Pressure Drop: As directed feet of head (kPa).
8. Liquid Velocity: As directed fps (m/s).
9. Fouling Factor: As directed 0.00025 sq. ft. x h x deg F/Btu (0.000045 sq. m x deg C/W), 0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W) or 0.001 sq. ft. x h x deg F/Btu (0.00022 sq. m x deg C/W).

F. Pump Horsepower:

1. Purge: As directed.
2. Refrigerant: As directed.
3. Solution: As directed.

G. Chiller Control Electrical Requirements:

1. Power Input: As directed kilowatts.
2. Minimum Circuit Ampacity: As directed A.
3. Maximum Overcurrent Protection Device: As directed A.
4. Characteristics: 120 V ac, single phase, 60 Hz.

H. Chiller Electrical Requirements:

1. Power Input: As directed kilowatts.
2. Minimum Circuit Ampacity: As directed A.
3. Maximum Overcurrent Protection Device: As directed A.
4. Characteristics: As directed 208, 240 or 480 V ac, three phase, 60 Hz.

I. Noise Rating: As directed 38, 51 or 80 dBA sound power level when measured in accordance with AHRI 575. Provide factory-installed sound treatment if necessary to achieve performance indicated.

2.4 MANUFACTURED UNIT

A. Description: Factory-assembled and -tested, hermetic-design chiller complete with absorber, evaporator, condenser, generator, solution heat exchanger, controls, absorbent solution pump with motor, refrigerant pump with motor, purge unit with motor, motor controllers, rupture disk, interconnecting unit piping and wiring, indicated accessories, and mounting frame.

1. Disassemble chiller into major assemblies as required for installation, after factory testing and before packaging for shipment.

B. Absorbent and Refrigerant:

1. Absorbent: Lithium bromide solution with corrosion inhibitor.
2. Refrigerant: Deionized or distilled water.

3. Performance Enhancer: Heat and mass transfer enhancer to improve performance.

C. Seismic Fabrication Requirements: Fabricate mounting base and attachment to chiller, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC" when mounting base is anchored to building structure.

2.5 PUMPS

A. Hermetically sealed, self-lubricating, and fitted with self-adjusting, spring-loaded, wear-compensating tapered carbon bearings.

B. Provide pump motor assembly designed to operate for not less than 25,000 or 50,000 hours between inspections.

C. Pump motors cooled, and bearings lubricated, either by liquid being pumped.

D. Provide isolation valves at pump suction and discharge.

E. Provide separate and dedicated pumps for absorbent solution and refrigerant.

1. Provide chiller manufacturer's recommended absorbent solution and refrigerant flow-control method, to comply with operating requirements indicated.

F. Purge System: Unit mounted and factory wired, equipped with controls and pump to automatically remove noncondensable vapors.

1. Purge Pump Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

a. Enclosure: Open dripproof or totally enclosed.

2.6 HEAT-EXCHANGER SHELLS

A. Configuration for Single-Effect Chillers: Two shells; one shell consists of absorber/evaporator and other shell consists of condenser/generator.

B. Configuration for Double-Effect Chillers: Two shells; one shell consists of absorber/evaporator, low-stage generator/condenser and other shell consists of high-stage generator.

C. Construction: Fabricated from continuously welded carbon-steel sheet or plate, or from seamless pipe.

D. Design Pressure and Temperature Rating: Comply with applicable requirements in ASME Boiler and Pressure Vessel Code.

E. End Tube Sheets: Carbon-steel plates continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between liquid in tubes and refrigerant in shell.

F. Intermediate Tube Sheets: Carbon-steel plates installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.

G. Generator/Condenser Shell Pressure Relief Device: Manufacturers standard rupture disk complying with requirements in ASHRAE 15 and ASHRAE 34 and in applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

2.7 ABSORBER

A. Nozzle or Dispersion Trays: Designed to evenly distribute absorbent solution over tubes. Constructed of brass, stainless steel, or another material that will not corrode.

B. Tubes:

1. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end and without damage to tube sheets and other tubes.
2. Material: Copper or Copper-nickel alloy as directed.
3. Minimum Wall Thickness: As directed 0.025 inch (0.6 mm), 0.028 inch (0.7 mm) or 0.035 inch (0.9 mm).
4. External Finish: Manufacturer's standard.
5. Internal Finish: Enhanced or smooth as directed.

C. Water Boxes:

1. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
2. Standard or Marine-type for water box with piping connections as directed.

    a. Water boxes and marine water-box covers with lifting lugs or eyebolts.
    b. Hinged water boxes.
    c. Hinged marine water-box covers.

3. Standard water box without piping connections.

    a. Water boxes with lifting lugs or eyebolts.
    b. Hinged water boxes.

4. Nozzle Pipe Connections: As directed Welded, ASME B16.5, flat-face flange, Welded, ASME B16.5, raised-face flange, grooved for mechanical-joint coupling or Grooved with mechanical-joint coupling and flange adapter.
5. Thermistor or RTD temperature sensor factory installed in each nozzle.
6. Fit each water box with 3/4-inch (19-mm) or 1-inch (25-mm) drain connection at low point and vent connection at high point, each with threaded plug.

D. Additional Corrosion Protection:

1. Electrolytic corrosion-inhibitor anode.
2. Coat wetted surfaces with a corrosion-resistant finish.

3. Using same material as tubes, clad surfaces of end tube sheets in contact with liquid. Coat other wetted surfaces, including water boxes, with corrosion-resistant finish.

E. Absorber/Condenser Crossover Piping: Factory furnished and installed piping connecting liquid connection of absorber discharge to condenser inlet.

2.8 EVAPORATOR

A. Nozzle or Dispersion Trays: Designed to evenly distribute refrigerant over tubes; constructed of brass, stainless steel, or another material that will not corrode when exposed to absorbent.

B. Refrigerant Holding Pan: Steel or stainless steel.

C. Tubes:

1. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end and without damage to tube sheets and other tubes, and integrity of tube-tube sheet connections.
2. Material: As directed Copper or Copper-nickel alloy.
3. Minimum Wall Thickness: As directed 0.025 inch (0.6 mm), 0.028 inch (0.7 mm) or 0.035 inch (0.9 mm).
4. External Finish: Manufacturer's standard.
5. Internal Finish: Enhanced or smooth.

D. Water Boxes:

1. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
2. As directed Standard or Marine-type for water box with piping connections.

    a. Water boxes and marine water-box covers with lifting lugs or eyebolts.
    b. Hinged water boxes.
    c. Hinged marine water-box covers.

3. Standard type for water box without piping connections.

    a. Water boxes with lifting lugs or eyebolts.
    b. Hinged water boxes.
    c. Hinged marine water-box covers.

4. Nozzle Pipe Connections: As directed Welded, ASME B16.5, flat-face flange, Welded, ASME B16.5, raised-face flange, grooved for mechanical-joint coupling or Grooved with mechanical-joint coupling and flange adapter.
5. Thermistor or RTD temperature sensor factory installed in each nozzle.
6. Fit each water box with 3/4-inch (19-mm) or 1-inch (25-mm) drain connection at low point and vent connection at high point, each with threaded plug.

2.9 CONDENSER

A. Refrigerant Holding Pan: Steel or stainless steel.

B. Tubes:

1. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end and without damage to tube sheets and other tubes.
2. Material: As directed Copper or Copper-nickel alloy.
3. Minimum Wall Thickness: Manufacturer's choice.
4. External Finish: Manufacturer's standard.
5. Internal Finish: Enhanced or smooth.

C. Water Boxes:

1. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
2. As directed Standard or Marine-type for water box with piping connections.
    a. Water boxes and marine water-box covers with lifting lugs or eyebolts.
    b. Hinged water boxes.
    c. Hinged marine water-box covers.
3. Standard type for water box without piping connections.
    a. Water boxes with lifting lugs or eyebolts.
    b. Hinged water boxes.
    c. Hinged marine water-box covers.
4. Nozzle Pipe Connections: As directed Welded, ASME B16.5, flat-face flange, Welded, ASME B16.5, raised-face flange, grooved for mechanical-joint coupling or Grooved with mechanical-joint coupling and flange adapter.
5. Thermistor or RTD temperature sensor factory installed in each nozzle.
6. Fit each water box with 3/4-inch (19-mm) or 1-inch (25-mm) drain connection at low point and vent connection at high point, each with threaded plug.

D. Additional Corrosion Protection:

1. Electrolytic corrosion-inhibitor anode.
2. Coat wetted surfaces with a corrosion-resistant finish.
3. Using same material as tubes, clad surfaces of end tube sheets in contact with liquid. Coat other wetted surfaces, including water boxes, with corrosion-resistant finish.

2.10 GENERATOR FOR SINGLE-EFFECT CHILLERS

A. Tubes:

1. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end and without damage to tube sheets and other tubes.
2. Material: 06/11 copper-nickel alloy.

3. Minimum Wall Thickness: As directed 0.035 inch (0.9 mm).
4. External Finish: Manufacturer's standard.
5. Internal Finish: Enhanced or smooth.

B. Water Boxes:

1. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
2. Standard type.
3. Provide water boxes with lifting lugs or eyebolts.
4. Nozzle Pipe Connections: As directed Welded, ASME B16.5, flat-face flange, Welded, ASME B16.5, raised-face flange, grooved for mechanical-joint coupling or Grooved with mechanical-joint coupling and flange adapter.
5. Thermistor or RTD temperature sensor factory installed in each nozzle.
6. Fit each water box with 3/4-inch (19-mm) or 1-inch (25-mm) drain connection at low point and vent connection at high point, each with threaded plug.

C. Additional Corrosion Protection:

1. Electrolytic corrosion-inhibitor anode.
2. Coat wetted surfaces with a corrosion-resistant finish.
3. Using same material as tubes, clad surfaces of end tube sheets in contact with liquid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.

2.11 FIRST-STAGE GENERATOR FOR DOUBLE-EFFECT CHILLERS

A. Tubes:

1. Replaceable, straight, or U tubes expanded into tube sheets.
2. Material: As directed or 06/11 copper-nickel alloy .
3. Minimum Wall Thickness: As directed 0.028 inch (0.7 mm), 0.035 inch (0.9 mm).
4. External Finish: Manufacturer's standard.
5. Internal Finish: Enhanced or smooth.

B. Water Boxes:

1. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
2. Standard type.
3. Provide water boxes with lifting lugs or eyebolts.
4. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange, Welded, ASME B16.5, raised-face flange, Grooved for mechanical-joint coupling or Grooved with mechanical-joint coupling and flange adapter.
5. Thermistor or RTD temperature sensor factory installed in each nozzle.
6. Fit each water box with 3/4-inch (19-mm), 1-inch (25-mm) or 3/4- or 1-inch (19- or 25-mm) drain connection as directed at low point and vent connection at high point, each with threaded plug.

C. Additional Corrosion Protection:

1. Electrolytic corrosion-inhibitor anode.
2. Coat wetted surfaces with a corrosion-resistant finish.
3. Using same material as tubes, clad surfaces of end tube sheets in contact with liquid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.

2.12 SECOND-STAGE GENERATOR FOR DOUBLE-EFFECT CHILLERS

A. Tubes:

1. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end and without damage to tube sheets and other tubes.
2. Material: Copper, Copper-nickel alloy or Copper or copper-nickel alloy as directed.
3. Minimum Wall Thickness: As directed 0.025 inch (0.6 mm), 0.028 inch (0.7 mm) or 0.035 inch (0.9 mm).
4. External Finish: Manufacturer's standard.
5. Internal Finish: Enhanced or smooth.

B. Water Boxes:

1. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
2. Standard type.
3. Provide water boxes with lifting lugs or eyebolts.
4. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange, Welded, ASME B16.5, raised-face flange, grooved for mechanical-joint coupling or Grooved with mechanical-joint coupling and flange adapter as directed.
5. Thermistor or RTD temperature sensor factory installed in each nozzle.
6. Fit each water box with 3/4-inch (19-mm) or 1-inch (25-mm) drain connection at low point and vent connection at high point, each with threaded plug.

C. Additional Corrosion Protection:

1. Electrolytic corrosion-inhibitor anode.
2. Coat wetted surfaces with a corrosion-resistant finish.
3. Using same material as tubes, clad surfaces of end tube sheets in contact with liquid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.

2.13 SOLUTION HEAT EXCHANGER

A. Description: Shell-and-tube or brazed-plate heat exchanger; integral part of chiller to increase cycle efficiency by preheating weak solution on its way to generator while precooling strong solution returning from generator.

2.14 STEAM CONDENSATE DRAIN COOLER

A. Description: Shell-and-tube heat exchanger constructed of carbon-steel shell and copper-nickel-alloy or stainless steel tubes.

2.15 FACTORY-APPLIED INSULATION

A. Factory-Applied Insulation on Cold Surfaces:

1. Closed-cell, flexible elastomeric thermal insulation complying with ASTM C534/C534M, Type I for tube and Type II for sheet materials.

    a. Thickness: 3/4 inch (19 mm) or 1-1/2 inches (38mm) as directed.

2. Adhesive: As recommended by insulation manufacturer.
3. Factory apply insulation over all cold surfaces of chiller capable of forming condensation. Insulated components include, but are not limited to, evaporator shell and end tube sheets; evaporator water boxes including nozzles; refrigerant pump; cold surfaces of motor; and cold piping.

    a. Apply adhesive to 100 percent of insulation contact surface.
    b. Before insulating steel surfaces, prepare surfaces for paint, and prime and paint as indicated for other painted components. Do not insulate unpainted steel surfaces.
    c. Seal seams and joints to provide a vapor barrier.
    d. After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.

B. Factory-Applied Insulation on Hot Surfaces:

1. Mineral-fiber board, pipe, or tank insulation complying with one of the following:

    a. ASTM C547, Type I or Type II, Grade A.
    b. ASTM C612, Type IB.
    c. ASTM C1393, Type II or Type IIIA, Category 2.
    d. Thickness: 1-1/2 inches (38 mm) or 2 inches (50mm) as directed.

2. Adhesive: As recommended by insulation manufacturer.
3. Factory apply materials over all hot surfaces to provide smooth, straight, and even surfaces; free of voids.

    a. Apply adhesive to insulation contact surface as recommended by insulation manufacturer.
    b. Install insulation anchor pins and washers if required by insulation manufacturer to secure insulation to surfaces to be insulated.
    c. Completely encapsulate insulation with metal jacket, leaving no exposed insulation. Provide removable jacket on components requiring access for service and inspection.
    d. Paint exposed surfaces of metal jacket to match other painted parts unless jacket material is aluminum or stainless steel.

2.16 ELECTRICAL

A. Factory installed and wired, and functionally tested at factory before shipment.

B. Single-point, field-power connection to fused disconnect switch, nonfused disconnect switch or circuit breaker as directed. Provide devices with minimum withstand rating as required by electrical power distribution system, but not less than 42,000 or 65,000 A as directed.

1. Branch power circuit to each motor, dedicated electrical load, and controls with disconnect switch or circuit breaker.

    a. NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection in accordance with IEC 60947-4-1.
    b. NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit-trip set point.

2. NEMA ICS 2, Class A, full-voltage, nonreversing motor controller, hand-off-auto switch, and overcurrent protection for each motor.
3. Control-circuit transformer with primary and secondary side fuses.

C. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Include spare wiring terminal block for connection to external controls or equipment.

D. Wiring Outside of Enclosures: Factory installed in metal raceway except make terminal connections with not more than a 24-inch (610-mm) length of liquidtight or flexible metallic conduit. Coordinate conduit requirements with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

2.17 CONTROLS

A. Control: Standalone and microprocessor based, with programs and configuration settings stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.

B. Enclosure: Unit mounted, NEMA 250, Type 1, Type 3R, Type 4 or Type 4x as directed, hinged or lockable.

C. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. Display following information in either imperial or metric units selectable through interface.

1. Date and time.
2. Operating or alarm status.
3. Operating hours.
4. Outdoor-air temperature if required for chilled-water reset.
5. Temperature and pressure of operating set points.
6. Entering and leaving temperatures of chilled and condenser water.
7. Refrigerant temperature.
8. Solution concentration and temperature.
9. Indication of solution and purge-pump operation.
10. Generator shell pressure.
11. Number of starts.
12. Number of purge cycles.

13. Hot-water valve actuator potentiometer position (percentage).
14. Entering and leaving hot-water temperatures.
15. Steam demand limit.
16. Inlet steam pressure and temperature.
17. Steam valve actuator potentiometer position (percentage).
18. First-stage generator pressure and temperature.
19. As directed status display items.

D. Control Functions:

1. Manual or automatic startup and shutdown time schedule.
2. Automatic cycle to prevent crystallization.
3. Entering and leaving chilled-water temperatures and control set points. Reset chilled-water temperature based on return-water, outdoor-air or space temperature as directed.
4. Condenser-liquid temperature.
5. Measure and record cooling provided and heating energy used within programmable time periods, minimum monthly.
6. As directed control functions.

E. Capacity Control: Automatically controls input flow rate of heat source to maintain chilled-water temperature set point for cooling loads ranging from 10 to 100 percent.

F. Control Valve Package: As directed Factory-furnished, for field installation, or Factory-installed control valve package suitable for energy source indicated.

1. Body: Cast-iron, carbon-steel, or stainless steel body with flanged connections.
2. Type: As directed V-notch ball, Butterfly or Globe style with cage-guide plug constructed of stainless steel.
3. Rating: Pressure and temperature rating to match heat exchanger.
4. Shutoff: Capable of bubble-tight shutoff against maximum system pressure.
5. Size: Determined by chiller manufacturer.
6. Modulation: As directed Two or Three way.
7. Turndown: As required to achieve stable control through indicated operating range.
8. Actuator: Electric powered from chiller control panel and installed on valve.

G. Safety Shutdowns: To automatically shut down chiller and require manual reset before restart. Display message following each safety shutdown.

1. Crystallization.
2. Low refrigerant temperature.
3. Loss of chilled- or condenser-water flow.
4. Low leaving chilled-water temperature, 2 deg F (1 deg C) below set point.
5. First-stage generator low-solution level.
6. First-stage generator high temperature or pressure.
7. Power failure.
8. Solution pump overloads.
9. External auxiliary safety shutdown.
10. High solution concentration.
11. Incomplete dilution cycle.
12. High entering-water temperature.
13. High inlet steam pressure and temperature.

H. Warning Conditions: Provide control panel that closes warning contacts and generates message when one of the following operating conditions is detected:

1. Low refrigerant temperature.
2. High generator temperature or pressure.
3. High entering generator-water temperature (single-stage generator only).
4. High or low entering condenser-water temperature.
5. Solution temperature sensor failure.
6. Low chilled-water flow.
7. As directed warning conditions.

I. Trending: Capability to trend analog data up to five parameters simultaneously over adjustable period and frequency of polling.

J. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: view only; view and operate; and view, operate, and service.

K. Control Authority: At least four conditions: off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.

L. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting printer or electronic monitoring device.

M. BAS Interface: Factory-installed hardware and software to enable BAS to monitor, control, and display chiller status and alarms.

1. Hardwired Points:

a. Monitoring: On-off status or common trouble alarm.
b. Control: On-off operation, chilled-water, discharge temperature set-point adjustment or generator heat source capacity limiting.

2. Provide As directed ASHRAE 135 (BACnet), LonTalk or Modbus of interface communication interface with BAS to enable BAS operator to control and monitor chiller from remote operator workstation. Provide for control features and monitoring points displayed locally at chiller control panel to be available through BAS.

2.18 FINISH

A. Paint chiller, using manufacturer's standard procedures, except comply with the following minimum requirements:

1. Provide at least one coat of primer with a total dry film thickness of at least 2 mils (0.05 mm).
2. Provide at least two coats of alkyd-modified, vinyl enamel, epoxy or polyurethane finish as directed with a total dry film thickness of at least 4 mils (0.10 mm).
3. Paint surfaces that are to be insulated before applying insulation.
4. Paint installed insulation to match adjacent uninsulated surfaces.
5. Color of finish coat as directed or custom color selected by Architect.

B. Furnish Owner with quart container of paint used in application of topcoat to use in touchup applications after Project closeout.

2.19 ACCESSORIES

A. Sight Glasses: Equip unit with sight glasses for visual inspection of absorbent solution and refrigerant levels. Provide at least one sight glass in absorber and evaporator sections.

B. Flow Switches:

1. Furnish chiller-manufacturer-supplied hall flow switch for each condenser, evaporator and condenser as directed and verify field-mounting location before installation.
2. Paddle Flow Switches:

    a. Vane operated to actuate double-pole, double-throw switch with one pole field wired to chiller control panel and other pole field wired to BAS.
    b. Contacts: Platinum alloy, silver alloy, or gold-plated switch contacts with a rating of 10 A at 120 V ac.
    c. Pressure rating equal to pressure rating of heat exchanger.
    d. Construct body and wetted parts of Type 316 stainless steel.
    e. House switch in a NEMA 250, Type 4 enclosure constructed of die-cast aluminum.
    f. Vane length to suit installation.

3. Pressure Differential Switches:

    a. Construction: Wetted parts of body and trim constructed of Type 316 stainless steel.
    b. Performance: Switch suitable to withstand, without damage, full-pressure rating of heat exchanger applied to either port and exhibit no set-point shift due to variation in working pressure.
    c. Set Point: Screw type, field adjustable.
    d. Electrical Connections: Internally mounted screw-type terminal blocks.
    e. Switch Enclosure: NEMA 250, Type 4.
    f. Switch Action: Double-pole, double-throw switch with one pole field wired to chiller control panel and other pole field wired to BAS.

C. Vibration Isolation:

1. Chiller-manufacturer-furnished, neoprene-pad vibration isolation for each chiller.

    a. Two layers of 0.375-inch- (10-mm-) thick, ribbed- or waffle-pattern neoprene pads separated by 16-gauge, stainless steel plate.
    b. Fabricate pads from 40- to 50-durometer neoprene.
    c. Provide stainless steel square bearing plate to load pad uniformly between 20 and 40 psi (138 and 276 kPa) with 0.12- to 0.16-inch (3- to 4-mm) deflection.

2.20 SOURCE QUALITY CONTROL

A. Perform functional run tests of chillers before shipping.

B. Factory test and inspect absorber, generator, evaporator, and condenser in accordance with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Pressure test tube-side of heat exchangers, including water boxes, to 1.5 times rated pressure. Vacuum and pressure test shells for leaks.

C. Allow Owner access to place where chillers are being tested. Notify Architect 14 days in advance of testing.

D. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

PART 3 - EXECUTION

3.1 INSTALLATION OF CHILLER

A. Examine chillers before installation. Reject chillers that are damaged.

B. Install chillers on support structure indicated.

C. Equipment Mounting:

1. Install chillers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.
2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

D. Maintain manufacturer's recommended clearances for service and maintenance.

E. Charge chiller with absorbent and refrigerant if not factory charged.

F. Install separate devices furnished by manufacturer and not factory installed.

G. Insulate hot and cold chiller surfaces that are recommended by chiller manufacturer to be insulated, and are not factory insulated. Comply with requirements in Section 230716 "HVAC Equipment Insulation."

3.2 PIPING CONNECTIONS

A. Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties" for hydronic piping. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Comply with requirements in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties" for steam and condensate piping. Drawings indicate general arrangement of piping, fittings, and specialties.

C. Where installing piping adjacent to chiller, allow space for service and maintenance.

D. Generator Steam Piping Connections:

1. Connect steam piping with trapped drip leg, gate valve, strainer, control valve, and pressure gauge. Install pressure reducing valve and safety relief valve upstream from steam-control valve to protect control valve from excessive steam pressure. Make connections to chiller with flange or union.
2. Connect steam condensate piping with vacuum breaker, trapped drip leg, gate valve, strainer, float and thermostatic trap(s), condensate cooler, condensate receiver, or condensate receiver and pump, and check valve. Make connections to chiller with flange or union.

E. Generator Hot-Water Connections: Connect to generator inlet with shutoff valve, strainer, flexible connector, control valve, thermometer, and plugged tee with shutoff valve and pressure gauge. Connect to generator outlet with shutoff valve, check valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with shutoff valve and pressure gauge, flow meter, and drain connection with valve. Make connections to chiller with a flange or mechanical coupling.

F. Evaporator-Liquid Connections: Connect to evaporator inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with shutoff valve and pressure gauge. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with shutoff valve and pressure gauge, flow meter, and drain connection with valve. Make connections to chiller with a flange or mechanical coupling.

G. Absorber/Condenser-Liquid Connections: Connect to inlet with shutoff valve, strainer, or flexible connector, thermometer, and plugged tee with shutoff valve and pressure gauge. Connect to outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with shutoff valve and pressure gauge, flow meter, and drain connection with valve. Make connections to chiller with a flange or mechanical coupling.

1. If not factory furnished or installed, provide pipe connecting liquid connection of absorber discharge and condenser inlet.

H. Refrigerant Pressure Relief Device Connections: As directed Extend vent piping or separate vent piping for each chiller to outdoors without valves or restrictions. Comply with ASHRAE 15. Connect to chiller pressure relief device with flexible connector and dirt leg with drain valve.

I. As directed Extend purge vent piping or separate purge vent piping for each chiller to outdoors. Comply with ASHRAE 15.

J. Connect each chiller drain connection with a union and drain pipe, and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection.

3.3 ELECTRICAL CONNECTIONS

A. Install electrical devices furnished with chiller but not factory mounted.

B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

D. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

E. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between control devices.

C. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections with the assistance of a factory-authorized service representative.

E. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

F. Absorption water chillers will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. As directed Engage a factory-authorized service representative to perform or Perform startup service.

1. Complete installation and startup checks in accordance with manufacturer's written instructions.
2. Operate chiller for run-in period.
3. Verify that absorbent and refrigerant charge is sufficient and chiller has been leak tested.
4. Verify that pumps are installed and functional.
5. Verify that thermometers and gauges are installed.
6. Operate chiller for run-in period.
7. Verify that refrigerant pressure relief device is vented outside.
8. Verify proper motor rotation.
9. Verify static deflection of vibration isolators including deflection during chiller startup and shutdown.
10. Verify and record performance of liquid flow and low-temperature interlocks for evaporator and condenser.
11. Verify and record performance of chiller protection devices.
12. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
13. Startup steps if any as directed.

B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assembly, installation, and connection.

C. Prepare test and inspection startup reports.

3.7 DEMONSTRATION

A. As directed Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain chillers. Video record training sessions.

END OF SECTION 236413.16

SECTION 236416 - CENTRIFUGAL WATER CHILLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Packaged, water-cooled, electric-motor-driven centrifugal chillers.

B. Related Requirements:

1. Section 284400 "Refrigerant Detection and Alarm" for refrigerant monitors, alarms, supplemental breathing apparatus, and ventilation equipment interlocks.

1.2 DEFINITIONS

A. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input, using consistent units for any given set of rating conditions.

B. DDC: Direct digital control.

C. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in terms of Btu/h to the total power input given in terms of watts at any given set of rating conditions.

D. IPLV: Integrated part-load value. A single-number part-load efficiency figure of merit for a single chiller calculated according to the method defined by AHRI 550/590 and referenced to AHRI standard rating conditions.

E. kVAR: Kilovolt-ampere reactive.

F. kW/Ton (kW/kW): The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons (kW) at any given set of rating conditions.

G. NPLV: Nonstandard part-load value. A single-number part-load efficiency figure of merit for a single chiller calculated according to the method defined by AHRI 550/590 and intended for operating conditions other than the AHRI standard rating conditions.

H. SCCR: Short-circuit current rating.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As submitted.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, load distribution, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:

1. Drawings, drawn to scale:

B. Certificates: For certification required in "Quality Assurance" Article.

C. Seismic Qualification Data: Certificates, for chillers, accessories, and components, from manufacturer.

D. Source quality-control reports.

E. Field Quality-Control Reports: Startup service reports.

F. Sample warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

A. AHRI Certification: Certify chiller according to AHRI 550 certification program.

B. Green Seal Compliance: Signed by manufacturer or Green Seal, certifying compliance with GS-31.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of chillers that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two, Three, Four, Five or 10 years from date of Substantial Completion, as directed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Centrifugal chillers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 - 1.0.

B. Condenser-Fluid Temperature Performance:

1. Startup Condenser-Fluid Temperature: Chiller shall be capable of starting with an entering condenser-fluid temperature of 60 deg F (16 deg C), 55 deg F (13 deg C) or 40 deg F (4 deg C), as directed and providing stable operation until the system temperature is elevated to the minimum operating entering condenser-fluid temperature.
2. Minimum Operating Condenser-Fluid Temperature: Chiller shall be capable of continuous operation over the entire capacity range indicated with an entering condenser-fluid temperature of 65 deg F (18 deg C), 60 deg F (16 deg C) or 55 deg F (13 deg C), as directed.
3. Make factory modifications to standard chiller design if necessary to comply with performance indicated.

C. Site Altitude: Chiller shall be suitable for altitude at which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.

D. Performance Tolerance: Comply with the following in lieu of AHRI 550/590:

1. Allowable Capacity Tolerance: Zero percent.
2. Allowable Full-Load Energy Efficiency Tolerance: Zero percent.
3. Allowable Part-Load Energy Efficiency Tolerance: Zero percent.

E. ASHRAE Compliance:

1. ASHRAE 15 for safety code for mechanical refrigeration.
2. ASHRAE 147 for refrigerant leaks, recovery, and handling and storage requirements.

F. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

G. ASME Compliance: Fabricate and label chillers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, as applicable to chiller design. For chillers charged with R-134a refrigerant, include an ASME U-stamp and nameplate certifying compliance.

H. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

I. Comply with requirements of Underwriters Laboratories Inc. and include label by a qualified testing agency showing compliance.

J. Operation Following Loss of Normal Power:

1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to backup power system shall automatically return equipment and associated controls to the operating state occurring immediately before loss of normal power without need for manual intervention by an operator when power is restored either through a backup power source, or through normal power if restored before backup power is brought online.
2. Refer to Drawings for equipment served by back-up power systems.
3. Provide means and methods required to satisfy requirement, even if not explicitly indicated.

K. Outdoor Installations:

1. Chiller shall be suitable for outdoor installation indicated. Provide adequate weather protection to ensure reliable service life over a 25-year period, with minimal degradation due to exposure to outdoor ambient conditions.
2. Chillers are equipped to provide safe and stable operation while achieving performance indicated when operating at extreme outdoor temperatures. Review historical weather database and provide equipment that can operate at extreme outdoor temperatures recorded over past 30-year period.

2.2 MANUFACTURERS

2.3 MANUFACTURED UNIT

A. Description: Factory-assembled and -tested chiller complete with compressor, compressor motor, compressor motor controller, lubrication system evaporator, condenser, controls, interconnecting unit piping and wiring, and indicated accessories.

1. Multi-Piece Assembly: Disassemble chiller into major assemblies as required by the installation after factory testing and before packaging for shipment.
2. Dual-Compressor Chillers: For chillers with dual compressors, provide each compressor with a dedicated motor and motor controller, and provide for continued operation when either compressor-drive assembly fails.

B. Fabricate chiller mounting base with reinforcement strong enough to resist chiller movement during a seismic event when chiller is anchored to field support structure.

2.4 COMPRESSOR-DRIVE ASSEMBLY

A. Description: Single-stage or multistage, variable- or dynamic-displacement, centrifugal-type compressor driven by an electric motor.

B. Oil-Free Technology:

1. Compressors shall have oil-free technology.

C. Compressor:

1. Casing: Cast iron, precision ground.
2. Impeller: High-strength cast-aluminum or cast-aluminum alloy on carbon- or alloy-steel shaft.

D. Drive: Direct-drive, hermetic, Gear-drive, hermetic, Gear-drive, open, Direct- or gear-drive, hermetic or Direct- or gear-drive, open or hermetic, as directed, design, using an electric motor as the driver.

1. Gear Drives:

   a. For chillers with oil-lubricated gear drives, provide single- or double-helical gear design continuously coated with oil while chiller is operating.
   b. For chillers with oil-free technology, gear drives shall be of single- or double-helical gear design without the need for oil while chiller is operating, starting, and stopping.
   c. Gears shall comply with American Gear Manufacturer Association standards.

2. Drive Coupling: For chillers with open drives, provide flexible disc with all-metal construction and no wearing parts to ensure long life without the need for lubrication.
3. Seals: Seal drive assembly to prevent refrigerant leakage.

E. Compressor Motor:

1. Continuous-duty, squirrel-cage, induction-type, two-pole motor with energy efficiency required to suit chiller energy efficiency indicated.
2. Factory mounted, aligned, and balanced as part of compressor assembly before shipping.
3. Motor shall be of sufficient capacity to drive compressor throughout entire operating range without overload and with sufficient capacity to start and accelerate compressor without damage.
4. For chillers with open drives, provide motor with open-dripproof, weather-protected, Type I, weather-protected, Type II or totally enclosed enclosure.
5. Provide motor with thermistor or RTD in single motor winding or each of three-phase motor windings to monitor temperature and report information to chiller control panel.
6. Provide motor with thermistor or RTD to monitor bearing temperature and report information to chiller control panel.
7. Provide open-drive motor with internal electric heater, internally powered from chiller power supply.

F. Vibration Balance: Balance chiller compressor and drive assembly to provide a precision balance that is free of noticeable vibration over the entire operating range.

1. Overspeed Test: At least 20 - 25 percent above design operating speed.
2. Vibration Limits: Velocities not to exceed 0.15 inches/s (3.8 mm/s) and 0.8 mils (0.02 mm) peak to peak on all axes.

G. Service: Easily accessible for inspection and service.

1. Compressor's internal components shall be accessible without having to remove compressor-drive assembly from chiller.
2. Provide lifting lugs or eyebolts attached to casing.

H. Economizers: For multistage chillers, provide interstage economizers.

I. Capacity Control: Modulating, variable-inlet, guide-vane assembly combined with hot-gas bypass, if necessary, to achieve performance indicated.

1. Maintain stable operation that is free of surge, cavitation, and vibration throughout range of operation. Configure to achieve most energy-efficient operation possible.
2. Operating Range: From 100 to 15, 10, 5 or zero percent of design capacity, as directed.
3. Condenser-Fluid Unloading Requirements over Operating Range: Constant-design of entering condenser-fluid temperature or Drop-in entering condenser-fluid temperature of 2.5 deg F (1.4 deg C) for each 10 percent in capacity reduction.
4. Chillers with variable-frequency controllers shall modulate compressor speed with variable-inlet, guide-vane control to achieve optimum energy efficiency.
5. Avoid use of hot-gas bypass if other options are available to achieve performance indicated. Apply hot-gas bypass according to ASHRAE/IES 90.1 and governing codes.

J. Oil Lubrication System: Consisting of pump, filtration, heater, cooler, factory-wired power connection, and controls.

1. Bearings, gears, and other rotating surfaces shall be lubricated at all operating, startup, coast down, and standby conditions, including power failure.
2. Manufacturer's standard method or Thermostatically controlled oil heater properly sized to remove refrigerant from oil.
3. Oil filter, Dual oil filters, one redundant, shall be the easily replaceable cartridge type, minimum 0.3 - 0.5-micron efficiency, with means of positive isolation while servicing.
4. Refrigerant, Water or Refrigerant- or watercooled oil cooler, as directed
5. Factory-installed and pressure-tested piping with isolation valves and accessories.
6. Oil compatible with refrigerant and chiller components.
7. Positive visual indication of oil level.

2.5 REFRIGERATION

A. Refrigerant:

1. Type: R-123; ASHRAE 34, Class B1 or R-134a; ASHRAE 34, Class A1.
2. Compatibility: Chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.

B. Refrigerant Flow Control: Manufacturer's standard refrigerant flow-control device satisfying performance requirements indicated.

C. Pressure Relief Device:

1. Comply with requirements in ASHRAE 15, ASHRAE 147, and applicable portions of ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

2. Select and configure pressure relief devices to protect against corrosion and inadvertent release of refrigerant.
3. Where dual pressure relief devices are installed in series, provide a sensor with indicator between devices to indicate refrigerant release past first device.
4. For Chillers Using R-123: Manufacturer's standard offering complying with ASHRAE 15 and ASHRAE 147, Rupture disc constructed of frangible carbon or spring-loaded, pressure relief valve; single- or multiple-reseating type.
5. For Chillers Using R-134a: ASME-rated, spring-loaded, pressure relief valve; single- or multiple-reseating type. Pressure relief valve(s) shall be provided for each heat exchanger. Condenser shall have dual valves with one being redundant and configured to allow either valve to be replaced without loss of refrigerant.

D. Refrigeration Transfer: Provide service valves and other factory-installed accessories required to facilitate transfer of refrigerant from chiller to a remote refrigerant storage and recycling system. Comply with requirements in ASHRAE 15 and ASHRAE 147.

E. Refrigerant Isolation for Chillers Using R-134a:

1. Factory install positive shutoff, manual isolation valves in the compressor discharge line to the condenser and the refrigerant liquid line leaving the condenser to allow for isolation and storage of full refrigerant charge in the chiller condenser shell.
2. Suction side of compressor from evaporator shall have an isolation valve to allow for isolation and storage of full refrigerant charge in the chiller evaporator shell.

F. Purge System:

1. For chillers operating at subatmospheric pressures (using R-123 refrigerant), factory install an automatic purge system for collection and return of refrigerant and lubricating oil and for removal of noncondensables, including, but not limited to, water, water vapor, and noncondensable gases.
2. System shall be of thermal purge design, refrigerant or air cooled, and equipped with a carbon filter that includes an automatic regeneration cycle.
3. Factory wire to chiller's main power supply and system complete with controls, piping, and refrigerant valves to isolate the purge system from the chiller.
4. Construct components of noncorrodible materials.
5. Controls shall interface with chiller control panel to indicate modes of operation, set points, data reports, diagnostics, and alarms.
6. Efficiency of not more than 0.02 lb of refrigerant per pound of air (9 g of refrigerant per gram of air) when rated according to AHRI 580.
7. Operation independent of chiller according to ASHRAE 147.

G. Positive-Pressure System:

1. For chillers operating at subatmospheric pressures (using R-123 refrigerant), factory install an automatic positive-pressure system.
2. During nonoperational periods, positive-pressure system shall automatically maintain a positive pressure for atmosphere in the refrigerant-pressure vessel of not less than 0.5 psig (3 kPa) adjustable up to a pressure that remains within the vessel design pressure limits.
3. System shall be factory wired and include controller, electric heat, pressure transmitter, or switch.

2.6 EVAPORATOR

A. Description: Shell-and-tube design, with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from condenser.

B. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.

C. Designed to prevent liquid refrigerant carryover from entering compressor.

D. Evaporator shall have sight glass or other form of positive visual verification of liquid-refrigerant level.

E. Tubes:

1. Individually replaceable from either end and without damage to tube sheets and other tubes.
2. Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
3. Material: Copper, Copper-nickel alloy, Stainless steel, Titanium, Copper, copper-nickel alloy, stainless steel, or titanium, as directed.
4. Nominal OD: Manufacturer's choice, 3/4 inch (19 mm), 1 inch (25 mm) or 3/4 or 1 inch (19 or 25 mm), as directed.
5. Minimum Wall Thickness: Manufacturer's choice, 0.025 inch (0.6 mm), 0.028 inch (0.7 mm) or 0.035 inch (0.9 mm), as directed.
6. External Finish: Manufacturer's standard.
7. Internal Finish: Enhanced, Smooth or Enhanced or smooth.

F. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes, with positive seal between fluid in tubes and refrigerant in shell.

G. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear, but not more than 4 feet (1.2 m) apart.

H. Water Box:

1. Cast-iron or carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
2. Standard or Marine type for water box with piping connections; standard type for water box without piping connections.
3. Provide water boxes and marine water-box covers with lifting lugs or eyebolts.
4. Hinged, Davited or Hinged or davited water boxes, as directed.
5. Hinged, Davited or Hinged or davited marine water-box covers, as directed
6. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange, Welded, ASME B16.5, raised-face flange, grooved for mechanical-joint coupling or Grooved with mechanical-joint coupling and flange adapter, as directed.
7. Thermistor or RTD temperature sensor factory installed in each nozzle.
8. Fit each water box with 3/4-inch (19-mm), 1-inch (25-mm) or 3/4- or 1-inch (19- or 25-mm), as directed, drain connection at low point and vent connection at high point, each with threaded plug.

I. Additional Corrosion Protection:

1. Electrolytic corrosion-inhibitor anode, zinc or magnesium.
2. Coat wetted surfaces with a corrosion-resistant finish.
3. Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.

J. Flow Sensor: Thermal dispersion type, factory calibrated for project-specific application.

2.7 CONDENSER

A. Description: Shell-and-tube design, with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from evaporator.

B. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.

C. Designed to prevent direct impingement of high-velocity hot gas from compressor discharge on tubes.

D. Condenser shall have sight glass or other form of positive visual verification of refrigerant charge and condition.

E. Tubes:

1. Individually replaceable from either end and without damage to tube sheets and other tubes.
2. Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
3. Material: Copper, Copper-nickel alloy, Stainless steel, Titanium, Copper, copper-nickel alloy, stainless steel, or titanium, as directed.
4. Nominal OD: Manufacturer's choice, 3/4 inch (19 mm), 1 inch (25 mm) or 3/4 or 1 inch (19 or 25 mm).
5. Minimum Wall Thickness: Manufacturer's choice, 0.025 inch (0.6 mm), 0.028 inch (0.7 mm) or 0.035 inch (0.9 mm), as directed.
6. External Finish: Manufacturer's standard.
7. Internal Finish: Enhanced, Smooth or Enhanced or smooth.

F. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes, with positive seal between fluid in tubes and refrigerant in shell.

G. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear, but not more than 4 feet (1.2 m) apart.

H. Water Box:

1. Cast-iron or carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
2. Standard or Marine type for water box with piping connections. Standard type for water box without piping connections.

3. Water boxes and marine water-box covers shall have lifting lugs or eyebolts.
4. Hinged, Davited, Hinged or davited water boxes, as directed.
5. Hinged, Davited, Hinged or davited marine water-box covers, as directed.
6. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange, Welded, ASME B16.5, raised-face flange, grooved for mechanical-joint coupling or Grooved with mechanical-joint coupling and flange adapter, as directed.
7. Thermistor or RTD temperature sensor factory installed in each nozzle.
8. Fit each water box with 3/4-inch (19-mm), 1-inch (25-mm) or 3/4- or 1-inch (19- or 25-mm) drain connection at low point and vent connection at high point, each with threaded plug.

I. Additional Corrosion Protection:

1. Electrolytic corrosion-inhibitor anode, zinc or magnesium.
2. Coat wetted surfaces with a corrosion-resistant finish.
3. Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.

J. Flow Sensor: Thermal dispersion type, factory calibrated for project-specific application.

2.8 INSULATION

A. Closed-cell, flexible elastomeric thermal insulation complying with ASTM C534, Type I for tubular materials and Type II for sheet materials.

1. Thickness: 3/4 inch (19 mm) or 1-1/2 inches (38 mm), as directed.

B. Adhesive: As recommended by insulation manufacturer.

C. Factory-applied insulation over all cold surfaces of chiller capable of forming condensation. Components shall include, but not be limited to, evaporator shell and end tube sheets, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, refrigerant-cooled motor, and auxiliary piping.

1. Apply adhesive to 100 percent of insulation contact surface.
2. Before insulating steel surfaces, prepare surfaces for paint, and prime and paint as indicated for other painted components. Do not insulate unpainted steel surfaces.
3. Seal seams and joints to provide a vapor barrier.
4. After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.
5. Manufacturer has option to factory or field insulate chiller components installed in multiple pieces to reduce potential for damage during installation.
6. Manufacturer has option to factory or field insulate water boxes and nozzles to reduce potential for damage during installation.

D. Field-Applied Insulation:

1. Components that are not factory insulated shall be field insulated to comply with requirements indicated.

2. Manufacturer shall be responsible for chiller insulation whether factory or field installed, to ensure manufacturer is the single point of responsibility for chillers.
3. Manufacturer factory-authorized service representative shall instruct and supervise installation of field-applied insulation.
4. After field-applied insulation is complete, paint insulation to match factory-applied finish.

2.9 ELECTRICAL

A. Factory installed and wired, and functionally tested at factory before shipment.

B. Single-point, field-power connection to fused disconnect switch, nonfused disconnect switch or circuit breaker. Minimum short circuit current rating (SCCR) according to UL 508 shall be as required by electrical power distribution system, but not less than 42,000, 65,000 or 100,000 A, as directed.

1. Branch power circuit to each motor, electric heater, dedicated electrical load, and control, with circuit breaker or disconnect switch having SCCR to match main disconnecting means.

    a. NEMA KS 1, heavy-duty fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
    b. NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit-trip set point.

2. NEMA ICS 2-rated motor controller for auxiliary motors, hand-off-auto switch, and overcurrent protection for each motor. Provide variable-frequency controller for each variable-speed motor furnished.
3. Control-circuit transformer with primary and secondary side fuses.

C. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.

D. Factory-installed wiring located outside of enclosures shall be installed in metal raceway, and terminal connections shall be made with not more than a 24-inch (610-mm) length of liquidtight, flexible metallic or liquidtight or flexible metallic conduit.

E. Factory install and wire capacitor bank for the purpose of power factor correction to 0.95 at full load or all operating conditions.

1. If capacitors are mounted in a dedicated enclosure, use same NEMA enclosure type as that for motor controller. Provide enclosure with service entrance knockouts and bushings for conduit.
2. Capacitors shall be of non-PCB dielectric fluid, metallized electrode design, with low loss with low-temperature rise. The kVAR ratings shall be indicated and shall not exceed the maximum limitations set by NFPA 70. Provide individual cells as required.

3. Provide each cell with current-limiting replaceable fuses and carbon-film discharge resistors to reduce residual voltage to less than 50 V within one minute after de-energizing.
4. Provide a ground terminal and a terminal block or individual connectors for phase connection.

2.10 MOTOR CONTROLLER

A. Enclosure: Factory installed, unit mounted, Factory furnished, field mounted, NEMA 250, NEMA ICS 6, Type 1, Type 4, Type 4X or Type 12, as directed, with hinged full-front access door with lock and key or padlock and key.

B. Control Circuit: Obtained from integral control power transformer with a control power transformer or source of enough capacity to operate connected control devices.

C. Overload Relay shall be sized according to UL 1995 or shall be an integral component of chiller control microprocessor.

D. Across-the-Line Controller: NEMA ICS 2, Class A, full voltage, nonreversing; include isolation switch and current-limiting fuses.

E. Star-Delta, Reduced-Voltage Controller: NEMA ICS 2, closed transition.

F. Autotransformer Reduced-Voltage Controller: NEMA ICS 2, closed transition; include isolation switch and current-limiting fuses.

G. Solid-State, Reduced-Voltage Controller: NEMA ICS 2.

1. Include surge suppressor in solid-state power circuits to provide three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
2. Visual indication of motor and control status, including the following conditions:

    a. Controller on.
    b. Overload trip.
    c. Loss of phase.
    d. Starter fault.

H. Accessories: Devices shall be factory installed in controller enclosure unless otherwise indicated.

1. Externally Operated, Door-Interlocked Disconnect: Fused disconnect switch, Nonfused disconnect switch or Circuit breaker, as directed. Short circuit current rating (SCCR) according to UL 508 shall be as required by electrical power distribution system, but not less than 42,000, 65,000 or 100,000 A, as directed.
2. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
3. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

4. Control Relays: Time-delay relays.
5. Elapsed-Time Meters: Numerical readout in hours on face of enclosure.
6. Number-of-Starts Counter: Numerical readout on face of enclosure.
7. Meters: Panel type, 2-1/2 inches (64 mm) or 4-1/4 inches (108 mm) with 90, 120 or 270-degree scale and 1 - 2 percent accuracy, as directed. Where indicated, provide transfer device with an off position. Meters shall indicate the following:

    a. Ammeter: Output current for each phase, with current sensors rated to suit application.
    b. Voltmeter: Output voltage for each phase.
    c. Frequency Meter: Output frequency.
    d. Real-time clock with current time and date.
    e. Total run time.

8. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

    a. Selectable, digital display of the following:

        1) Phase Currents, Each Phase: Plus or minus 1 percent.
        2) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
        3) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
        4) Three-Phase Real Power: Plus or minus 2 percent.
        5) Three-Phase Reactive Power: Plus or minus 2 percent.
        6) Power Factor: Plus or minus 2 percent.
        7) Frequency: Plus or minus 0.5 percent.
        8) Integrated Demand with Demand Interval Selectable from Five to 60 Minutes: Plus or minus 2 percent.
        9) Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

    b. Mounting: Display and control unit flush or semirecessed in instrument compartment door.

9. Phase-Failure, Phase-Reversal, Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hardwired connection.
10. Power Protection: Chiller shall shut down within six cycles of power interruption.

2.11 VARIABLE-FREQUENCY CONTROLLER

A. Motor controller shall be factory mounted and wired on the chiller to provide a single-point, field-power termination to the chiller and its auxiliaries.

B. Description: NEMA ICS 2; listed and labeled according to UL 508 as a complete unit and arranged to provide variable speed by adjusting output voltage and frequency.

C. Enclosure: Unit mounted, NEMA 250, Type 1, Type 4, Type 4x or Type 12, as directed, with hinged full-front access door with lock and key.

D. Integral Disconnecting Means: Door-interlocked, NEMA AB 1, instantaneous-trip circuit breaker with lockable handle. Minimum short circuit current rating (SCCR) according to UL 508 shall be as required by electrical power distribution system, but not less than 42,000 65,000, 100,000 A, as directed.

E. Technology: Pulse width modulated (PWM) output with insulated gate bipolar transistors; suitable for variable torque loads.

F. Controller shall consist of a rectifier converter section, a digital/analog driver regulator section, and an inverter output section.

1. Rectifier section shall be a full-wave diode bridge that changes fixed-voltage, fixed-frequency, ac line power to a fixed dc voltage. Silicon controller rectifiers, current source inverters, and paralleling of devices are unacceptable. Rectifier shall be insensitive to phase rotation of the ac line.
2. Regulator shall provide full digital control of frequency and voltage.
3. Inverter section shall change fixed dc voltage to variable-frequency, variable ac voltage for application to a squirrel-cage motor. Inverter shall produce a sine-coded, PWM output waveform and shall conduct no RFI back to the input power supply.

G. Output Rating: Three phase, with voltage proportional to frequency throughout voltage range.

H. Operating Requirements:

1. Input AC Voltage Tolerance: 460-V ac, plus 10 percent or 506 V maximum.
2. Input frequency tolerance of 60 Hz, plus or minus 2 Hz.
3. Capable of driving full load, without derating, under the following conditions:

    a. Ambient Temperature: Zero to 40 - 50 deg C.
    b. Relative Humidity: Up to 90 -95 percent (noncondensing).
    c. Altitude: Up to 3300 feet (1005 m) or 6600 feet (2010 m).

4. Minimum Efficiency: 96 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 95 percent without harmonic filter; 98 percent with harmonic filter.
6. Overload Capability: 1.05 times the full-load current for seven seconds.
7. Starting Torque: As required by compressor-drive assembly.
8. Speed Regulation: Plus or minus 1 percent.
9. Isolated control interface to allow controller to follow control signal over a 10:1 speed range.
10. To avoid equipment resonant vibrations, provide critical speed lockout circuitry to allow bands of operating frequency at which controller shall not operate continuously.
11. Capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.

I. Internal Adjustability Capabilities: Integral to controller or through chiller control panel.

1. Minimum Output Frequency: 6 Hz.
2. Maximum Output Frequency: 60 Hz.
3. Acceleration: Two seconds to a minimum of 60 seconds.
4. Deceleration: Two seconds to a minimum of 60 seconds.

5. Current Limit: 30 percent to a minimum of 100 percent of maximum rating.

J. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions shall not result in component failure or the need for replacement:

1. Overtemperature.
2. Short circuit at controller output.
3. Ground fault at controller output. Variable-frequency controller shall be able to start a grounded motor.
4. Open circuit at controller output.
5. Input undervoltage.
6. Input overvoltage.
7. Loss of input phase.
8. Reverse phase.
9. AC line switching transients.
10. Instantaneous overload, line to line or line to ground.
11. Sustained overload exceeding 100 percent of controller-rated current.
12. Starting a rotating motor.

K. Motor Protection: Controller shall protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.

L. Automatic Reset and Restart:

1. Capable of three - five restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction.
2. Controller shall be capable of automatic restart on phase-loss and overvoltage and undervoltage trips.

M. Visual Indication: On face of controller enclosure or chiller control enclosure. indicating the following conditions:

1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.
6. External fault.
7. Motor speed (percent).
8. Fault or alarm status (code).
9. DC-link voltage.
10. Motor output voltage.
11. Input kilovolt amperes.
12. Total power factor.
13. Input kilowatts.
14. Input kilowatt-hours.
15. Three-phase input voltage.
16. Three-phase output voltage.
17. Three-phase input current.
18. Three-phase output current.

19. Three-phase input voltage THD.
20. Three-phase input current THD.
21. Output frequency (Hertz).
22. Elapsed operating time (hours).
23. Diagnostic and service parameters.

N. Operator Interface: At controller or chiller control panel; with start-stop and auto-manual selector with manual-speed-control potentiometer.

O. Control Signal Interface:

1. Electric Input Signal Interface: A minimum of two analog inputs (0 to 10 V or 0/4-20 mA) and six programmable digital inputs.
2. Manufacturer has option to incorporate control signal interface into chiller control panel.

P. Active Harmonic Distortion Filter:

1. Factory mounted and wired to limit total voltage and current distortion to 5 percent.
2. Factory mounted and wired to limit total demand distortion (TDD) to 5 percent of unit input.

Q. Input Line Conditioning: As directed.

R. Cooling: Air, Refrigerant, Water or Air, refrigerant, or water cooled, as directed.

S. Accessories: Devices shall be factory installed in controller enclosure unless otherwise indicated.

1. Control Relays: Auxiliary and adjustable time-delay relays.

T. Chiller Capacity Control Interface: Equip chiller with adaptive control logic to automatically adjust the compressor motor speed and the compressor pre-rotation inlet vane position independently to achieve maximum part-load efficiency in response to sensor inputs that are integral to the chiller controls.

2.12 CONTROLS

A. Control: Standalone and microprocessor based, with all memory stored in nonvolatile memory, so that reprogramming is not required on loss of electrical power.

B. Enclosure: Unit mounted, NEMA 250, Type 1, Type 4, Type 4x or Type 12, as directed, hinged or lockable, factory wired with a single-point, with field-power connection and a separate control circuit.

C. Factory-installed wiring outside of enclosures shall be in a NFPA 70-approved raceway. Make terminal connections with liquidtight or flexible metallic conduit.

D. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. In either imperial or metric units selectable through the interface, display the following information:

1. Date and time.
2. Operating or alarm status.
3. Fault history with not less than last 10 faults displayed.
4. Set points of controllable parameters.
5. Trend data.
6. Operating hours.
7. Number of chiller starts.
8. Outdoor-air temperature or space temperature if required for chilled-water reset.
9. Entering- and leaving-fluid temperatures of evaporator and condenser.
10. Difference in fluid temperatures of evaporator and condenser.
11. Fluid flow of evaporator and condenser.
12. Fluid-pressure drop of evaporator and condenser.
13. Refrigerant pressures in evaporator and condenser.
14. Refrigerant saturation temperature in evaporator and condenser shell.
15. Compressor refrigerant suction and discharge temperature.
16. Compressor bearing temperature.
17. Motor bearing temperature.
18. Motor winding temperature.
19. Oil temperature.
20. Oil discharge pressure.
21. Phase current.
22. Percentage of motor-rated load amperage.
23. Phase voltage.
24. Demand power (kilowatts).
25. Energy use (kilowatt-hours).
26. Power factor.
27. For chillers equipped with variable-frequency controllers and harmonic filters, include the following:

    a. Output voltage and frequency.
    b. Voltage THD for each phase.
    c. Supply current TDD for each phase.
    d. Inlet vane position.
    e. Controller internal ambient temperature.
    f. Heatsink temperature.

28. Purge suction temperature if purge system is provided.
29. Purge elapsed time if purge system is provided.

E. Control Functions:

1. Manual or automatic startup and shutdown time schedule.
2. Entering and leaving chilled-water temperatures, control set points, and motor load limits. Evaporator-fluid temperature shall be reset based on return-water, outdoor-air or space temperature, as directed.
3. Current limit and demand limit.
4. Condenser-fluid temperature.
5. External chiller emergency stop.
6. Variable evaporator flow.
7. Thermal storage.
8. Heat reclaim.

F. Manually Reset Safety Controls: The following conditions shall shut down chiller and require manual reset:

1. Low evaporator pressure, temperature or pressure or temperature; high condenser pressure.
2. Low evaporator-fluid temperature.
3. Low oil differential pressure.
4. High or low oil pressure.
5. High oil temperature.
6. High compressor-discharge temperature.
7. Loss of condenser-fluid flow.
8. Loss of evaporator-fluid flow.
9. Motor overcurrent.
10. Motor overvoltage.
11. Motor undervoltage.
12. Motor phase reversal.
13. Motor phase failure.
14. Sensor- or detection-circuit fault.
15. Processor communication loss.
16. Motor controller fault.
17. Extended compressor surge.
18. Excessive air-leakage detection for chillers using R-123 refrigerant.

G. Trending: Capability to trend analog data of up to five parameters simultaneously over an adjustable period and frequency of polling.

H. Security Access: Provide electronic security access to controls through identification and password, with at least three levels of access: view only; view and operate; and view, operate, and service.

I. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.

J. Communication Port: RS-232 port, USB 2.0 port or higher, or equivalent connection capable of connecting a printer and a notebook computer.

K. BAS or DDC System Interface: Factory install hardware and software to enable system to monitor, control, and display chiller status and alarms.

1. Hardwired I/O Points:

a. Monitoring: On-off status, common trouble alarm, electrical power demand (kilowatts), electrical power consumption (kilowatt-hours) or power factor, directed.
b. Control: On-off operation, chilled-water, discharge temperature set-point adjustment or electrical power demand limit, as directed.

2. Communication Interface: ASHRAE 135 (BACnet), LonTalk, Modbus or Industry-accepted, open-protocol, as directed communication interface shall enable control system operator to remotely control and monitor the chiller from an operator workstation.

a. Control features and monitoring points displayed locally at chiller control panel shall be available through the control system, including, as a minimum, the following:

1) Start-stop command from remote source.
2) Unit control source, local, analog, digital or modem.
3) Chiller control panel start-stop.
4) Accumulated operating hours.
5) Accumulated starts.
6) Compressor motor status.
7) Unit operation code.
8) Unit safety fault code.
9) Unit cycling fault code.
10) Chilled-water pump status.
11) Chilled-water flow proof.
12) Chilled-water entering temperature.
13) Chilled-water leaving temperature.
14) Chilled-water leaving temperature set-point adjustment from remote source.
15) Condenser(s) water entering temperature.
16) Condenser(s) water leaving temperature.
17) Evaporator refrigerant pressure.
18) Condenser(s) refrigerant pressure.
19) Evaporator refrigerant saturation temperature.
20) Condenser(s) refrigerant saturation temperature.
21) Refrigerant discharge temperature.
22) Refrigerant level.
23) Refrigerant liquid level set point.
24) Oil pressure differential.
25) Oil sump pressure.
26) Oil pump pressure.
27) Oil sump temperature.
28) High-speed thrust bearing proximity position.
29) High-speed thrust bearing proximity reference.
30) Motor current percent of full-load amps.
31) Motor current phase A.
32) Motor current phase B.
33) Motor current phase C.
34) Motor current set-point adjustment from remote source.
35) Motor bearing shaft end vibration.
36) Motor bearing opposite shaft end vibration.
37) Motor bearing shaft end temperature.
38) Motor bearing opposite shaft end temperature.
39) Motor average winding temperature.
40) Variable-frequency controller selection, auto or fixed.
41) Variable-frequency controller output voltage.
42) Variable-frequency controller input power, rate.
43) Variable-frequency controller input power, consumption.
44) Variable-frequency controller DC bus voltage.
45) Variable-frequency controller inverter link current.
46) Variable-frequency controller output frequency.
47) Variable-frequency controller internal ambient temperature.

48) Variable-frequency controller converter heatsink temperature.
49) Variable-frequency controller harmonic filter installed, true or false.
50) Harmonic Filter THD at maximum voltage, percent.
51) Harmonic filter total demand distortion at maximum current, percent.
52) Harmonic filter total supply kVA.
53) Anti-recycle time remaining.
54) Liquid line solenoid.
55) Pre-rotation vanes position.
56) Adaptive capacity control valve surge map installed, true or false.
57) Adaptive capacity control new surge point, true or false.
58) Adaptive capacity control surge type, pressure differential or current.
59) Adaptive capacity control surge count.
60) Adaptive capacity control PRV position.
61) Adaptive capacity control output frequency.

L. Quick-Start Feature:

1. Automatically restore chiller operation up to 100 percent capacity within three - five minutes after a 15-second power interruption.
2. Quick-start feature shall ensure guide vanes remain open following a power interruption event and quick ramp-up speed logic is employed to facilitate shortest time to deliver chilled water at set-point temperature.
3. Chiller manufacturer shall provide integral UPS unit(s) with chiller controls if required to keep chiller integral controls operational to comply with requirement.
4. Chiller manufacturer shall demonstrate chiller start time with the quick-start feature enabled while simulating power fault, power service return, restart time, and capacity control, to produce desired chilled-water temperature at load indicated.

2.13 ACCESSORIES

A. Flow Switches:

1. Chiller manufacturer shall furnish a switch for each evaporator and condenser and verify field-mounting location before installation.
2. Paddle Flow Switches:

    a. Vane operated to actuate a double-pole, double-throw switch, with one pole field wired to the chiller control panel and the other pole field wired to the DDC system for HVAC.
    b. Contacts: Platinum alloy, silver alloy, or gold-plated switch contacts with a rating of 10 A at 120-V ac.
    c. Pressure rating equal to pressure rating of heat exchanger.
    d. Construct body and wetted parts of Type 316 stainless steel.
    e. House switch in a NEMA 250, Type 4 enclosure constructed of die-cast aluminum.
    f. Vane length to suit installation.

3. Pressure-Differential Switches:

a. Construction: Wetted parts of body and trim constructed of Type 316 stainless steel.
b. Performance: Switch shall withstand, without damage, the full-pressure rating of the heat exchanger applied to either port and exhibit zero set-point shift due to variation in working pressure.
c. Set Point: Screw type, field adjustable.
d. Electrical Connections: Internally mounted screw-type terminal blocks.
e. Switch Enclosure: NEMA 250, Type 4.
f. Switch Action: Double-pole, double-throw switch, with one pole field wired to the chiller control panel and the other pole field wired to the DDC system for HVAC.

B. Vibration Isolation:

1. Chiller manufacturer shall furnish vibration isolation for each chiller.
2. Neoprene Pad:

a. Two layers of 0.375-inch- (10-mm-) thick, ribbed- or waffle-pattern neoprene pads separated by a 16-gage, stainless-steel plate.
b. Fabricate pads from 40- to 50 – 60 durometer neoprene.
c. Provide stainless-steel square bearing plate to load the pad uniformly between 20 and 40 psig (138 and 276 kPa) with a 0.12- to 0.16-inch (3- to 4-mm) deflection.

3. Spring Isolator:

a. Stable in operation and designed for not less than 30 percent reserve deflection beyond actual operating conditions.
b. Isolators shall be designed so that the Kx/Ky ratio shall be 1.0 or more for stability.
c. Provide PVC or neoprene-coated springs and hot-dip, galvanized-steel components. Aluminum components shall be etched and painted. Nuts, bolts, and washers shall be zinc electroplated.
d. Isolators shall be adjustable and with an open spring, having one or more coil springs attached to a top compression plate and a baseplate.
e. An elastomeric pad with a minimum thickness of 0.25 inch (6 mm) shall be bonded to the baseplate.
f. Spring assembly shall be removable and fit within a welded-steel enclosure consisting of a top plate and rigid lower housing, which serves as a blocking device during installation.
g. Isolated restraining bolts shall not be engaged during normal operation and shall connect the top plate and lower housing to prevent the isolated equipment from rising when drained of fluid.
h. Isolators shall be selected for a nominal 1-inch (25-mm) or 2-inch (50-mm) deflection.
i. Integrate seismic restraints in applications that require seismic requirements.

C. Sound Barrier:

1. Provide sound barrier only if required to comply with sound requirements indicated.
2. Furnish removable and reusable sound-barrier covers over the compressor housing, hermetic motor, compressor suction and discharge piping, and condenser shell.
3. Provide for repeated installation and removal without use of tape or calk.

4. Inner and outer cover shall consist of a PTFE-impregnated fiberglass cloth enclosing heavy-density, needled fiberglass insulation material with a mass-loaded vinyl acoustic barrier.
5. Covers shall be double sewn and lock stitched, with edges folded and sewn so no raw cut edges are exposed.
6. Form covers around control devices, gages, conduit, piping, and supports without degrading sound-barrier performance.
7. Continuously lap all exposed seams at least 2 inches (50 mm) for better sound containment.
8. Permanently label each section of cover to indicate its location, description, size, and number sequence.
9. Randomly place stainless-steel quilting pins to prevent covers from shifting and sagging.

2.14 CAPACITIES AND CHARACTERISTICS

A. Capacity: As directed, tons (kW).

B. Full-Load Efficiency:

1. COP: As directed.
2. EER: As directed.
3. Power Input/Cooling Output: As directed, kW/ton.
4. Comply with GS-31.
5. Comply with FEMP.

C. Part-Load Efficiency:

1. IPLV: As directed.
2. NPLV: As directed.
3. Comply with GS-31.
4. Comply with FEMP.

D. Evaporator:

1. Pressure Rating: As directed, psig (kPa).
2. Number of Passes: One, Two or Three, as directed.
3. Fluid Type: Water.
4. Design Fluid Flow Rate: As directed, gpm.
5. Minimum Fluid Flow Rate: As directed, gpm (L/s).
6. Entering-Fluid Temperature: As directed, deg F (deg C).
7. Leaving-Fluid Temperature: As directed, deg F (deg C).
8. Fluid-Pressure Drop: As directed, feet of head (kPa).
9. Fluid Velocity: As directed, fps (m/s).
10. Fouling Factor: 0.0001 sq. ft. x h x deg F/Btu (0.000018 sq. m x deg C/W), 0.00025 sq. ft. x h x deg F/Btu (0.000044 sq. m x deg C/W) or 0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W), as directed.

E. Condenser:

1. Pressure Rating: As directed, psig (kPa).

2. Number of Passes: One, Two or Three, as directed.
3. Fluid Type: Water.
4. Design Fluid Flow Rate: As directed, gpm (L/s).
5. Minimum Fluid Flow Rate: As directed, gpm (L/s).
6. Entering-Fluid Temperature: As directed, deg F (deg C).
7. Leaving-Fluid Temperature: As directed, deg F (deg C).
8. Fluid-Pressure Drop: As directed, feet of head (kPa).
9. Fluid Velocity: As directed, fps (m/s).
10. Fouling Factor: 0.00025 sq. ft. x h x deg F/Btu (0.000044 sq. m x deg C/W), 0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W) or 0.001 sq. ft. x h x deg F/Btu (0.00022 sq. m x deg C/W).

F. Compressor:

1. Number of Compressors: One – Two, as directed.
2. First Compressor Rated-Load Amperes: As directed, A.
3. First Compressor Locked-Rotor Amperes: As directed, A.
4. Second Compressor Rated-Load Amperes: As directed, A.
5. Second Compressor Locked-Rotor Amperes: As directed, A.

G. Chiller Control Electrical Requirements:

1. Power Connections: Integral or Field.
2. Power Input: As directed, kW.
3. Minimum Circuit Ampacity: As directed, A.
4. Maximum Overcurrent Protection Device: As directed, A.
5. Volts: 120-V ac.
6. Phase: Single or Three
7. Hertz: 60.

H. Chiller Electrical Requirements:

1. Power Input: As directed, kW.
2. Power Factor: 0.90 - 0.95, as directed.
3. Minimum Circuit Ampacity: As directed, A.
4. Maximum Overcurrent Protection Device: As directed, A.
5. Volts: 208, 240, 480, 600, 2300 or 4160-V ac., as directed.
6. Phase: Three.
7. Hertz: 60.

I. Noise Rating: 85-dBA sound power level when measured according to AHRI 575. Provide factory-installed sound treatment if necessary to achieve performance indicated.

2.15 SOURCE QUALITY CONTROL

A. Perform functional run tests of chillers before shipping.

B. Factory Performance Testing:

1. Factory performance test chillers, before shipping, according to AHRI 550/590.

2. Test the following conditions:

    a. Design conditions indicated.
    b. Reduction in capacity from design to minimum load in steps of 10, 25 or 33, as directed with condenser fluid at design conditions.
    c. Reduction in capacity from design to minimum load in steps of 10, 25 or 33, as directed with varying entering condenser-fluid temperature from design to minimum conditions in 5 deg F (3 deg C) increments.
    d. At one, two, three, four, five or 10, as directed, point(s) of varying part-load performance to be selected by Owner at time of test.

3. Allow Owner access to place where chillers are being tested. Notify Owner in writing at least 30 days in advance of testing.
4. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

C. Factory Sound Testing:

1. For chillers located indoors, rate sound power level according to AHRI 575.
2. Factory sound test chillers, before shipping, according to AHRI 575.
3. Test the following conditions:

    a. Design conditions indicated.
    b. Chiller operating at calculated worst-case sound condition.
    c. At one, two, three, four or five, as directed, point(s) of varying part-load performance to be selected by Owner at time of test.

4. Allow Owner access to place where chillers are being tested. Notify Owner in writing at least 30 days in advance of testing.
5. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

D. Factory test and inspect evaporator and condenser according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

E. Factory test and inspect evaporator and condenser according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Pressure test fluid side of heat exchangers, including water boxes, to 1.5 times the rated pressure. Pressure proof test refrigerant side of heat exchangers to a minimum of 45 psig (310 kPa). Vacuum and pressure test for leaks.

F. Eddy Current Testing:

1. Perform factory testing of evaporator and condenser tubes of each chiller to ensure tube quality and longevity.
2. Submit test report, including, as a minimum:

    a. List of equipment used and equipment settings.
    b. Test data reports and accompanying strip charts of calibrations.
    c. Identify tubes with significant defects and typical indications.
    d. Statistical summary of defect indications.

e. Recommendations concerning tube condition, tube replacement, tube removal for evaluation, and future frequency of testing.
f. Approval by an American Society for Nondestructive Testing, Level III eddy current technician.

PART 3 - EXECUTION

3.1 CHILLER INSTALLATION

A. Equipment Mounting:

1. Install chillers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." Or Section 033053 "Miscellaneous Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

B. Maintain manufacturer's recommended clearances for service and maintenance.

C. Maintain clearances required by governing code.

D. Chiller manufacturer's factory-trained service personnel shall charge chiller with refrigerant and fill with oil if not factory installed.

E. Install separate devices furnished by manufacturer and not factory installed.

1. Chillers shipped in multiple major assemblies shall be field assembled by chiller manufacturer's factory-trained service personnel.

3.2 PIPING CONNECTIONS

A. Comply with requirements for piping specified in Section 232113 "Hydronic Piping," Section 232116 Hydronic Piping Specialties," and Section 232300 "Refrigerant Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to chillers, allow space for service and maintenance.

C. Evaporator-Fluid Connections:

1. Connect to evaporator inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with pressure gage.
2. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, and drain connection with valve.
3. Make connections to chiller with a flange, mechanical coupling or flange or mechanical coupling.

D. Condenser-Fluid Connections:

1. Connect to condenser inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with pressure gage.
2. Connect to condenser outlet with shutoff valve, balancing valve, flexible connector, thermometer, plugged tee with shutoff valve and pressure gage, low meter, and drain connection with valve.
3. Make connections to chiller with a flange, mechanical coupling or flange or mechanical coupling.

E. Refrigerant-Pressure Relief Device Connections:

1. For chillers installed indoors, extend vent piping or separate vent piping for each chiller to the outdoors without valves or restrictions.
2. Comply with ASHRAE 15.
3. Connect to chiller pressure relief device with flexible connector and dirt leg with drain valve.

F. For chillers equipped with a purge system, extend purge vent piping or separate purge vent piping for each chiller to the outdoors. Comply with ASHRAE 15 and ASHRAE 147.

G. Connect each chiller drain connection with a drain valve, which is full size of drain connection. Connect drain pipe to drain valve with union, and extend drain pipe to terminate over floor drain.

H. Connect each chiller water box vent connection with an automatic or manual vent, which is full size of vent connection.

3.3 ELECTRICAL POWER CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection. Nameplate shall be laminated phenolic layers of black with engraved white letters at least 1/2 inch (13 mm) high. Locate nameplate where easily visible.

3.4 CONTROLS CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between chillers and other equipment to interlock operation as required to provide a complete and functioning system.

C. Connect control wiring between chiller control interface and DDC control system for remote monitoring and control of chillers. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC" .

D. Install nameplate on face of chiller control panel indicating the control equipment designation serving chiller and the I/O point designation for each control connection. Nameplate shall be laminated phenolic layers of black with engraved white letters at least 0.5 inches high.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain chillers.

END OF SECTION 236416

SECTION 236423.13 - AIR-COOLED, SCROLL WATER CHILLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes packaged, air-cooled, electric-motor-driven, scroll water chillers.

1.2 DEFINITIONS

A. BAS: Building automation system.

B. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.

C. DDC: Direct digital control.

D. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in Btu/h to the total power input given in watts at any given set of rating conditions.

E. GFI: Ground fault interrupt.

F. IPLV: Integrated part-load value. A single-number part-load efficiency figure of merit for a single chiller calculated per the method defined by AHRI 550/590 and referenced to AHRI standard rating conditions.

G. I/O: Input/output.

H. kW/Ton: The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons at any given set of rating conditions.

I. NPLV: Nonstandard part-load value. A single number part-load efficiency figure of merit for a single chiller calculated per the method defined by AHRI 550/590 and intended for operating conditions other than the AHRI standard rating conditions.

J. SCCR: Short-circuit current rating.

K. TEAO: Totally enclosed air over.

L. TENV: Totally enclosed nonventilating.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: Complete set of manufacturer's prints of water chiller assemblies, control panels, sections and elevations, and unit isolation. Include the following:

1. Assembled unit dimensions.
2. Weight and load distribution.
3. Required clearances for maintenance and operation.
4. Size and location of piping and wiring connections.
5. Diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Certificates: For certification required in "Quality Assurance" Article.

B. Seismic Qualification Data: Certificates, for water chillers, accessories, and components, from manufacturers.

C. Installation instructions.

D. Source quality-control reports.

E. Startup service reports.

F. Sample warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

A. AHRI Certification: Certify chiller according to AHRI 590 certification program.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of water chillers that fail in materials or workmanship within specified warranty period.

1. Extended warranties include, but are not limited to, the following:

a. Complete chiller including refrigerant and oil charge.
b. Complete compressor and drive assembly including refrigerant and oil charge.
c. Refrigerant and oil charge.

1) Loss of refrigerant charge for any reason due to manufacturer's product defect and product installation.

d. Parts only or and labor, as directed.

2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Scroll water chillers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 - 1.0.

B. Site Altitude: Chiller shall be suitable for altitude at which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.

C. Performance Tolerance: Comply with the following in lieu of AHRI 550/590:

1. Allowable Capacity Tolerance: Zero percent.
2. Allowable Full-Load Energy Efficiency Tolerance: Zero percent.
3. Allowable Part-Load Energy Efficiency Tolerance: Zero percent.

D. AHRI Rating: Rate water chiller performance according to requirements in AHRI 550/590.

E. ASHRAE Compliance: ASHRAE 15 for safety code for mechanical refrigeration.

F. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

G. ASME Compliance: Fabricate and stamp water chiller heat exchangers to comply with ASME Boiler and Pressure Vessel Code.

H. Comply with NFPA 70.

I. Comply with requirements of UL 1995, "Heating and Cooling Equipment," and include label by a qualified testing agency showing compliance.

J. Operation Following Loss of Normal Power:

1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to backup power system shall automatically return equipment and associated controls to the operating state occurring immediately before loss of normal power without need for manual intervention by an operator when power is restored either through a backup power source, or through normal power if restored before backup power is brought on-line.
2. See drawings for equipment served by backup power systems.
3. Provide means and methods required to satisfy requirement even if not explicitly indicated.

K. Outdoor Installations:

1. Chiller shall be suitable for outdoor installation indicated. Provide adequate weather protection to ensure reliable service life over a 25-year period with minimal degradation due to exposure to outdoor ambient conditions.
2. Chillers equipped to provide safe and stable operation while achieving performance indicated when operating at extreme outdoor temperatures encountered by the installation. Review historical weather database and provide equipment that can operate at extreme outdoor temperatures recorded over past 30-year period.

2.2 MANUFACTURERS

2.3 MANUFACTURED UNITS

A. Description: Factory-assembled and run-tested water chiller complete with compressor(s), compressor motors and motor controllers, evaporator, condenser with fans, electrical power, controls, and indicated accessories.

B. Fabricate water chiller mounting base with reinforcement strong enough to resist water chiller movement during a seismic event when water chiller is anchored to field support structure.

2.4 CABINET

A. Base: Galvanized-steel base extending the perimeter of water chiller. Secure frame, compressors, and evaporator to base to provide a single-piece unit.

B. Frame: Rigid galvanized-steel frame secured to base and designed to support cabinet, condenser, control panel, and other chiller components not directly supported from base.

C. Casing: Galvanized steel.

D. Finish: Coat base, frame, and casing with a corrosion-resistant coating capable of withstanding a 500-hour salt-spray test according to ASTM B117.

2.5 COMPRESSOR-DRIVE ASSEMBLIES

A. Compressors:

1. Description: Positive-displacement direct drive with hermetically sealed casing.
2. Operating Speed: Nominal 3600 rpm for 60-Hz applications.
3. Capacity Control: On-off compressor cycling, plus hot-gas bypass.

    a. Digital compressor unloading is an acceptable alternative to achieve capacity control.

4. Oil Lubrication System: Automatic pump with strainer, sight glass, filling connection, filter with magnetic plug or removable magnet in sump, and initial oil charge.

a. Manufacturer's other standard methods of providing positive lubrication are acceptable in lieu of an automatic pump.

5. Vibration Isolation: Mount individual compressors on vibration isolators.

a. For multiple compressor assemblies, it is acceptable to isolate each compressor assembly in lieu of each compressor.

B. Compressor Motors:

1. Hermetically sealed and cooled by refrigerant suction gas.
2. High-torque, two-pole induction type with inherent thermal-overload protection on each phase.

C. Compressor Motor Controllers:

1. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing.

2.6 REFRIGERATION

A. Refrigerant: R-410A. Classified as Safety Group A1 according to ASHRAE 34.

B. Refrigerant Compatibility: Parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.

C. Refrigerant Circuit: Each circuit shall include an electronic or a thermal-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.

D. Pressure Relief Device:

1. Comply with requirements in ASHRAE 15, ASHRAE 147, and applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Select and configure pressure relief devices to protect against corrosion and inadvertent release of refrigerant.
3. ASME-rated, spring-loaded, pressure relief valve; single- or multiple-reseating type. Pressure relief valve(s) shall be provided for each heat exchanger.

2.7 EVAPORATOR

A. Shell and Tube:

1. Description: Direct-expansion, shell-and-tube design with fluid flowing through the shell and refrigerant flowing through the tubes within the shell.
2. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
3. Shell Material: Carbon steel.
4. Shell Heads: Removable carbon-steel heads with multipass baffles designed to ensure positive oil return and located at each end of the tube bundle.

5. Shell Nozzles: Fluid nozzles located along the side of the shell and terminated with mechanical-coupling end connections for connection to field piping. Furnish flange adapters to mate to flanged piping.
6. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.

B. Brazed Plate:

1. Direct-expansion, single-pass, brazed-plate design.
2. Type 304 or 316 stainless-steel construction.
3. Code Compliance: Tested according to ASME Boiler and Pressure Vessel Code.
4. Fluid Nozzles: Terminate with mechanical-coupling end connections for connection to field piping. Furnish flange adapters to mate to flanged piping.
5. Inlet Strainer: Factory-furnished, 20 or 40-mesh strainer for field installation in supply piping to evaporator. Manufacturer has option to factory install strainer.

C. Flow Switch: Factory-furnished and -installed, thermal-type flow switch wired to chiller operating controls.

D. Heater: Factory-installed and -wired electric heater with integral controls designed to protect the evaporator to minus 20 deg F (minus 29 deg C).

E. Remote-Mounting Kit: Designed for remote field mounting where indicated. Provide kit for field installation.

2.8 AIR-COOLED CONDENSER

A. Coil(s) with integral subcooling on each circuit.

B. Copper Tube with Plate Fin Coils:

1. Construct coils of copper tubes mechanically bonded to aluminum, aluminum with precoated epoxy-phenolic or copper fins.

C. Aluminum Microchannel Coils:

1. Series of flat tubes containing a series of multiple, parallel-flow microchannels layered between refrigerant header manifolds.
2. Single- or multiple-pass arrangement.
3. Construct fins, tubes, and header manifolds of aluminum alloy treated with a corrosion-resistant coating.

D. Corrosion-Resistant Coating: Coat coils with an epoxy or a phenolic corrosion-resistant coating after fabrication.

E. Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.

F. Fans: Direct-drive propeller type with statically and dynamically balanced fan blades, arranged for vertical air discharge.

G. Fan Motors: TENV or TEAO enclosure, with sealed and permanently lubricated bearings, and having built-in overcurrent- and thermal-overload protection.

1. Overcurrent- and thermal-overload protection not integral to motor is acceptable if provided with chiller electrical power package.

H. Fan Guards: Removable steel safety guards with corrosion-resistant PVC coating.

2.9 INSULATION

A. Factory-applied insulation over all cold surfaces of chiller capable of forming condensation. Components shall include, but not be limited to, evaporator, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, refrigerant-cooled motor, and auxiliary piping.

2.10 ELECTRICAL

A. Factory installed and wired, and functionally tested at factory before shipment.

B. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to water chiller.

C. House in a unit-mounted, NEMA 250, Type 3R enclosure with hinged access door with lock and key or padlock and key.

D. Wiring shall be numbered and color-coded to match wiring diagram.

E. Factory wiring shall be located outside of an enclosure in a metal raceway. Terminal connections shall be made with not more than a 24-inch (610-mm) length of liquidtight or flexible metallic conduit.

F. Field power interface shall be to wire lugs, NEMA KS 1, heavy-duty, nonfused disconnect switch or circuit breaker. Minimum SCCR according to UL 508 shall be as required by electrical power distribution system, but not less than 42,000, 65,000 or 100,000 A, as directed.

G. Each motor shall have branch power circuit and controls with one of the following disconnecting means having SCCR to match main disconnecting means:

1. NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
2. NEMA KS 1, heavy-duty, nonfusible switch.
3. UL 489, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

H. Each motor shall have overcurrent protection.

I. Overload relay sized according to UL 1995, or an integral component of water chiller control microprocessor.

J. Phase-Failure and Undervoltage: Solid-state sensing with adjustable settings.

K. Power Factor Correction: Capacitors to correct power factor to 0.90 - 0.95, as directed at full load.

L. Controls Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.

M. Control Relays: Auxiliary and adjustable time-delay relays, or an integral to water chiller microprocessor.

N. Service Receptacle:

1. Unit-mounted, 120-V GFI duplex receptacle.
2. Power receptacle from chiller internal electrical power wiring.

O. Indicate the following for water chiller electrical power supply:

1. Current, phase to phase, for all three phases.
2. Voltage, phase to phase and phase to neutral for all three phases.
3. Three-phase real power (kilowatts).
4. Three-phase reactive power (kilovolt amperes reactive).
5. Power factor.
6. Running log of total power versus time (kilowatt hours).
7. Fault log, with time and date of each.

2.11 CONTROLS

A. Factory installed and wired, and functionally tested at factory before shipment.

B. Standalone, microprocessor based, with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.

C. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure of matching construction.

D. Operator Interface: Keypad or pressure-sensitive touch screen. Multiple-character, digital display. Display the following:

1. Date and time.
2. Operating or alarm status.
3. Operating hours.
4. Outside-air temperature if required for chilled-water reset.
5. Temperature and pressure of operating set points.
6. Chilled-water entering and leaving temperatures.
7. Refrigerant pressures in evaporator and condenser.
8. Saturation temperature in evaporator and condenser.
9. No cooling load condition.
10. Elapsed time meter (compressor run status).
11. Pump status.
12. Antirecycling timer status.

13. Percent of maximum motor amperage.
14. Current-limit set point.
15. Number of compressor starts.
16. Alarm history with retention of operational data before unit shutdown.
17. Superheat.

E. Control Functions:

1. Manual or automatic startup and shutdown time schedule.
2. Capacity control based on evaporator leaving-fluid temperature.
3. Capacity control compensated by rate of change of evaporator entering-fluid temperature.
4. Chilled-water entering and leaving temperatures, control set points, and motor load limit. Chilled-water leaving temperature shall be reset based on return-water, outside-air or space temperature, as directed.
5. Current limit and demand limit.
6. Condenser-water temperature.
7. External water chiller emergency stop.
8. Antirecycling timer.
9. Automatic lead-lag switching.
10. Ice-building mode.

F. Manual-Reset Safety Controls: The following conditions shall shut down water chiller and require manual reset:

1. Low evaporator pressure or high condenser pressure.
2. Low chilled-water temperature.
3. Refrigerant high pressure.
4. High or low oil pressure.
5. High oil temperature.
6. Loss of chilled-water flow.
7. Loss of condenser-water flow.
8. Control device failure.

G. BAS or DDC System Interface: Factory-install hardware and software to enable system to monitor, control, and display chiller status and alarms.

1. Hardwired I/O Points:

   a. Monitoring: On/off status, common trouble alarm, electrical power demand (kilowatts) or electrical power consumption (kilowatt hours), as directed.
   b. Control: On/off operation, chilled-water discharge temperature set-point adjustment or electrical power demand limit, as directed.

2. Communication Interface: ASHRAE 135 (BACnet), LonTalk, Modbus or Industry-accepted open-protocol, as directed, communication interface shall enable control system operator to remotely control and monitor the water chiller from an operator workstation. Control features and monitoring points displayed locally at water chiller control panel shall be available through DDC system for HVAC.

H. Factory-installed wiring outside of enclosures shall be in NFPA 70-complaint raceway. Make terminal connections with liquid tight or flexible metallic conduit.

2.12 ACCESSORIES

A. Factory-furnished neoprene or spring isolators with seismic restraints for field installation.

1. Spring Deflection: 1 inch (25 mm) or 2 inches (50 mm), as directed.

2.13 CAPACITIES AND CHARACTERISTICS

A. Capacity: As directed, tons (kW).

B. Full-Load Efficiency:

1. COP: As directed.
2. EER: As directed.
3. Power Input/Cooling Output, kW/Ton (kW/kW).

C. Part-Load Efficiency:

1. IPLV: As directed.
2. NPLV: As directed.

D. Low Ambient Operation: Chiller designed for operation to 0 deg F (minus 18 deg C) or minus 20 deg F (minus 29 deg C), as directed.

E. High Ambient Operation: Chiller designed for operation to 115 deg F (46 deg C) or 120 deg F (50 deg C), as directed.

F. Evaporator:

1. Type: Brazed plate or shell and tube.
2. Pressure Rating: As directed, psig (kPa).
3. Fluid Type: Water.
4. Design Fluid Flow Rate: As directed, gpm (L/s).
5. Minimum Fluid Flow Rate: As directed, gpm (L/s).
6. Entering-Fluid Temperature: As directed, deg F (deg C).
7. Leaving-Fluid Temperature: As directed, deg F (deg C).
8. Fluid Pressure Drop: As directed, feet of head (kPa).
9. Fouling Factor: 0.0001 sq. ft. x h x deg F/Btu (0.000018 sq. m x deg C/W), 0.00025 sq. ft. x h x deg F/Btu (0.000044 sq. m x deg C/W) or 0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W).

G. Condenser Entering-Air Temperature: As directed, deg F (deg C).

H. Site Altitude: As directed, feet (m).

I. Number of Refrigeration Circuits: One – Two, as directed.

J. Compressor Rated Load Amperes: As directed.

K. Compressor Locked-Rotor Amperes: As directed.

L. Controls Power Connection: Fed through integral transformer.

M. Chiller Power Input: As directed, kilowatts.

N. Chiller Minimum Circuit Ampacity: As directed.

O. Chiller Maximum Overcurrent Protection Device: As directed.

P. Chiller Electrical Characteristics: 208, 240, 480 or 600V ac, three phase, 60 Hz, as directed.

Q. Noise Rating: As directed, dBA at as directed, distance in feet (m) when measured according to AHRI 370.

2.14 SOURCE QUALITY CONTROL

A. Perform functional test of water chillers before shipping.

B. Factory performance test water chillers, before shipping, according to AHRI 550/590.

1. Test the following conditions:

a. Design conditions indicated.
b. AHRI 550/590 part-load points.

2. Allow Owner access to place where water chillers are being tested. Notify Owner 14 - 30 days in advance of testing.

C. Factory test and inspect evaporator and water-cooled condenser according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Stamp with ASME label.

D. For water chillers located outdoors, rate sound power level according to AHRI 370 procedure.

PART 3 - EXECUTION

3.1 WATER CHILLER INSTALLATION

A. Coordinate sizes and locations of bases with actual equipment provided. Cast anchor-bolt inserts into concrete bases.

B. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures with actual equipment provided.

C. Install water chillers on support structure indicated.

D. Equipment Mounting:

1. Install water chillers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." Or Section 033053 "Miscellaneous Cast-in-Place Concrete.", as directed.
2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

E. Maintain manufacturer's recommended clearances for service and maintenance.

F. Maintain clearances required by governing code.

G. Chiller manufacturer's factory-trained service personnel shall charge water chiller with refrigerant if not factory charged and fill with oil if not factory installed.

H. Install separate devices furnished by manufacturer and not factory installed.

1. Chillers shipped in multiple major assemblies shall be field assembled by chiller manufacturer's factory-trained service personnel.

3.2 PIPING CONNECTIONS

A. Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Comply with requirements in Section 232300 "Refrigerant Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

C. Where installing piping adjacent to chillers, allow space for service and maintenance.

D. Connect each drain connection with a drain valve, full size of drain connection. Connect drain pipe to drain valve with union and extend drain pipe to terminate over floor drain.

E. Connect each chiller vent connection with an automatic or a manual vent, full size of vent connection.

3.3 ELECTRICAL POWER CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Provide nameplate for each electrical connection indicating electrical equipment designation and circuit number feeding connection. Nameplate shall be laminated phenolic layers of black

with engraved white letters at least 1/2 inch (13 mm) high. Locate nameplate where easily visible.

3.4 CONTROLS CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between chillers and other equipment to interlock operation as required to provide a complete and functioning system.

C. Connect control wiring between chiller control interface and DDC system for remote monitoring and control of chillers. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."

D. Provide nameplate on face of chiller control panel indicating control equipment designation serving chiller and the I/O point designation for each control connection. Nameplate shall be laminated phenolic layers of black with engraved white letters at least 1/2 inch (13 mm) high.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform or Perform startup service.

B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.

C. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

1. Verify that refrigerant charge is sufficient and water chiller has been leak tested.
2. Verify that pumps are installed and functional.
3. Verify that thermometers and gages are installed.
4. Operate water chiller for run-in period.
5. Check bearing lubrication and oil levels.
6. Verify that refrigerant pressure relief device for chillers installed indoors is vented outside.
7. Verify proper motor rotation.
8. Verify static deflection of vibration isolators, including deflection during water chiller startup and shutdown.
9. Verify and record performance of chilled-water flow and low-temperature interlocks.
10. Verify and record performance of water chiller protection devices.
11. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

D. Visually inspect chiller for damage before starting. Repair or replace damaged components, including insulation. Do not start chiller until damage that is detrimental to operation has been corrected.

E. Prepare a written startup report that records results of tests and inspections.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain water chillers. Video record the training sessions and provide electronic copy to Owner.

1. Instructor shall be factory trained and certified.
2. Provide not less than eight hours of training.
3. Train personnel in operation and maintenance and to obtain maximum efficiency in plant operation.
4. Provide instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
5. Obtain Owner sign-off that training is complete.
6. Owner training shall be held at Project site.

END OF SECTION 236423.13

SECTION 236423.16 - WATER-COOLED, SCROLL WATER CHILLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes packaged, water-cooled, electric-motor-driven, scroll water chillers.

1.2 DEFINITIONS

A. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.

B. DDC: Direct digital control.

C. EER: Energy efficiency ratio. The ratio of the cooling capacity given in terms of Btu/h to the total power input given in terms of watts at any given set of rating conditions.

D. IPLV: Integrated Part-Load Value. A single number part-load efficiency figure of merit for a single chiller calculated per the method defined by AHRI 550/590 and referenced to AHRI standard rating conditions.

E. kW/Ton: The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons at any given set of rating conditions.

F. NPLV: Nonstandard Part-Load Value. A single number part-load efficiency figure of merit for a single chiller calculated per the method defined by AHRI 550/590 and intended for operating conditions other than the AHRI standard rating conditions.

1.3 ACTION SUBMITTALS

A. Product Data: Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: Complete set of manufacturer's prints of water chiller assemblies, control panels, sections and elevations, and unit isolation. Include the following:

1. Assembled unit dimensions.
2. Weight and load distribution.
3. Required clearances for maintenance and operation.
4. Size and location of piping and wiring connections.
5. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Certificates: For certification required in "Quality Assurance" Article.

B. Seismic Qualification Data: Certificates, for water chillers, accessories, and components, from manufacturer.

C. Source quality-control test reports.

D. Startup service reports.

E. Sample warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

A. AHRI Certification: Certify chiller according to AHRI 590 certification program.

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of water chillers that fail in materials or workmanship within specified warranty period.

1. Extended warranties include, but are not limited to, the following:

a. Complete chiller including refrigerant and oil charge.
b. Complete compressor and drive assembly including refrigerant and oil charge.
c. Refrigerant and oil charge.

1) Loss of refrigerant charge for any reason due to manufacturer product defect and product installation.

d. Parts only, and/or labor, as directed.

2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Scroll water chillers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 - 1.0, as directed.

B. Condenser-Fluid Temperature Performance:

1. Startup Condenser-Fluid Temperature: Chiller shall be capable of starting with an entering condenser-fluid temperature of 60 deg F (16 deg C), 55 deg F (13 deg C) or 40 deg F (4 deg C), as directed and providing stable operation until the system temperature is elevated to the minimum operating entering condenser-fluid temperature.
2. Minimum Operating Condenser-Fluid Temperature: Chiller shall be capable of continuous operation over the entire capacity range indicated with an entering condenser-fluid temperature of 65 deg F (18 deg C), 60 deg F (16 deg C) or 55 deg F (13 deg C), as directed.
3. Make factory modifications to standard chiller design if necessary to comply with performance indicated.

C. Site Altitude: Chiller shall be suitable for altitude at which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.

D. Performance Tolerance: Comply with the following in lieu of AHRI 550/590:

1. Allowable Capacity Tolerance: Zero percent.
2. Allowable Full-Load Energy Efficiency Tolerance: Zero percent.
3. Allowable Part-Load Energy Efficiency Tolerance: Zero percent.

E. AHRI Rating: Rate water chiller performance according to requirements in AHRI 550/590, "Water Chilling Packages Using the Vapor Compression Cycle."

F. ASHRAE Compliance: ASHRAE 15 for safety code for mechanical refrigeration.

G. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

H. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

I. Comply with requirements of UL 1995 "Heating and Cooling Equipment," and include label by a qualified testing agency showing compliance.

J. ASME Compliance: Fabricate and label water chiller heat exchangers to comply with ASME Boiler and Pressure Vessel Code.

K. Operation Following Loss of Normal Power:

1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to backup power system shall automatically return equipment and associated controls to the operating state occurring immediately before loss of normal power without need for manual intervention by an operator when power is restored, either through a backup power source or through normal power if restored before backup power is brought on-line.
2. See Drawings for equipment served by backup power systems.
3. Provide means and methods required to satisfy requirement even if not explicitly indicated.

L. Outdoor Installations:

1. Chiller shall be suitable for outdoor installation indicated with adequate weather protection to ensure reliable service life over a 25-year period with minimal degradation due to exposure to outdoor ambient conditions.
2. Chillers shall be equipped for safe and stable operation while achieving performance indicated when operating at extreme outdoor temperatures encountered by the installation. Review historical weather database. Equipment shall be capable of operating at extreme outdoor temperatures recorded over past 30-year period.

2.3 MANUFACTURED UNITS

A. Description: Factory-assembled and run-tested water chiller complete with compressor(s), compressor motors and motor controllers, evaporator, condenser where indicated, electrical power, controls, and indicated accessories.

B. Fabricate water chiller mounting base with reinforcement strong enough to resist water chiller movement during a seismic event when water chiller is anchored to field support structure.

2.4 COMPRESSOR-DRIVE ASSEMBLIES

A. Compressors:

1. Description: Positive-displacement direct drive with hermetically sealed casing.
2. Operating Speed: Nominal 3600 rpm for 60-Hz applications.
3. Capacity Control: On-off compressor cycling, plus hot-gas bypass.

    a. Digital compressor unloading is an acceptable alternative to achieve capacity control.

4. Oil Lubrication System: Automatic pump with strainer, sight glass, filling connection, filter with magnetic plug or removable magnet in sump, and initial oil charge.

a. Manufacturer's other standard methods of providing positive lubrication are acceptable in lieu of an automatic pump.

5. Vibration Isolation: Mount individual compressors on vibration isolators.

a. For multiple compressor assemblies, it is acceptable to isolate each compressor assembly in lieu of each compressor.

6. Sound-reduction package shall consist of acoustic enclosures around the compressors that are designed to reduce sound level without affecting performance.

B. Compressor Motors:

1. Hermetically sealed and cooled by refrigerant suction gas.
2. High-torque, two-pole induction type with inherent thermal-overload protection on each phase.

C. Compressor Motor Controllers:

1. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing.

2.5 REFRIGERATION SYSTEM

A. Refrigerant Type: R-410A. Classified as Safety Group A1 according to ASHRAE 34.

B. Refrigerant Compatibility: Parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.

C. Refrigerant Circuit: Each circuit shall include an electronic or a thermal-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.

D. Pressure Relief Device:

1. Comply with requirements in ASHRAE 15, ASHRAE 147, and applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Select and configure pressure relief devices to protect against corrosion and inadvertent release of refrigerant.
3. Device shall be ASME-rated, spring-loaded, pressure relief valve; single- or multiple-reseating type. Each heat exchanger shall be equipped with pressure relief valve(s).

2.6 EVAPORATOR

A. Shell and Tube:

1. Description: Direct-expansion, shell-and-tube design with fluid flowing through the shell and refrigerant flowing through the tubes within the shell.
2. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.

3. Shell Material: Carbon steel.
4. Shell Heads: Removable carbon-steel heads with multipass baffles designed to ensure positive oil return and located at each end of the tube bundle.
5. Shell Nozzles: Fluid nozzles located along the side of the shell and terminated with mechanical-coupling end connections for connection to field piping. Furnish flange adapters to mate to flanged piping.
6. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.

B. Brazed Plate:

1. Direct-expansion, single-pass, brazed-plate design.
2. Type 304 or Type 316 stainless-steel construction.
3. Code Compliance: Tested according to ASME Boiler and Pressure Vessel Code.
4. Fluid Nozzles: Terminate with mechanical-coupling end connections for connection to field piping.
5. Inlet Strainer: Factory-furnished 20 or 40 mesh strainer for field installation in supply piping to evaporator. Manufacturer has option to factory install strainer.

2.7 CONDENSER

A. Shell and Tube:

1. Description: Shell-and-tube design with refrigerant flowing through the shell and fluid flowing through the tubes within the shell.
2. Positive subcooling of liquid refrigerant.
3. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
4. Shell Material: Carbon steel.
5. Water Boxes: Removable, of carbon-steel construction, located at each end of the tube bundle with fluid nozzles terminated with mechanical-coupling end connections for connection to field piping. Furnish flange adapters to mate to flanged piping.
6. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
7. Each condenser shall have a pressure relief device, purge cock, and liquid-line shutoff valve.

B. Brazed Plate:

1. Direct-expansion, single-pass, brazed-plate design for positive subcooling of liquid refrigerant.
2. Type 316 stainless-steel construction.
3. Code Compliance: Tested according to ASME Boiler and Pressure Vessel Code.
4. Fluid Nozzles: Terminate with mechanical-coupling end connections for connection to field piping.
5. Inlet Strainer: Factory-furnished 20 or 40 mesh strainer for field installation in supply piping to condenser. Manufacturer has option to factory install strainer.

2.8 INSULATION

A. Factory-applied insulation over all cold surfaces of chiller capable of forming condensation. Components shall include, but not be limited to, evaporator, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, refrigerant-cooled motor, and auxiliary piping.

2.9 ELECTRICAL

A. Factory installed and wired, and functionally tested at factory before shipment.

B. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to water chiller.

C. House in a unit-mounted, NEMA 250, Type 1 enclosure with hinged access door with lock and key or padlock and key.

D. Wiring shall be numbered and color-coded to match wiring diagram.

E. Install factory wiring located outside of an enclosure in a metal raceway. Make terminal connections with not more than a 24-inch (610-mm) length of liquidtight or flexible metallic conduit.

F. Field power interface shall be to wire lugs, NEMA KS 1, heavy-duty, nonfused disconnect switch or circuit breaker. Minimum short circuit current rating (SCCR) according to UL 508 shall be as required by electrical power distribution system, but not less than 42,000, 65,000 or 100,000 A, as directed.

G. Each motor shall have branch power circuit and controls with one of the following disconnecting means having SCCR to match main disconnecting means:

1. NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses for Type 2 protection according to IEC 60947-4-1.
2. NEMA KS 1, heavy-duty, nonfusible switch.
3. NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

H. Each motor shall have overcurrent protection.

I. Overload relay sized according to UL 1995, or an integral component of water chiller control microprocessor.

J. Phase Failure and Undervoltage: Solid-state sensing with adjustable settings.

K. Controls Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.

L. Control Relays: Auxiliary and adjustable time-delay relays, or an integral component to water chiller microprocessor.

M. Indicate the following for water chiller electrical power supply:

1. Current, phase to phase, for all three phases.
2. Voltage, phase to phase and phase to neutral for all three phases.
3. Three-phase real power (kilowatts).
4. Three-phase reactive power (kilovolt amperes reactive).
5. Power factor.
6. Running log of total power versus time (kilowatt hours).
7. Fault log, with time and date of each.

2.10 CONTROLS

A. Factory installed and wired, and functionally tested at factory before shipment.

B. Standalone, microprocessor based, with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.

C. Enclosure: Share enclosure with electrical power devices or include a separate enclosure of matching construction.

D. Operator Interface: Keypad or pressure-sensitive touch screen. Multiple-character, backlit, liquid-crystal display or light-emitting diodes. Display the following:

1. Date and time.
2. Operating or alarm status.
3. Operating hours.
4. Outside-air temperature if required for chilled-water reset.
5. Temperature and pressure of operating set points.
6. Entering and leaving temperatures of chilled water.
7. Entering and leaving temperatures of condenser water.
8. Refrigerant pressures in evaporator and condenser.
9. Saturation temperature in evaporator and condenser.
10. No cooling load condition.
11. Elapsed time meter (compressor run status).
12. Pump status.
13. Antirecycling timer status.
14. Percentage of maximum motor amperage.
15. Current-limit set point.
16. Number of compressor starts.
17. Alarm history with retention of operational data before unit shutdown.
18. Superheat.

E. Control Functions:

1. Manual or automatic startup and shutdown time schedule.
2. Capacity control based on evaporator leaving-fluid temperature.
3. Capacity control compensated by rate of change of evaporator entering-fluid temperature.
4. Entering and leaving chilled-water temperatures, control set points, and motor load limit. Chilled-water leaving temperature shall be reset based on return-water, outside-air or space temperature, as directed.
5. Current limit and demand limit.
6. Condenser-water temperature.

7. External water chiller emergency stop.
8. Antirecycling timer.
9. Automatic lead-lag switching.
10. Ice-building mode.

F. Manual-Reset Safety Controls: The following conditions shall shut down water chiller and require manual reset:

1. Low evaporator pressure or high condenser pressure.
2. Low chilled-water temperature.
3. Refrigerant high pressure.
4. High or low oil pressure.
5. High oil temperature.
6. Loss of chilled-water flow.
7. Loss of condenser-water flow.
8. Control device failure.

G. Building Automation or DDC System Interface: Factory install hardware and software to enable system to monitor, control, and display chiller status and alarms.

1. Hardwired I/O Points:

a. Monitoring: On/off status, common trouble alarm, electrical power demand (kilowatts) or electrical power consumption (kilowatt hours), as directed.
b. Control: On/off operation, chilled-water discharge temperature set-point adjustment or electrical power demand limit, as directed.

2. Communication Interface: ASHRAE 135 (BACnet), LonTalk, Modbus or Industry-accepted open-protocol, communication interface shall enable control system operator to remotely control and monitor the water chiller from an operator workstation, as directed. Control features and monitoring points displayed locally at water chiller control panel shall be available through DDC system for HVAC.

H. Factory-installed wiring outside of enclosures shall be in an NFPA 70 complaint raceway. Make terminal connections with liquidtight or flexible metallic conduit.

2.11 ACCESSORIES

A. Factory-furnished, chilled and condenser water paddle or pressures differential type flow switches for field installation.

1. Manufacturer has option to factory install switches.

B. Individual compressor suction and discharge pressure gages with shutoff valves for each refrigeration circuit.

1. Pressure measurement and display through chiller integral controls is an acceptable alternative.

C. Factory-furnished neoprene or spring isolators with seismic restraints for field installation.

2.12 CAPACITIES AND CHARACTERISTICS

A. Capacity: As directed, tons (kW).

B. Full-Load Efficiency:

1. COP: As directed.
2. EER: As directed.
3. Power Input/Cooling Output, kW/Ton (kW/kW): As directed.

C. Part-Load Efficiency:

1. IPLV: As directed.
2. NPLV: As directed.

D. Evaporator:

1. Type: Brazed plate, Shell and tube or Brazed plate or shell and tube.
2. Pressure Rating: As directed, psig (kPa).
3. Fluid Type: Water.
4. Design Fluid Flow Rate: As directed, gpm (L/s).
5. Minimum Fluid Flow Rate: As directed, gpm (L/s).
6. Entering-Fluid Temperature: As directed, deg F (deg C).
7. Leaving-Fluid Temperature: As directed, deg F (deg C).
8. Fluid Pressure Drop: As directed, feet of head (kPa).
9. Fouling Factor: 0.0001 sq. ft. x h x deg F/Btu (0.000018 sq. m x deg C/W), 0.00025 sq. ft. x h x deg F/Btu (0.000044 sq. m x deg C/W) or 0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W), as directed.

E. Condenser:

1. Type: Brazed plate, Shell and tube or Chiller without integral condenser.
2. Pressure Rating: As directed, psig (kPa).
3. Fluid Type: Water.
4. Design Fluid Flow Rate: As directed, gpm (L/s).
5. Minimum Fluid Flow Rate: As directed, gpm (L/s).
6. Entering-Fluid Temperature: As directed, deg F (deg C).
7. Leaving-Fluid Temperature: As directed, deg F (deg C).
8. Fluid Pressure Drop: As directed, feet of head (kPa).
9. Fouling Factor: 0.00025 sq. ft. x h x deg F/Btu (0.000044 sq. m x deg C/W), 0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W) or 0.001 sq. ft. x h x deg F/Btu (0.00022 sq. m x deg C/W), as directed.

F. Number of Refrigeration Circuits: One – Two, as directed.

G. Compressor Rated Load Amperes: As directed.

H. Compressor Locked-Rotor Amperes: As directed.

I. Controls Power Connection: Fed through integral transformer.

J. Chiller Power Input: As directed.

K. Chiller Minimum Circuit Ampacity: As directed.

L. Chiller Maximum Overcurrent Protection Device: As directed.

M. Chiller Electrical Characteristics: 208, 240, 480 or 600-V ac, three phase, 60 Hz, as directed.

N. Noise Rating: As directed, dBA at as directed distance in feet (m) when measured according to AHRI 575.

2.13 SOURCE QUALITY CONTROL

A. Perform functional test of water chillers before shipping.

B. Factory performance test water chillers, before shipping, according to AHRI 550/590, "Water Chilling Packages Using the Vapor Compression Cycle."

1. Test the following conditions:

a. Design conditions indicated.
b. AHRI 550/590 part-load points.

2. Allow Owner access to place where water chillers are being tested. Notify Owner 14 -30 days in advance of testing.

C. Factory test and inspect evaporator and water-cooled condenser according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Stamp with ASME label.

D. For water chillers located indoors, rate sound power level according to AHRI 575 procedure.

PART 3 - EXECUTION

3.1 WATER CHILLER INSTALLATION

A. Coordinate sizes and locations of bases with actual equipment to be installed. Cast anchor-bolt inserts into concrete bases.

B. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures with actual equipment to be installed.

C. Install water chillers on support structure indicated.

D. Equipment Mounting:

1. Install water chillers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." Or Section 033053 "Miscellaneous Cast-in-Place Concrete."

2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

E. Maintain manufacturer's recommended clearances for service and maintenance.

F. Maintain clearances required by governing code.

G. Chiller manufacturer's factory-trained service personnel shall charge water chiller with refrigerant if not factory charged and fill with oil if not factory installed.

H. Install separate devices furnished by manufacturer and not factory installed.

1. Chillers shipped in multiple major assemblies shall be field assembled by chiller manufacturer's factory-trained service personnel.

3.2 PIPING CONNECTIONS

A. Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Comply with requirements in Section 232300 "Refrigerant Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

C. Where installing piping adjacent to chillers, allow space for service and maintenance.

D. Evaporator Fluid Connections:

1. Connect to evaporator inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with pressure gage, as directed.
2. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve, as directed.
3. Make connections to water chiller with a union, flange, mechanical coupling, union, flange, or mechanical coupling, as directed.

E. Condenser Fluid Connections:

1. Connect to condenser inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with pressure gage, as directed.
2. Connect to condenser outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with pressure gage, flow meter and drain connection with valve.
3. Make connections to water chiller with a union, flange, mechanical coupling, union, flange, or mechanical coupling, as directed.

F. Refrigerant Pressure Relief Valve Connections: For water chillers installed indoors, extend vent piping to the outside without valves or restrictions. Comply with ASHRAE 15.

G. Connect each drain connection with a drain valve, full size of drain connection. Connect drain pipe to drain valve with union and extend drain pipe to terminate over floor drain.

H. Connect each chiller vent connection with an automatic or a manual vent, full size of vent connection.

3.3 ELECTRICAL POWER CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install nameplate for each electrical connection indicating electrical equipment designation and circuit number feeding connection. Nameplate shall be laminated phenolic layers of black with engraved white letters at least 0.5 inch high. Locate nameplate where easily visible.

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between chillers and other equipment to interlock operation as required for a complete and functioning system.

C. Connect control wiring between chiller control interface and DDC System for remote monitoring and control of chillers. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."

D. Install nameplate on face of chiller control panel indicating control equipment designation serving chiller and the I/O point designation for each control connection. Nameplate shall be laminated phenolic layers of black with engraved white letters at least 0.5 inch high.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform or Perform startup service.

B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.

C. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

1. Verify that refrigerant charge is sufficient and water chiller has been leak tested.
2. Verify that pumps are installed and functional.
3. Verify that thermometers and gages are installed.
4. Operate water chiller for run-in period.
5. Check bearing lubrication and oil levels.

6. Verify that refrigerant pressure relief device for chillers installed indoors is vented outside.
7. Verify proper motor rotation.
8. Verify static deflection of vibration isolators, including deflection during water chiller startup and shutdown.
9. Verify and record performance of chilled- and condenser-water flow and low-temperature interlocks.
10. Verify and record performance of water chiller protection devices.
11. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

D. Inspect field-assembled components; equipment installation; and piping, controls, and electrical connections for proper assembly, installation, and connection.

E. Visually inspect chiller for damage before starting. Repair or replace damaged components, including insulation. Do not start chiller until damage that is detrimental to operation has been corrected.

F. Prepare a written startup report that records results of tests and inspections.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain water chillers. Video record the training sessions and provide electronic copy to Owner.

1. Instructor shall be factory trained and certified.
2. Provide not less than eight hours of training.
3. Train personnel in operation and maintenance and to obtain maximum efficiency in plant operation.
4. Provide instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
5. Obtain Owner sign-off that training is complete.
6. Owner training shall be held at Project site.

END OF SECTION 236423.16

SECTION 236426.13 - AIR-COOLED, ROTARY-SCREW WATER CHILLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes packaged, air-cooled chillers.

1.2 DEFINITIONS

A. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.

B. DDC: Direct digital control.

C. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in terms of Btu/h to the total power input given in terms of watts at any given set of rating conditions.

D. IPLV: Integrated part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by AHRI 550/590 and referenced to AHRI standard rating conditions.

E. kW/Ton (kW/kW): The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons (kW) at any given set of rating conditions.

F. NPLV: Nonstandard part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by AHRI 550/590 and intended for operating conditions other than AHRI standard rating conditions.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings:

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, drawn to scale, and coordinated with each other, using input from installers of the items involved.

B. Seismic Qualification Data: Certificates, for chillers, accessories, and components, from manufacturer.

C. Source quality-control reports.

D. Field Test Reports: Startup service reports.

E. Sample warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

A. AHRI Certification: Certify chiller according to AHRI 590 certification program(s).

B. AHRI Rating: Rate chiller performance according to requirements in AHRI 550/590.

C. ASHRAE Compliance:

1. ASHRAE 15 for safety code for mechanical refrigeration.
2. ASHRAE 147 for refrigerant leaks, recovery, and handling and storage requirements.

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.

E. ASME Compliance: Fabricate and label chiller to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, and include an ASME U-stamp and nameplate certifying compliance.

F. Comply with NFPA 70.

G. Comply with requirements of UL and UL Canada and include label by a qualified testing agency showing compliance.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of chillers that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two, Three, Four or Five years from date of Substantial Completion, as directed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Chillers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

B. Site Altitude: Chiller shall be suitable for altitude in which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.

C. Performance Tolerance: Comply with the following in lieu of AHRI 550/590:

1. Allowable Capacity Tolerance: Zero percent.
2. Allowable IPLV/NPLV Performance Tolerance: Zero percent.

2.2 PACKAGED, AIR-COOLED CHILLERS

A. Description: Factory-assembled and run-tested chiller complete with base and frame, condenser casing, compressors, compressor motors and motor controllers, evaporator, condenser coils, condenser fans and motors, electrical power, controls, and accessories.

B. Fabricate base, frame, and attachment to chiller components strong enough to resist chiller movement during a seismic event when chiller base is anchored to field support structure.

C. Cabinet:

1. Base: Galvanized-steel base extending the perimeter of chiller. Secure frame, compressors, and evaporator to base to provide a single-piece unit.
2. Frame: Rigid galvanized-steel frame secured to base and designed to support cabinet, condenser, control panel, and other chiller components not directly supported by base.
3. Casing: Galvanized steel.

D. Compressors:

1. Description: Positive displacement, hermetically sealed.
2. Casing: Cast iron, precision machined for minimum clearance about periphery of rotors.
3. Rotors: Manufacturer's standard one- or two-rotor design.
4. Each compressor provided with suction and discharge shutoff valves, crankcase oil heater, and suction strainer.

E. Service: Easily accessible for inspection and service.

F. Capacity Control: On-off compressor cycling and modulating slide-valve assembly or port unloaders combined with hot-gas bypass, if necessary, to achieve performance indicated.

1. Maintain stable operation throughout range of operation. Configure to achieve most energy-efficient operation possible.
2. Operating Range: From 100 to 20, 15, 10, 5 or zero percent of design capacity, as directed.
3. Condenser-Air Unloading Requirements over Operating Range: Constant-design, entering condenser-air temperature or Drop-in, entering condenser-air temperature of 5 deg F (3 deg C) drop for each 10 percent in capacity reduction.

G. Oil Lubrication System: Consisting of pump if required, filtration, heater, cooler, factory-wired power connection, and controls.

1. Provide lubrication to bearings, gears, and other rotating surfaces at all operating, startup, shutdown, and standby conditions including power failure.
2. Thermostatically controlled oil heater properly sized to remove refrigerant from oil.
3. Factory-installed and pressure-tested piping with isolation valves and accessories.
4. Oil compatible with refrigerant and chiller components.
5. Positive visual indication of oil level.

H. Vibration Control:

1. Vibration Balance: Balance chiller compressors and drive assemblies to provide a precision balance that is free of noticeable vibration over the entire operating range.

    a. Overspeed Test: 25 percent above design operating speed.

2. Isolation: Mount individual compressors on vibration isolators.

I. Compressor Motors:

1. Hermetically sealed and cooled by refrigerant suction gas.
2. High-torque, induction type with inherent thermal-overload protection on each phase.

J. Compressor Motor Controllers:

1. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing.
2. Star-Delta, Reduced-Voltage Controller: NEMA ICS 2, closed transition.
3. Solid-state controller.
4. Variable-Frequency Controller:

    a. Motor controller shall be factory mounted and wired on the chiller to provide a single-point, field-power termination to the chiller and its auxiliaries.
    b. Description: NEMA ICS 2; listed and labeled as a complete unit and arranged to provide variable speed by adjusting output voltage and frequency.
    c. Enclosure: Unit mounted, NEMA 250, Type 3R with hinged full-front access door with lock and key.
    d. Integral Disconnecting Means: Door-interlocked, UL 489, instantaneous-trip circuit breaker with lockable handle. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000, 65,000 or 100,000A.
    e. Technology: Pulse-width-modulated output suitable for constant or variable torque loads.

f. Motor current at start shall not exceed the rated load amperes, providing no electrical inrush.

K. Refrigerant Circuits:

1. Refrigerant: Type as indicated on Drawings.
2. Refrigerant Type: R-134a, R-407c or any HFC, as directed. Classified as Safety Group A1 according to ASHRAE 34.
3. Refrigerant Compatibility: Chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
4. Refrigerant Circuit: Each shall include a thermal- or electronic-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.
5. Pressure Relief Device:

    a. Comply with requirements in ASHRAE 15 and in applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
    b. ASME-rated, spring-loaded pressure relief valve; single- or multiple-reseating type.

L. Evaporator:

1. Description: Shell-and-tube design.

    a. Direct-expansion type with fluid flowing through the shell, and refrigerant flowing through the tubes within the shell.
    b. Flooded type with fluid flowing through tubes and refrigerant flowing around tubes within the shell.

2. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
3. Shell Material: Carbon steel.
4. Shell Heads: Removable carbon-steel heads located at each end of the tube bundle.
5. Fluid Nozzles: Terminated with mechanical-coupling or flanged end connections for connection to field piping.
6. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.

M. Air-Cooled Condenser:

1. Plate-fin coil with integral subcooling on each circuit, rated at 450 psig (3103 kPa).

    a. Construct coil casing of galvanized or stainless steel.
    b. Construct coils of copper tubes mechanically bonded to aluminum, aluminum with precoated epoxy-phenolic or copper fins.
    c. Coat coils with a corrosion-resistant coating after fabrication.
    d. Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.

2. Fans: Direct-drive propeller type with statically and dynamically balanced fan blades, arranged for vertical air discharge.
3. Fan Motors: Totally enclosed nonventilating or totally enclosed air over enclosure, with permanently lubricated bearings. Equip each motor with overload protection integral to either the motor or chiller controls.
4. Fan Guards: Steel safety guards with PVC or corrosion-resistant coating.

N. Corrosion-Resistant Coating: Apply a corrosion-resistant coating capable of withstanding a 3,000-hour salt-spray test according to ASTM B117 to base, frame, and casing.

1. Standards:

   a. ASTM B117 for salt spray.
   b. ASTM D2794 for minimum impact resistance of 100 in-lb (11.3 N-m).
   c. ASTM B3359 for cross-hatch adhesion of 5B.

2. Application: Immersion or Spray.
3. Thickness: 1 mil.
4. Gloss: Minimum of 50 gloss units on a single-angle, 60-degree meter.
5. UV Protection: Spray-applied topcoat.

O. Electrical Power:

1. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a multipoint or single-point, field-power connection to chiller.
2. House in a unit-mounted, NEMA 250, Type 3R enclosure with hinged access door with lock and key or padlock and key.
3. Wiring shall be numbered and color-coded to match wiring diagram.
4. Install factory wiring outside of an enclosure in a raceway.
5. Field-power interface shall be to wire lugs, NEMA KS 1, heavy-duty, nonfused disconnect switch, UL 489, instantaneous-trip circuit breaker with lockable handle.

   a. Disconnect means shall be interlocked with door operation.
   b. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000, 65,000 or 100,000 A, as directed.

6. Provide branch power circuit to each motor and to controls with one of the following disconnecting means:

   a. NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
   b. UL 489, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit-trip set point.

7. Provide each motor with overcurrent protection.
8. Overload relay sized according to UL 1995 or an integral component of chiller control microprocessor.
9. Phase-Failure and Undervoltage Relays: Solid-state sensing with adjustable settings.

10. Provide power factor correction capacitors to correct power factor to 0.90 - 0.95 at full load.
11. Control Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.

    a. Power unit-mounted controls where indicated.
    b. Power unit-mounted, ground fault interrupt duplex receptacle.

12. Control Relays: Auxiliary and adjustable time-delay relays.
13. For chiller electrical power supply, indicate the following:

    a. Current and phase to phase for all three phases.
    b. Voltage, phase to phase, and phase to neutral for all three phases.
    c. Three-phase real power (kilowatts).
    d. Three-phase reactive power (kilovolt amperes reactive).
    e. Power factor.
    f. Running log of total power versus time (kilowatt-hours).
    g. Fault log, with time and date of each.

P. Controls:

1. Standalone and microprocessor based.
2. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure for remote mounting in the field.
3. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. In either imperial or metric units, display the following information:

    a. Date and time.
    b. Operating or alarm status.
    c. Operating hours.
    d. Outdoor-air temperature if required for chilled-water reset.
    e. Temperature and pressure of operating set points.
    f. Entering and leaving temperatures of chilled water.
    g. Refrigerant pressures in evaporator and condenser.
    h. Saturation temperature in evaporator and condenser.
    i. No cooling load condition.
    j. Elapsed time meter (compressor run status).
    k. Pump status.
    l. Antirecycling timer status.
    m. Percent of maximum motor amperage.
    n. Current-limit set point.
    o. Number of compressor starts.

4. Control Functions:

    a. Manual or automatic startup and shutdown time schedule.
    b. Entering and leaving chilled-water temperatures, control set points, and motor load limits. Chilled-water leaving temperature shall be reset based on return-water, outdoor-air or space temperature, as directed.
    c. Current limit and demand limit.

d. External chiller emergency stop.
e. Antirecycling timer.
f. Automatic lead-lag switching.
g. Variable evaporator flow.
h. Thermal storage.

5. Manually Reset Safety Controls: The following conditions shall shut down chiller and require manual reset:

a. Low evaporator pressure or high condenser pressure.
b. Low chilled-water temperature.
c. Refrigerant high pressure.
d. High or low oil pressure.
e. High oil temperature.
f. Loss of chilled-water flow.
g. Control device failure.

6. Trending: Capability to trend analog data of up to five parameters simultaneously over an adjustable period and frequency of polling.
7. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: view only; view and operate; and view, operate, and service.
8. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.
9. Interface with DDC System for HVAC: Factory-installed hardware and software to enable the DDC system for HVAC to monitor, control, and display chiller status and alarms.

a. Hardwired Points:

1) Monitoring: On-off status, common trouble alarm, electrical power demand (kilowatts) or electrical power consumption (kilowatt-hours), as directed.
2) Control: On-off operation, chilled-water, discharge temperature set-point adjustment or electrical power demand limit, as directed.

b. ASHRAE 135 (BACnet), LonTalk, Modbus or Industry-accepted, open-protocol communication interface with the DDC system for HVAC shall enable the DDC system for HVAC operator to remotely control and monitor the chiller from an operator workstation, as directed. Control features and monitoring points displayed locally at chiller control panel shall be available through the DDC system for HVAC.

Q. Insulation: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C534, Type I for tubular materials and Type II for sheet materials.

R. Accessories:

1. Factory-furnished, chilled-water flow switches for field installation.
2. Individual compressor suction and discharge pressure gages with shutoff valves for each refrigerant circuit.
3. Factory-furnished neoprene or spring isolators for field installation.

S. Capacities and Characteristics:

1. Capacity: As directed, tons (kW).
2. Full-Load Efficiency (COP): As directed.
3. Full-Load Efficiency (EER): As directed.
4. Full-Load Efficiency (Power Input/Cooling Output): As directed, kW/ton (kW/kW).
5. Part-Load Efficiency (IPLV): As directed.
6. Part-Load Efficiency (NPLV): As directed.
7. Low Ambient Operation: Chiller designed for operation to 0 deg F (minus 18 deg C).
8. High Ambient Operation: Chiller designed for operation to 115 deg F (46 deg C).
9. Evaporator:

    a. Configuration: Integral to chiller or Shipped loose for field installation.
    b. Pressure Rating: 150 psig (1034 kPa) - 300 psig (2068 kPa).
    c. Fluid Type: Water.
    d. Design Fluid Flow Rate: As directed, gpm (L/s).
    e. Minimum Fluid Flow Rate: As directed, gpm (L/s).
    f. Entering-Fluid Temperature: As directed, deg F (deg C).
    g. Leaving-Fluid Temperature: As directed, deg F (deg C).
    h. Fluid Pressure Drop: As directed, feet of head (kPa).
    i. Fluid Velocity: As directed, fps (m/s).
    j. Fouling Factor: 0.0001 sq. ft. x h x deg F/Btu (0.000018 sq. m x deg C/W), 0.00025 sq. ft. x h x deg F/Btu (0.000044 sq. m x deg C/W) or 0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W), as directed.

10. Condenser Entering-Air Temperature: As directed, deg F (deg C).
11. Condenser Fan External Static Pressure: As directed, wg (Pa).
12. Site Altitude: As directed, feet (m).
13. Number of Refrigerant Circuits: Two or Each compressor on an independent circuit, as directed.
14. Compressor:

    a. Number of Compressors: As directed.
    b. Rated Load Amperes: As directed.
    c. Locked-Rotor Amperes: As directed.

15. Control Electrical Requirements:

    a. Power Connection: Fed through integral transformer or Separate field-power connection, as directed.
    b. Power Input: As directed.
    c. Minimum Circuit Ampacity: As directed.
    d. Maximum Overcurrent Protection Device: As directed.
    e. Volts: 120-V ac.
    f. Phase: Single.
    g. Hertz: 60.

16. Chiller Electrical Requirements:

    a. Power Input: As directed.
    b. Power Factor: As directed.

c. Minimum Circuit Ampacity: As directed.
d. Maximum Overcurrent Protection Device: As directed.
e. Volts: 208, 240, 480 or 600, as directed.
f. Phase: Three.
g. Hertz: 60.

17. Noise Rating: As directed, dBA sound power level when measured according to AHRI 370. Provide factory-installed sound treatment if necessary to achieve the performance indicated.

2.3 SOURCE QUALITY CONTROL

A. Perform functional tests of chillers before shipping.

B. Factory run test each air-cooled chiller with water flowing through evaporator.

C. Factory performance test air-cooled chillers, before shipping, according to AHRI 550/590.

1. Test the following conditions:

a. Design conditions indicated.
b. Reduction in capacity from design to minimum load in steps of 10, 25 or 33 with condenser air at design conditions, as directed.
c. At one, two, three, four or five point(s) of varying part-load performance to be selected by Owner at time of test.

2. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

D. Factory sound test air-cooled chillers, before shipping, according to AHRI 370.

1. Test the following conditions:

a. Design conditions indicated.
b. Chiller operating at calculated worst-case sound condition.
c. At one, two, three, four or five point(s) of varying part-load performance to be selected by Owner at time of test.

2. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

E. Factory test and inspect evaporator and condenser according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

F. For chillers located indoors, rate sound power level according to AHRI 575.

G. For chillers located outdoors, rate sound power level according to AHRI 370.

PART 3 - EXECUTION

3.1 CHILLER INSTALLATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.

B. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures.

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

D. Install chillers on support structure indicated.

E. Equipment Mounting:

1. Install chillers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." Or Section 033053 "Miscellaneous Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

F. Maintain manufacturer's recommended clearances for service and maintenance.

G. Charge chiller with refrigerant and fill with oil if not factory installed.

H. Install separate devices furnished by manufacturer and not factory installed.

3.2 CONNECTIONS

A. Comply with requirements for piping specified in Section 232113 "Hydronic Piping," Section 232116 Hydronic Piping Specialties," and Section 232300 "Refrigerant Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to chiller to allow service and maintenance.

C. Evaporator Fluid Connections: Connect to evaporator inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with pressure gage. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, and drain connection with valve. Make connections to chiller with a flange or mechanical coupling.

D. Condenser Fluid Connections: Connect to condenser inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with pressure gage. Connect to condenser outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, and drain connection with valve. Make connections to chiller with a flange or mechanical coupling.

E. Refrigerant Pressure Relief Device Connections: For chillers installed indoors, extend vent piping or separate vent piping for each chiller to the outdoors without valves or restrictions. Comply with ASHRAE 15. Connect vent to chiller pressure relief device with flexible connector and dirt leg with drain valve.

F. Connect each chiller drain connection with a union and drain pipe, and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection.

3.3 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that refrigerant charge is sufficient and chiller has been leak tested.
3. Verify that pumps are installed and functional.
4. Verify that thermometers and gages are installed.
5. Operate chiller for run-in period.
6. Check bearing lubrication and oil levels.
7. For chillers installed indoors, verify that refrigerant pressure relief device is vented outdoors.
8. Verify proper motor rotation.
9. Verify static deflection of vibration isolators, including deflection during chiller startup and shutdown.
10. Verify and record performance of fluid flow and low-temperature interlocks for evaporator and condenser.
11. Verify and record performance of chiller protection devices.
12. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assembly, installation, and connection.

C. Prepare test and inspection startup reports.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain chillers.

END OF SECTION 236426.13

SECTION 236426.16 - WATER-COOLED, ROTARY-SCREW WATER CHILLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes packaged, water-cooled, single or multiple compressor chillers.

B. Related Requirements:

1. Section 284400 "Refrigerant Detection and Alarm" for refrigerant monitors, alarms, supplemental breathing apparatus, and ventilation equipment interlocks.

1.2 DEFINITIONS

A. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.

B. DDC: Direct digital control.

C. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in terms of Btu/h to the total power input given in terms of watts at any given set of rating conditions.

D. IPLV: Integrated part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by AHRI 550/590 and referenced to AHRI standard rating conditions.

E. kVAr: Kilovolt amperes reactive.

F. kW/Ton (kW/kW): The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons (kW) at any given set of rating conditions.

G. NPLV: Nonstandard part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by AHRI 550/590 and intended for operating conditions other than AHRI standard rating conditions.

H. RTD: Resistance temperature detector.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings:

1. Include plans, elevations, sections, and attachment details.

2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, drawn to scale, and coordinated with each other, using input from installers of the items involved.

B. Seismic Qualification Data: Certificates, for chillers, accessories, and components, from manufacturer.

C. Source quality-control reports.

D. Field Quality-Control: Startup service reports.

E. Sample warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

A. AHRI Certification: Certify chiller according to AHRI 550 certification program.

B. AHRI Rating: Rate chiller performance according to requirements in AHRI 550/590.

C. ASHRAE Compliance:

1. ASHRAE 15 for safety code for mechanical refrigeration.
2. ASHRAE 147 for refrigerant leaks, recovery, and handling and storage requirements.

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.

E. ASME Compliance: Fabricate and label chiller to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, and include an ASME U-stamp and nameplate certifying compliance.

F. Comply with NFPA 70.

G. Comply with requirements of UL and UL Canada and include label by a qualified testing agency showing compliance.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of chillers that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two, Three, Four or Five years from date of Substantial Completion, as directed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Chillers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

B. Condenser-Fluid Temperature Performance:

1. Startup Condenser-Fluid Temperature: Chiller shall be capable of starting with an entering condenser-fluid temperature of 60 deg F (16 deg C), 55 deg F (13 deg C) or 40 deg F (4 deg C) and providing stable operation until the system temperature is elevated to the minimum operating entering condenser-fluid temperature, as directed.
2. Minimum Operating Condenser-Fluid Temperature: Chiller shall be capable of continuous operation over the entire capacity range indicated with an entering condenser-fluid temperature of 65 deg F (18 deg C), 60 deg F (16 deg C) or 55 deg F (13 deg C), as directed.
3. Make factory modifications to standard chiller design if necessary to comply with performance indicated.

C. Site Altitude: Chiller shall be suitable for altitude in which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.

D. Performance Tolerance: Comply with the following in lieu of AHRI 550/590:

1. Allowable Capacity Tolerance: Zero percent.
2. Allowable IPLV/NPLV Performance Tolerance: Zero percent.

2.2 PACKAGED, WATER-COOLED, SINGLE-COMPRESSOR CHILLERS

A. Description: Factory-assembled and run-tested chiller with compressor, compressor motor, compressor motor controller, lubrication system, evaporator, condenser, controls, interconnecting unit piping and wiring, and indicated accessories.

B. Fabricate chiller mounting base with reinforcement strong enough to resist chiller movement during a seismic event when chiller is anchored to field support structure.

C. Compressor:

1. Description: Hermetic or open, positive displacement, and oil lubricated.
2. Casing: Cast iron, precision machined for minimum clearance about periphery of rotors.
3. Rotors: Manufacturer's standard one-, two-, or three-rotor design.
4. Drive Coupling: For chillers with open drives, provide flexible disc with all-metal construction and no wearing parts to ensure long life without the need for lubrication.
5. Seals: Seal drive assembly to prevent refrigerant leakage.

D. Compressor Motor:

1. Continuous-duty, squirrel-cage, induction-type motor with energy efficiency required to suit chiller energy efficiency indicated.
2. Factory mounted, aligned, and balanced as part of compressor assembly before shipping.
3. Motor shall be of sufficient capacity to drive compressor throughout entire operating range without overload and with sufficient capacity to start and accelerate compressor without damage.
4. For chillers with open drives, provide motor with open-drip proof, weather-protected, Type I, weather-protected, Type II or totally enclosed] enclosure.
5. Provide motor with thermistor or RTD in single motor winding or each of three-phase motor windings to monitor temperature and report information to chiller control panel.
6. Provide motor with thermistor or RTD to monitor bearing temperature and report information to chiller control panel.
7. Provide open-drive motor with internal electric heater, internally powered from chiller power supply.

E. Vibration Balance: Balance chiller compressor and drive assembly to provide a precision balance that is free of noticeable vibration over the entire operating range.

1. Overspeed Test: 25 percent above design operating speed.

F. Service: Easily accessible for inspection and service.

G. Capacity Control: Modulating slide-valve assembly or port unloaders combined with a variable-frequency controller, if applicable, and hot-gas bypass, if necessary, to achieve performance indicated.

1. Maintain stable operation throughout range of operation. Configure to achieve most energy-efficient operation possible.
2. Operating Range: From 100 to 20, 15, 10, 5 or zero percent of design capacity.
3. Condenser-Fluid Unloading Requirements over Operating Range: Constant-design, entering condenser-fluid temperature or Drop-in, entering condenser-fluid temperature of 2.5 deg F (1.4 deg C) drop for each 10 percent in capacity reduction

H. Oil Lubrication System: Consisting of pump if required, filtration, heater, cooler, factory-wired power connection, and controls.

1. Provide lubrication to bearings, gears, and other rotating surfaces at all operating, startup, shutdown, and standby conditions including power failure.
2. Thermostatically controlled oil heater properly sized to remove refrigerant from oil.

3. Oil filter or Dual oil filters, one redundant, shall be the easily replaceable cartridge type, minimum 0.5-micron efficiency, with means of positive isolation while servicing, as directed.
4. Refrigerant, Water or Refrigerant or water cooled oil cooler, as directed.
5. Factory-installed and pressure-tested piping with isolation valves and accessories.
6. Oil compatible with refrigerant and chiller components.
7. Positive visual indication of oil level.

I. Refrigerant Circuit:

1. Refrigerant Type: R-134a or any HFC Classified as Safety Group A1 according to ASHRAE 34.
2. Refrigerant Compatibility: Chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
3. Refrigerant Flow Control: Manufacturer's standard refrigerant flow-control device satisfying performance requirements indicated.
4. Pressure Relief Device:

    a. Comply with requirements in ASHRAE 15 and in applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
    b. ASME-rated, spring-loaded pressure relief valve; single- or multiple-reseating type. Pressure relief valve(s) shall be provided for each heat exchanger. Condenser shall have dual valves with one being redundant and configured to allow either valve to be replaced without loss of refrigerant.

5. Refrigeration Transfer: Provide service valves and other factory-installed accessories required to facilitate transfer of refrigerant from chiller to a remote refrigerant storage and recycling system. Comply with requirements in ASHRAE 15 and ASHRAE 147.

J. Evaporator:

1. Description: Shell-and-tube design with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from condenser.
2. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.
3. Designed to prevent liquid refrigerant carryover from entering compressor.
4. Provide evaporator with sight glass or other form of positive visual verification of liquid-refrigerant level.
5. Tubes:

    a. Individually replaceable from either end and without damage to tube sheets and other tubes.
    b. Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
    c. Material: Copper, Copper-nickel alloy or Copper or copper-nickel alloy, as directed.
    d. External Finish: Manufacturer's standard.
    e. Internal Finish: Enhanced or smooth.

6. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.

7. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.
8. Water Box:

    a. Cast-iron or carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
    b. Standard or Marine type for water box with piping connections. Standard type for water box without piping connections.
    c. Provide water boxes and marine water-box covers with lifting lugs or eyebolts.
    d. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange, Welded, ASME B16.5, raised-face flange, grooved for mechanical-joint coupling or Grooved with mechanical-joint coupling and flange adapter, as directed.
    e. Thermistor or RTD temperature sensor factory installed in each nozzle.
    f. Fit each water box with 3/4-inch (19-mm), 1-inch (25-mm) or 3/4- or 1-inch (19- or 25-mm) drain connection at low point and vent connection at high point, each with threaded plug, as directed.

K. Condenser:

1. Description: Shell-and-tube design with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from evaporator.
2. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.
3. Designed to prevent direct impingement of high-velocity hot gas from compressor discharge on tubes.
4. Tubes:

    a. Individually replaceable from either end and without damage to tube sheets and other tubes.
    b. Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
    c. Material: Copper, Copper-nickel alloy or Copper or copper-nickel alloy, as directed.
    d. External Finish: Manufacturer's standard.
    e. Internal Finish: Enhanced or smooth.

5. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.
6. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.
7. Water Box:

    a. Cast-iron or carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
    b. Standard or Marine type for water box with piping connections. Standard type for water box without piping connections.
    c. Provide water boxes and marine water-box covers with lifting lugs or eyebolts.

d. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange, Welded, ASME B16.5, raised-face flange, Grooved for mechanical-joint coupling or Grooved with mechanical-joint coupling and flange adapter.
e. Thermistor or RTD temperature sensor factory installed in each nozzle.
f. Fit each water box with 3/4-inch (19-mm), 1-inch (25-mm) or 3/4- or 1-inch (19- or 25-mm) drain connection at low point and vent connection at high point, each with threaded plug, as directed.

L. Electrical Power:

1. Factory installed and wired, and functionally tested at factory before shipment.
2. Single-point, field-power connection to fused disconnect switch, nonfused disconnect switch or circuit breaker, as directed. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000 - 65,000A, as directed.

    a. Provide branch power circuit to each motor, electric heater, dedicated electrical load, and controls with disconnect switch or circuit breaker.
    b. NEMA ICS 2-rated motor controller for auxiliary motors, hand-off-auto switch, and overcurrent protection for each motor. Provide variable-frequency controller for each variable-speed motor furnished.
    c. Control-circuit transformer with primary and secondary side fuses.

3. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
4. Factory-installed wiring outside of enclosures shall be in metal raceway except make connections to each motor and heater with not more than a 24-inch (610-mm) length of liquid tight conduit.
5. Factory install and wire capacitor bank for the purpose of power factor correction to 0.95 at all operating conditions.

    a. If capacitors are mounted in a dedicated enclosure, use same NEMA enclosure type as motor controller. Provide enclosure with service entrance knockouts and bushings for conduit.
    b. Capacitors shall be non-PCB dielectric fluid, metallized electrode design, low loss with low-temperature rise. The kVAr ratings shall be indicated and shall not exceed the maximum limitations set by NFPA 70. Provide individual cells as required.
    c. Provide each cell with current-limiting replaceable fuses and carbon-film discharge resistors to reduce residual voltage to less than 50 V within one minute after de-energizing.
    d. Provide a ground terminal and a terminal block or individual connectors for phase connection.

M. Motor Controller:

1. Enclosure: Factory installed, unit mounted, Factory furnished, field mounted, NEMA 250 or NEMA ICS 6, Type 1, Type 4, Type 4X or Type 12 with hinged full-front access door with lock and key or padlock and key, as directed.
2. Control Circuit: Obtained from integral control power transformer with a control power transformer or source of enough capacity to operate connected control devices.

3. Overload Relay: Shall be sized according to UL 1995 or shall be an integral component of chiller control microprocessor.
4. Across-the-Line Controller: NEMA ICS 2, Class A, full voltage, nonreversing; include isolation switch and current-limiting fuses.
5. Star-Delta, Reduced-Voltage Controller: NEMA ICS 2, closed transition.
6. Autotransformer Reduced-Voltage Controller: NEMA ICS 2, closed transition; include isolation switch and current-limiting fuses.
7. Solid-State, Reduced-Voltage Controller: NEMA ICS 2.

    a. Surge suppressor in solid-state power circuits providing three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
    b. Visual indication of motor and control status, including the following conditions:

        1) Controller on.
        2) Overload trip.
        3) Loss of phase.
        4) Starter fault.

8. Accessories: Devices shall be factory installed in controller enclosure unless otherwise indicated.

    a. Externally Operated, Door-Interlocked Disconnect: Fused disconnect switch, Nonfused disconnect switch or Circuit breaker. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000 - 65,000A, as directed.
    b. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
    c. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.
    d. Control Relays: Time-delay relays.
    e. Elapsed-Time Meters: Numerical readout in hours on face of enclosure.
    f. Number-of-Starts Counter: Numerical readout on face of enclosure.
    g. Meters: Panel type, 2-1/2 inches (64 mm) or 4-1/4 inches (108 mm)] with 90, 120 or 270 degree scale and 1 – 2 percent accuracy. Where indicated, provide transfer device with an off position. Meters shall indicate the following:

        1) Ammeter: Output current for each phase, with current sensors rated to suit application.
        2) Voltmeter: Output voltage for each phase.
        3) Frequency Meter: Output frequency.
        4) Real-time clock with current time and date.
        5) Total run time.

    h. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

        1) Selectable, digital display of the following:

a) Phase Currents, Each Phase: Plus or minus 1 percent.
b) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
c) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
d) Three-Phase Real Power: Plus or minus 2 percent.
e) Three-Phase Reactive Power: Plus or minus 2 percent.
f) Power Factor: Plus or minus 2 percent.
g) Frequency: Plus or minus 0.5 percent.
h) Integrated Demand with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
i) Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

2) Mounting: Display and control unit flush or semirecessed in instrument compartment door.

i. Phase-Failure, Phase-Reversal, Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hardwired connection.
j. Power Protection: Chiller shall shut down within six cycles of power interruption.

N. Variable-Frequency Controller:

1. Motor controller shall be factory mounted and wired on the chiller to provide a single-point, field-power termination to the chiller and its auxiliaries.
2. Description: NEMA ICS 2; listed and labeled as a complete unit and arranged to provide variable speed by adjusting output voltage and frequency.
3. Enclosure: Unit mounted, NEMA 250, Type 1 with hinged full-front access door with lock and key.
4. Integral Disconnecting Means: Door-interlocked, UL 489, instantaneous-trip circuit breaker with lockable handle. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000, 65,000 or 100,000A, as directed.
5. Technology: Pulse-width-modulated output suitable for constant or variable torque loads.
6. Output Rating: Three phase; with voltage proportional to frequency throughout voltage range.
7. Operating Requirements:

a. Input AC Voltage Tolerance: 460-V ac, plus 10 percent or 506 V maximum.
b. Input frequency tolerance of 60 Hz, plus or minus 2 Hz.
c. Capable of driving full load, without derating, under the following conditions:

1) Ambient Temperature: 0 to 40 deg C.
2) Relative Humidity: Up to 90 - 95 percent (noncondensing).
3) Altitude: 3300 feet (1005 m) - 6600 feet (2010 m).

d. Minimum Efficiency: 96 percent at 60 Hz, full load.
e. Minimum Displacement Primary-Side Power Factor: 98 percent.
f. Overload Capability: 1.05 times the full-load current for seven seconds.
g. Starting Torque: As required by compressor-drive assembly.
h. Speed Regulation: Plus or minus 1 percent.

i. Isolated control interface to allow controller to follow control signal over a 10:1 speed range.
j. To avoid equipment resonant vibrations, provide critical speed lockout circuitry to allow bands of operating frequency at which controller shall not operate continuously.
k. Capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.

8. Internal Adjustability Capabilities:

a. Minimum Output Frequency: 6 Hz.
b. Maximum Output Frequency: 60 Hz.
c. Acceleration: 2 to 60 seconds.
d. Deceleration: Zero to 60 seconds.
e. Current Limit: 30 to a minimum of 100 percent of maximum rating.

9. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions shall not result in component failure or the need for replacement:

a. Overtemperature.
b. Short circuit at controller output.
c. Ground fault at controller output. Variable-frequency controller shall be able to start a grounded motor.
d. Open circuit at controller output.
e. Input undervoltage.
f. Input overvoltage.
g. Loss of input-phase.
h. Reverse phase.
i. AC line switching transients.
j. Instantaneous overload, line to line or line to ground.
k. Sustained overload exceeding 100 percent of controller rated current.
l. Starting a rotating motor.

10. Motor Protection: Controller shall protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.
11. Automatic Reset and Restart: Capable of three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Controller shall be capable of automatic restart on phase-loss, and overvoltage and undervoltage trips.
12. Visual Indication: On face of controller enclosure or chiller control enclosure; indicating the following conditions:

a. Power on.
b. Run.
c. Overvoltage.
d. Line fault.
e. Overcurrent.
f. External fault.
g. Motor speed (percent).
h. Fault or alarm status (code).
i. Motor output voltage.

j. Input kilovolt amperes.
k. Total power factor.
l. Input kilowatts.
m. Input kilowatt-hours.
n. Three-phase input voltage.
o. Three-phase output voltage.
p. Three-phase input current.
q. Three-phase output current.
r. Output frequency (Hertz).
s. Elapsed operating time (hours).
t. Diagnostic and service parameters.

13. Operator Interface: At controller or chiller control panel; with start-stop and auto-manual selector with manual-speed-control potentiometer.
14. Harmonic Distortion Filter: Factory mounted and wired to limit total voltage and current distortion to 5 percent.

O. Controls:

1. Standalone and microprocessor based with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.
2. Enclosure: Unit mounted, NEMA 250, Type 1, Type 4, Type 4x or Type 12, hinged or lockable; factory wired with a single-point, field-power connection and a separate control circuit.
3. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. In either imperial or metric units, display the following information:

a. Date and time.
b. Operating or alarm status.
c. Fault history with not less than last 10 faults displayed.
d. Set points of controllable parameters.
e. Trend data.
f. Operating hours.
g. Number of chiller starts.
h. Outdoor-air temperature or space temperature if required for chilled-water reset.
i. Temperature and pressure of operating set points.
j. Entering- and leaving-fluid temperatures of evaporator and condenser.
k. Difference in fluid temperatures of evaporator and condenser.
l. Fluid flow of evaporator and condenser.
m. Fluid pressure drop of evaporator and condenser.
n. Refrigerant pressures in evaporator and condenser.
o. Refrigerant saturation temperature in evaporator and condenser.
p. Pump status.
q. Antirecycling timer status.
r. Percent of maximum motor amperage.
s. Current-limit set point.
t. Compressor bearing temperature.
u. Motor bearing temperature.
v. Motor winding temperature.
w. Oil temperature.

x. Oil discharge pressure.
y. Phase current.
z. Percent of motor rated load amperes.
aa. Phase voltage.
bb. Demand power (kilowatts).
cc. Energy use (kilowatt-hours).
dd. Power factor.

4. Control Functions:

   a. Manual or automatic startup and shutdown time schedule.
   b. Entering and leaving chilled-water temperatures, control set points, and motor load limits. Evaporator fluid temperature shall be reset based on return-water, outdoor-air or space temperature, as directed.
   c. Current limit and demand limit.
   d. Condenser-fluid temperature.
   e. External chiller emergency stop.
   f. Antirecycling timer.
   g. Variable evaporator flow.
   h. Thermal storage.

5. Manually Reset Safety Controls: The following conditions shall shut down chiller and require manual reset:

   a. Low evaporator pressure or temperature; high condenser pressure.
   b. Low evaporator fluid temperature.
   c. Low oil differential pressure.
   d. High or low oil pressure.
   e. High oil temperature.
   f. High compressor-discharge temperature.
   g. Loss of condenser-fluid flow.
   h. Loss of evaporator-fluid flow.
   i. Motor overcurrent.
   j. Motor overvoltage.
   k. Motor undervoltage.
   l. Motor phase reversal.
   m. Motor phase failure.
   n. Sensor- or detection-circuit fault.
   o. Processor communication loss.
   p. Motor controller fault.
   q. Extended compressor surge.

6. Trending: Capability to trend analog data of up to five parameters simultaneously over an adjustable period and frequency of polling.
7. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: view only; view and operate; and view, operate, and service.
8. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.
9. Communication Port: RS-232 port or equivalent connection capable of connecting a printer and a notebook computer.

10. Interface with the DDC System for HVAC: Factory-installed hardware and software to enable the DDC system for HVAC to monitor, control, and display chiller status and alarms.

    a. Hardwired Points:

        1) Monitoring: On-off status, common trouble alarm, electrical power demand (kilowatts), electrical power consumption (kilowatt-hours) or power factor, as directed.
        2) Control: On-off operation, chilled-water, discharge temperature set-point adjustment or electrical power demand limit.

    b. ASHRAE 135 (BACnet), LonTalk, Modbus or Industry-accepted, open-protocol communication interface with the DDC system for HVAC shall enable the DDC system for HVAC operator to remotely control and monitor the chiller from an operator workstation, as directed. Control features and monitoring points displayed locally at chiller control panel shall be available through the DDC system for HVAC.

P. Insulation: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C534, Type I for tubular materials and Type II for sheet materials.

Q. Finish: Paint chiller, using manufacturer's standard procedures.

R. Accessories:

1. Flow Switches:

    a. If required and not factory installed, chiller manufacturer shall furnish a switch for each condenser or evaporator and condenser and verify field-mounting location before installation.
    b. Paddle Flow Switches:

        1) Vane operated to actuate a double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the DDC system for HVAC.
        2) Contacts: Platinum alloy, silver alloy, or gold-plated switch contacts with a rating of 10 A at 120-V ac.
        3) Pressure rating equal to pressure rating of heat exchanger.
        4) Construct body and wetted parts of Type 316 stainless steel.
        5) House switch in a NEMA 250, Type 4 enclosure constructed of die-cast aluminum.
        6) Vane length to suit installation.

    c. Pressure Differential Switches:

        1) Construction: Wetted parts of body and trim constructed of Type 316 stainless steel.
        2) Performance: Switch shall withstand, without damage, the full-pressure rating of the heat exchanger applied to either port and exhibit zero set-point shift due to variation in working pressure.

3) Set Point: Screw type, field adjustable.
4) Electrical Connections: Internally mounted screw-type terminal blocks.
5) Switch Enclosure: NEMA 250, Type 4.
6) Switch Action: Double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the DDC system for HVAC.

2. Vibration Isolation:

a. Chiller manufacturer shall furnish vibration isolation for each chiller.
b. Neoprene Pad:

1) Two layers of 0.375-inch- (10-mm-) thick, ribbed- or waffle-pattern neoprene pads separated by a 16-gage, stainless-steel plate.
2) Fabricate pads from 40- to 50-durometer neoprene.
3) Provide stainless-steel square bearing plate to load the pad uniformly between 20 and 40 psig (138 and 276 kPa) with a 0.12- to 0.16-inch (3- to 4-mm) deflection.

c. Spring Isolator:

1) Stable in operation and designed for not less than 30 percent reserve deflection beyond actual operating conditions. Isolators shall be designed such that the Kx/Ky ratio shall be 1.0 or more for stability.
2) Provide PVC or neoprene-coated springs and hot-dip, galvanized-steel components. Aluminum components shall be etched and painted. Nuts, bolts, and washers shall be zinc electroplated.
3) Isolators shall be adjustable and with an open spring, having one or more coil springs attached to a top compression plate and a baseplate. An elastomeric pad with a minimum thickness of shall be bonded to the baseplate.
4) Spring assembly shall be removable and shall fit within a welded steel enclosure consisting of a top plate and rigid lower housing, which serves as a blocking device during installation. Isolated restraining bolts shall not be engaged during normal operation and shall connect the top plate and lower housing to prevent the isolated equipment from rising when drained of fluid.
5) Isolators shall be selected for a nominal 1-inch (25-mm) or 2-inch (50-mm) deflection.

S. Capacities and Characteristics:

1. Capacity: As directed, tons (kW).
2. Full-Load Efficiency (COP): As directed.
3. Full-Load Efficiency (EER): As directed.
4. Full-Load Efficiency (Power Input/Cooling Output): As directed, kW/ton (kW/kW).
5. Part-Load Efficiency (IPLV): As directed.
6. Part-Load Efficiency (NPLV): As directed.
7. Evaporator:

a. Pressure Rating: As directed, psig (kPa).

b. Number of Passes: One, Two or Three, as directed.
c. Fluid Type: Water
d. Design Fluid Flow Rate: As directed, gpm (L/s).
e. Minimum Fluid Flow Rate: As directed, gpm (L/s).
f. Entering-Fluid Temperature: As directed, deg F (deg C).
g. Leaving-Fluid Temperature: As directed, deg F (deg C).
h. Fluid Pressure Drop: As directed, feet of head (kPa).
i. Fluid Velocity: As directed, fps (m/s).
j. Fouling Factor: 0.0001 sq. ft. x h x deg F/Btu (0.000018 sq. m x deg C/W), 0.00025 sq. ft. x h x deg F/Btu (0.000044 sq. m x deg C/W) or 0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W), as directed.

8. Condenser:

a. Pressure Rating: As directed, psig (kPa).
b. Number of Passes: One, Two or Three.
c. Fluid Type: Water.
d. Design Fluid Flow Rate: As directed, gpm (L/s).
e. Entering-Fluid Temperature: As directed, deg F (deg C).
f. Leaving-Fluid Temperature: As directed, deg F (deg C).
g. Fluid Pressure Drop: As directed, feet of head (kPa).
h. Fluid Velocity: As directed, fps (m/s).
i. Fouling Factor: 0.00025 sq. ft. x h x deg F/Btu (0.000044 sq. m x deg C/W), 0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W) or 0.001 sq. ft. x h x deg F/Btu (0.00022 sq. m x deg C/W), as directed.

9. Compressor:

a. Rated Load Amperes: As directed.
b. Locked-Rotor Amperes: As directed.

10. Chiller Electrical Requirements:

a. Power Input: As directed.
b. Power Factor: 0.90 - 0.95.
c. Minimum Circuit Ampacity: As directed.
d. Maximum Overcurrent Protection Device: As directed.
e. Volts: 208, 240, 480, 600, 2300 or 4160.
f. Phase: Three.
g. Hertz: 60.

11. Noise Rating: 85 dBA sound power level when measured according to AHRI 575. Provide factory-installed sound treatment if necessary to achieve the performance indicated.

2.3 PACKAGED, WATER-COOLED, MULTIPLE-COMPRESSOR CHILLERS

A. Description: Factory-assembled and run-tested chiller with compressor(s), compressor motors and motor controllers, evaporator, condenser where indicated, electrical power, controls, and indicated accessories.

B. Fabricate chiller mounting base with reinforcement strong enough to resist chiller movement during a seismic event when chiller is anchored to field support structure.

C. Compressors:

1. Description: Positive displacement, hermetically sealed.
2. Casing: Cast iron, precision machined for minimum clearance about periphery of rotors.
3. Rotors: Manufacturer's standard one- or two-rotor design.

D. Service: Easily accessible for inspection and service.

E. Capacity Control: On-off compressor cycling and modulating slide-valve assembly or port unloaders combined with hot-gas bypass, if necessary, to achieve performance indicated.

1. Maintain stable operation throughout range of operation. Configure to achieve most energy-efficient operation possible.
2. Operating Range: From 100 to 20, 15, 10, 5 or zero percent of design capacity.
3. Condenser-Fluid Unloading Requirements over Operating Range: Constant-design, entering condenser-fluid temperature or Drop-in, entering condenser-fluid temperature of 2.5 deg F (1.4 deg C) drop for each 10 percent in capacity reduction, as directed.

F. Oil Lubrication System: Consisting of pump if required, filtration, heater, cooler, factory-wired power connection, and controls.

1. Provide lubrication to bearings, gears, and other rotating surfaces at all operating, startup, shutdown, and standby conditions including power failure.
2. Thermostatically controlled oil heater properly sized to remove refrigerant from oil.
3. Factory-installed and pressure-tested piping with isolation valves and accessories.
4. Oil compatible with refrigerant and chiller components.
5. Positive visual indication of oil level.

G. Vibration Control:

1. Vibration Balance: Balance chiller compressor and drive assembly to provide a precision balance that is free of noticeable vibration over the entire operating range.

    a. Overspeed Test: 25 percent above design operating speed.

2. Isolation: Mount individual compressors on vibration isolators.

H. Compressor Motors:

1. Hermetically sealed and cooled by refrigerant suction gas.
2. High-torque, induction type with inherent thermal-overload protection on each phase.

I. Refrigerant Circuits:

1. Refrigerant Type: R-134a or any HFC Classified as Safety Group A1 according to ASHRAE 34.

2. Refrigerant Compatibility: Chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
3. Refrigerant Circuit: Each shall include a thermal- or electronic-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.
4. Pressure Relief Device:

    a. Comply with requirements in ASHRAE 15 and in applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
    b. ASME-rated, spring-loaded pressure relief valve; single- or multiple-reseating type.

J. Evaporator:

1. Description: Shell-and-tube design.

    a. Direct-expansion type with fluid flowing through the shell, and refrigerant flowing through the tubes within the shell.
    b. Flooded type with fluid flowing through tubes and refrigerant flowing around tubes within the shell.

2. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
3. Shell Material: Carbon steel.
4. Shell Heads: Removable carbon-steel heads with multipass baffles, and located at each end of the tube bundle.
5. Fluid Nozzles: Terminated with mechanical-coupling or flanged end connections for connection to field piping.
6. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.

K. Condenser:

1. Shell and tube, or without integral condenser; as indicated.
2. Shell and Tube:

    a. Description: Shell-and-tube design with refrigerant flowing through shell, and fluid flowing through tubes within shell.
    b. Provides positive subcooling of liquid refrigerant.
    c. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
    d. Shell Material: Carbon steel.
    e. Water Boxes: Removable, of carbon-steel construction, located at each end of the tube bundle with fluid nozzles terminated with mechanical-coupling end connections for connection to field piping.
    f. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
    g. Provide each condenser with a pressure relief device, purge cock, and liquid-line shutoff valve.

3. Provide chiller without an integral condenser and design chiller for field connection to remote condenser. Coordinate requirements with Section 236313 "Air-Cooled Refrigerant Condensers."

L. Electrical Power:

1. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a multipoint or single-point, field-power connection to chiller.
2. House in a unit-mounted, NEMA 250, Type 1 enclosure with hinged access door with lock and key or padlock and key.
3. Wiring shall be numbered and color-coded to match wiring diagram.
4. Install factory wiring outside of an enclosure in a raceway.
5. Field-power interface shall be to wire lugs, NEMA KS 1, heavy-duty, nonfused disconnect switch or UL 489, instantaneous-trip circuit breaker with lockable handle.

    a. Disconnect means shall be interlocked with door operation.
    b. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000, 65,000, 100,000 A, as directed.

6. Provide branch power circuit to each motor and to controls with one of the following disconnecting means:

    a. NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
    b. UL 489, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit-trip set point.

7. Provide each motor with overcurrent protection.
8. Overload relay sized according to UL 1995 or an integral component of chiller control microprocessor.
9. Phase-Failure and Undervoltage Relays: Solid-state sensing with adjustable settings.
10. Control Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.
11. Control Relays: Auxiliary and adjustable time-delay relays.
12. For chiller electrical power supply, indicate the following:

    a. Current and phase to phase for all three phases.
    b. Voltage, phase to phase, and phase to neutral for all three phases.
    c. Three-phase real power (kilowatts).
    d. Three-phase reactive power (kVAr).
    e. Power factor.
    f. Running log of total power versus time (kilowatt-hours).
    g. Fault log, with time and date of each.

M. Compressor Motor Controllers:

1. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing, or solid state.
2. Star-Delta, Reduced-Voltage Controller: NEMA ICS 2, closed or open transition, or solid state.

N. Controls:

1. Standalone and microprocessor based.
2. Enclosure: Share enclosure with electrical-power devices or provide a separate enclosure of matching construction.
3. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. In either imperial or metric units, display the following information:

    a. Date and time.
    b. Operating or alarm status.
    c. Fault history with not less than last 10 faults displayed.
    d. Set points of controllable parameters.
    e. Trend data.
    f. Operating hours.
    g. Number of chiller starts.
    h. Outdoor-air temperature or space temperature if required for chilled-water reset.
    i. Temperature and pressure of operating set points.
    j. Entering- and leaving-fluid temperatures of evaporator and condenser.
    k. Difference in fluid temperatures of evaporator and condenser.
    l. Refrigerant pressures in evaporator and condenser.
    m. Refrigerant saturation temperature in evaporator and condenser.
    n. No cooling load condition.
    o. Elapsed time meter (compressor run status).
    p. Pump status.
    q. Antirecycling timer status.
    r. Percent of maximum motor amperage.
    s. Current-limit set point.
    t. Number of compressor starts.
    u. Compressor refrigerant suction and discharge temperature.
    v. Oil temperature.
    w. Oil discharge pressure.
    x. Phase current.
    y. Percent of motor rated load amperes.
    z. Phase voltage.

4. Control Functions:

    a. Manual or automatic startup and shutdown time schedule.
    b. Entering and leaving chilled-water temperatures, control set points, and motor load limits. Chilled-water leaving temperature shall be reset based on return-water, outdoor-air or space temperature, as directed.
    c. Current limit and demand limit.
    d. Condenser-fluid temperature.
    e. External chiller emergency stop.
    f. Antirecycling timer.
    g. Automatic lead-lag switching.
    h. Variable evaporator flow.
    i. Thermal storage.

5. Manually Reset Safety Controls: The following conditions shall shut down chiller and require manual reset:

    a. Low evaporator pressure or high condenser pressure.
    b. Low chilled-water temperature.
    c. Refrigerant high pressure.
    d. High or low oil pressure.
    e. High oil temperature.
    f. Loss of chilled-water flow.
    g. Loss of condenser-fluid flow.
    h. Control device failure.

6. Trending: Capability to trend analog data of up to five parameters simultaneously over an adjustable period and frequency of polling.
7. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: view only; view and operate; and view, operate, and service.
8. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.
9. Interface with DDC System for HVAC: Factory-installed hardware and software to enable the DDC system for HVAC to monitor, control, and display chiller status and alarms.

    a. Hardwired Points:

        1) Monitoring: On-off status, common trouble alarm, electrical power demand (kilowatts) or electrical power consumption (kilowatt-hours), as directed.
        2) Control: On-off operation, chilled-water, discharge temperature set-point adjustment or electrical power demand limit.

    b. ASHRAE 135 (BACnet), LonTalk, Modbus or Industry-accepted, open-protocol communication interface with the DDC system for HVAC shall enable the DDC system for HVAC operator to remotely control and monitor the chiller from an operator workstation, as directed. Control features and monitoring points displayed locally at chiller control panel shall be available through the DDC system for HVAC.

O. Insulation: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C534, Type I for tubular materials and Type II for sheet materials.

P. Finish: Paint chiller, using manufacturer's standard procedures.

Q. Accessories:

1. Factory-furnished, chilled and condenser water flow switches for field installation.
2. Individual compressor suction and discharge pressure gages with shutoff valves for each refrigerant circuit.
3. Factory-furnished neoprene or spring isolators for field installation.

R. Capacities and Characteristics:

1. Capacity: As directed, tons (kW).
2. Full-Load Efficiency (COP): As directed.
3. Full-Load Efficiency (EER): As directed.
4. Full-Load Efficiency (Power Input/Cooling Output): As directed, kW/ton (kW/kW).
5. Part-Load Efficiency (IPLV): As directed.
6. Part-Load Efficiency (NPLV): As directed.
7. Evaporator:

    a. Pressure Rating: As directed, psig (kPa).
    b. Number of Passes: One, Two or Three, as directed.
    c. Fluid Type: Water.
    d. Design Fluid Flow Rate: As directed, gpm (L/s).
    e. Minimum Fluid Flow Rate: As directed, gpm (L/s).
    f. Entering-Fluid Temperature: As directed, deg F (deg C).
    g. Leaving-Fluid Temperature: As directed, deg F (deg C).
    h. Fluid Pressure Drop: As directed, feet of head (kPa).
    i. Fluid Velocity: As directed, fps (m/s).
    j. Fouling Factor: 0.0001 sq. ft. x h x deg F/Btu (0.000018 sq. m x deg C/W), 0.00025 sq. ft. x h x deg F/Btu (0.000044 sq. m x deg C/W) or 0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W), as directed.

8. Condenser:

    a. Pressure Rating: As directed, psig (kPa).
    b. Fluid Type: Water.
    c. Design Fluid Flow Rate: As directed, gpm (L/s).
    d. Entering-Fluid Temperature: As directed, deg F (deg C).
    e. Leaving-Fluid Temperature: As directed, deg F (deg C).
    f. Fluid Pressure Drop: As directed, feet of head (kPa).
    g. Fluid Velocity: As directed, fps (m/s).
    h. Fouling Factor: 0.00025 sq. ft. x h x deg F/Btu (0.000044 sq. m x deg C/W), 0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W) or 0.001 sq. ft. x h x deg F/Btu (0.00022 sq. m x deg C/W), as directed.

9. Number of Refrigerant Circuits: One – Two, as directed.
10. Compressors:

    a. Number of Compressors: As directed.
    b. Rated Load Amperes: As directed.
    c. Locked-Rotor Amperes: As directed.

11. Control Electrical Requirements:

    a. Power Connection: Fed through integral transformer or Separate field-power connection.
    b. Power Input: As directed.
    c. Minimum Circuit Ampacity: As directed.
    d. Maximum Overcurrent Protection Device: As directed.
    e. Volts:120V ac.
    f. Phase: Single or Three.
    g. Hertz: 60.

12. Chiller Electrical Requirements:

    a. Power Input: As directed.
    b. Power Factor: As directed
    c. Minimum Circuit Ampacity: As directed.
    d. Maximum Overcurrent Protection Device: As directed.
    e. Volts: 208, 240, 480 or 600, as directed
    f. Phase: Three.
    g. Hertz: 60.

13. Noise Rating: As directed, dBA sound power level when measured according to AHRI 575. Provide factory-installed sound treatment if necessary to achieve the performance indicated.

2.4 SOURCE QUALITY CONTROL

A. Perform functional tests of chillers before shipping.

B. Factory performance test water-cooled chillers, before shipping, according to AHRI 550/590.

1. Test the following conditions:

    a. Design conditions indicated.
    b. Reduction in capacity from design to minimum load in steps of 10, 25 or 33 with condenser fluid at design conditions, as directed.
    c. Reduction in capacity from design to minimum load in steps of 10, 25 or 33 with varying entering condenser-fluid temperature from design to minimum conditions in 5 deg F (3 deg C) increments, as directed.
    d. At one, two, three, four, five or 10 point(s) of varying part-load performance to be selected by Owner at time of test.

2. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

C. Factory sound test water-cooled chillers, before shipping, according to AHRI 575.

1. Test the following conditions:

    a. Design conditions indicated.
    b. Chiller operating at calculated worst-case sound condition.
    c. At one, two, three, four or five point(s) of varying part-load performance to be selected by Owner at time of test.

2. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

D. Factory test and inspect evaporator and condenser according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

E. For chillers located indoors, rate sound power level according to AHRI 575.

F. For chillers located outdoors, rate sound power level according to AHRI 370.

PART 3 - EXECUTION

3.1 CHILLER INSTALLATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.

B. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures.

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

D. Install chillers on support structure indicated.

E. Equipment Mounting:

1. Install chillers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." Or Section 033053 "Miscellaneous Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

F. Maintain manufacturer's recommended clearances for service and maintenance.

G. Charge chiller with refrigerant and fill with oil if not factory installed.

H. Install separate devices furnished by manufacturer and not factory installed.

3.2 CONNECTIONS

A. Comply with requirements for piping specified in Section 232113 "Hydronic Piping," Section 232116 "Hydronic Piping Specialties," and Section 232300 "Refrigerant Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to chiller to allow service and maintenance.

C. Evaporator Fluid Connections: Connect to evaporator inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with pressure gage, as directed. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, and drain connection with valve. Make connections to chiller with a flange or mechanical coupling.

D. Condenser Fluid Connections: Connect to condenser inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with pressure gage, as directed. Connect to condenser outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer,

plugged tee with shutoff valve and pressure gage, flow meter, and drain connection with valve. Make connections to chiller with a flange or mechanical coupling.

E. Refrigerant Pressure Relief Device Connections: For chillers installed indoors, extend vent piping or separate vent piping for each chiller to the outdoors without valves or restrictions. Comply with ASHRAE 15. Connect vent to chiller pressure relief device with flexible connector and dirt leg with drain valve.

F. Connect each chiller drain connection with a union and drain pipe, and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection.

3.3 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that refrigerant charge is sufficient and chiller has been leak tested.
3. Verify that pumps are installed and functional.
4. Verify that thermometers and gages are installed.
5. Operate chiller for run-in period.
6. Check bearing lubrication and oil levels.
7. For chillers installed indoors, verify that refrigerant pressure relief device is vented outdoors.
8. Verify proper motor rotation.
9. Verify static deflection of vibration isolators, including deflection during chiller startup and shutdown.
10. Verify and record performance of fluid flow and low-temperature interlocks for evaporator and condenser.
11. Verify and record performance of chiller protection devices.
12. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assembly, installation, and connection.

C. Prepare test and inspection startup reports.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain chillers. Video record the training sessions.

END OF SECTION 236426.16

SECTION 236513.13 - OPEN-CIRCUIT, FORCED-DRAFT COOLING TOWERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes factory-assembled, open-circuit, forced-draft cooling towers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Manufacturer's drawings of assembled cooling towers, control panels, sections, and elevations.
2. Assembled unit dimensions.
3. Diagram showing each separate piece requiring field assembly.
4. Shipped sub-assembly dimensions and weights for field assembly.
5. Operating weight and load distribution.
6. Unit vibration isolation and seismic controls.
7. Required clearances for maintenance and operation.
8. Sizes and dimensioned locations of piping and wiring connections.
9. Diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal: For cooling tower support structure indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of support structure.
2. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment.
3. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and wind restraints and for designing vibration isolation bases.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:

1. Drawings on which the following items are shown and coordinated with each other, using input from Installers of the items involved.
2. Each view to show screened background with the following:

    a. Structural grids.
    b. Adjacent walls, floors, and roofs.

c. Equipment and products of other trades that are located in vicinity of cooling towers and are part of final installation, such as controls, power, lighting, fire-suppression systems, and plumbing systems.

B. Product Certificates: For certification required in "Quality Assurance" Article.

C. Seismic Qualification Data: Certificates, for cooling towers, accessories, and components, from manufacturer.

D. Source quality-control reports.

E. Field quality-control reports.

F. Field Test Reports: Include startup service reports.

G. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Certified by CTI or An NRTL, as directed.

B. CTI Certification: Cooling tower thermal performance according to CTI STD 201RS.

C. FM Global: Approval and listing in the latest edition of FM Global's "Approval Guide."

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace the following components of cooling towers that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design cooling tower support structure and seismic restraints and wind restraints, including comprehensive engineering analysis.

B. Structural Performance: Cooling tower and support structure shall withstand the effects of loads and stresses within limits and under conditions indicated according to ASCE/SEI 7, IBC, as directed.

C. Seismic Performance: Cooling towers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: .5 - 1.0.
3. Component Amplification Factor: As directed.
4. Component Response Modification Factor: As directed.

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

F. Operation Following Loss of Normal Power:

1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to backup power system shall automatically return equipment and associated controls to the operating state occurring immediately before loss of normal power without need for manual intervention by an operator when power is restored either through a backup power source, or through normal power if restored before backup power is brought online.
2. Include means and methods required to satisfy requirement even if not explicitly indicated.

G. Vibration:

1. Rotating assemblies shall be dynamically balanced to achieve a balance level of "good" while complying with industry-standard requirements for cooling towers.
2. Critical speed shall be at least 115 percent of design speed.

2.3 DESIGN ARRANGEMENT

A. Counterflow pattern with inlet airflow from bottom and forced-draft, bottom-mounted axial fans; and with pressurized pipe distribution near top.

B. Counterflow pattern with inlet airflow from one side and forced-draft, bottom-mounted centrifugal fans; and with pressurized pipe distribution near top.

C. Low-profile design with counterflow pattern, with inlet airflow from one side and forced-draft, side-mounted centrifugal fans to reduce overall height; and with pressurized pipe distribution near top.

2.4 CASING AND FRAME

A. Casing Material: FRP with UV inhibitors, HDPE with UV inhibitors, galvanized steel, ASTM A653/A653M, G210 (Z600) coating, galvanized steel, ASTM A653/A653M, G235 (Z700) coating or polymer-coated galvanized steel, as directed.

B. Frame Material: FRP with UV inhibitors, HDPE with UV inhibitors, galvanized steel, ASTM A653/A653M, G210 (Z600) coating, galvanized steel, ASTM A653/A653M, G235 (Z700) coating, polymer-coated galvanized steel or materials to match casing, as directed.

C. Hardware: Galvanized or stainless steel.

D. Joints and Seams: Sealed watertight.

E. Welded Connections: Sealed watertight by continuous welds.

2.5 COLLECTION BASIN

A. Factory-Assembled Collection Basin:

1. Material: FRP with UV inhibitors, HDPE with UV inhibitors, Galvanized steel, ASTM A653/A653M, G210 (Z600) coating, Galvanized steel, ASTM A653/A653M, G235 (Z700) coating or Polymer-coated galvanized steel, as directed.
2. Hardware: Galvanized or stainless steel.
3. Joints and Seams: Sealed watertight.
4. Welded Connections: Sealed watertight by continuous welds.
5. Removable stainless-steel strainer with openings smaller than nozzle orifices.
6. Overflow and drain connections.
7. Makeup-water connection.
8. Outlet Connection: Configured to mate to ASME B16.5, Class 150 flange.
9. Removable equalization flume plate between adjacent cells of multiple-cell towers.
10. Equalizer connection for field-installed equalizer piping configured to mate to ASME B16.5, Class 150 flange.

2.6 COLLECTION BASIN MAKEUP-WATER ASSEMBLY

A. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.

B. Electric/Electronic, Collection Basin Water-Level Controller with Makeup-Water Valve:

1. Enclosures: NEMA 250, Type 4 or Type 4X.
2. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to control makeup-water valve, control makeup-water valve and low-level alarm, control makeup-water valve and low- and high-level alarms, control makeup-water valve, low- and high-level alarms, and output for shutoff of pump on low level, as directed.
3. Electrode Probes: Stainless steel.

4. Water-Stilling Chamber: Corrosion-resistant material, FRP, galvanized steel, PVC pipe, stainless steel, Grade 304 or stainless steel, Grade 316, as directed.
5. Makeup-Water Valve:

    a. Slow closing with stainless-steel body.
    b. Valve actuator controlled and powered through level controller in response to water-level set point.
    c. Actuator Enclosure: NEMA 250, Type 4 or Type 4X.
    d. Fail Position: Closed, Open or Last.
    e. Action: Two position or modulating.

6. Electrical Connection Requirements: 120-V ac, single phase, 60 Hz.

2.7 COLLECTION BASIN HEATER

A. Electric Heater:

1. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
2. Heater Control Panel: Mounted on the side of each cooling tower cell.
3. Enclosure: NEMA 250, Type 3R, Type 4 or Type 4X.
4. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
5. Control-circuit transformer with primary and secondary side fuses.
6. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
7. Single-point, field-power connection to a fused disconnect switch, nonfused disconnect switch or circuit breaker and heater branch circuiting complying with NFPA 70.
8. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures; except, connections to each electric basin heater shall be liquidtight conduit.

    a. Raceway shall be corrosion-resistant stainless steel or PVC-coated steel.

2.8 PRESSURIZED DISTRIBUTION NETWORK

A. Main header and lateral branch piping designed for even distribution over fill and heat-exchanger coils throughout the entire flow range without the need for balancing valves and for connecting individual, easily removable, nonclogging spray nozzles.

B. Pipe Material: Schedule 40 PVC.

C. Spray Nozzle Material: Plastic, Polypropylene or PVC.

D. Piping Supports: Corrosion-resistant hangers and supports to resist movement during operation and shipment.

2.9 FILL

A. PVC:

1. Flame-Spread Index: 5 - 25 according to ASTM E84.
2. Minimum Thickness: 15 mils (0.4 mm) or 20 mils (0.5 mm) before forming.
3. Fabrication: Fill-type sheets, fabricated, formed, and bonded together after forming into removable assemblies that are factory installed by manufacturer.
4. Fill Material Operating Temperature: Suitable for entering-water temperatures up through 120 deg F (49 deg C).

B. Galvanized or stainless steel:

1. Minimum Material Thickness: As directed, before forming.
2. Fabrication: Fill-type sheets, fabricated, formed, and bonded together after forming into removable assemblies that are factory installed by manufacturer.
3. Fill Material Operating Temperature: Suitable for entering-water temperatures up through 170 deg F (77 deg C).

C. Hardware: Galvanized or stainless steel.

2.10 DRIFT ELIMINATORS

A. Material: PVC with maximum flame-spread index of 5 - 25 according to ASTM E84.

B. UV Treatment: Inhibitors to protect against damage caused by UV radiation.

C. Arrangement: Multiple, easily removable sections.

D. Configuration: Multipass, designed and tested to reduce water carryover to 0.001 percent of design flow rate indicated.

E. Hardware: Galvanized or stainless steel.

2.11 AIR INLET

A. Removable Air-Intake Screens:

1. Galvanized, Polymer-coated, galvanized or Stainless steel wire mesh, with openings of size sufficient to not restrict airflow or impact performance.
2. Segmented into manageable individual sections arranged to facilitate independent removal of each section without disturbing adjoining sections.

B. Hardware: Galvanized or stainless steel.

2.12 FAN AND DRIVE ASSEMBLY

A. Axial Fans: Factory balanced after assembly.

1. Blade Material: Aluminum, galvanized steel or thermoplastic, as directed.
2. Hub Material: Aluminum or galvanized steel.
3. Blade Pitch: Field adjustable.
4. Fan Shaft: Steel, coated to resist corrosion.
5. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C). Bearings designed for an L-10 life of 40,000, 50,000 or 100,000 hours, as directed.
6. Bearing Grease Fittings: Extended lubrication lines to an easily accessible location.

B. Centrifugal Fans: Double-width, double-inlet, forward-curved blades; statically and dynamically balanced at the factory after assembly.

1. Cooling Tower Cell Fan Assembly: Each cooling tower cell shall have a single fan or multiple fans connected to a common shaft.
2. Fan Wheel and Housing Materials: Hot-dip galvanized steel.
3. Fan Shaft: Steel, coated to resist corrosion.
4. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C). Bearings designed for an L-10 life of 40,000, 50,000 or 100,000 hours, as directed.
5. Bearing Grease Fittings: Extended lubrication lines to an easily accessible location.
6. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens complying with OSHA regulations.

C. Belt Drives:

1. Service Factor: 1.5 based on motor nameplate horsepower.
2. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
3. Belt: Multiple V-belt design with a matched set of cogged belts.
4. Belt: One-piece, multigrooved, solid-back belt.
5. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
6. Belt-Drive Guard: Comply with OSHA regulations.
7. Two-Motor, Single-Fan Drive:

    a. Two single-speed motors per cooling tower cell fan assembly; one sized for full speed and load and the other sized for 67 - 100 percent of full-load speed.
    b. Each motor shall have belt drive and be configured for operation when other motor fails.
    c. Controls and wiring same as two-speed, two-winding motor.

D. Direct Drives: Fan hub directly connected, and properly secured, to motor shaft.

E. Fan Motors:

1. Comply with NEMA MG 1 unless otherwise indicated.
2. Description: NEMA MG 1, Design B as required to comply with capacity and torque characteristics; medium induction motor.

3. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
4. Motor Enclosure: Totally enclosed, totally enclosed air-over (TEAO) or totally enclosed fan cooled (TEFC) and with epoxy or polyurethane finish, as directed.
5. Rotor: Random wound, squirrel cage.
6. Energy Efficiency: Comply with ASHRAE/IES 90.1 or NEMA Premium Efficient.
7. Service Factor: 1.15.
8. Temperature Rise: Match or One class lower than insulation rating, as directed.
9. Insulation: Class F or Class H.
10. Variable-Speed Motors: Inverter-duty rated according to NEMA MG 1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
11. Motor Location: Mounted outside of cooling tower airstream.
12. Severe-Duty Rating:

    a. Rotor and stator protected with corrosion-inhibiting epoxy resin.
    b. Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C).
    c. Internal Heater: Automatically energized when motor is de-energized.
    d. Complying with IEEE 841.

13. Motor Base: Adjustable, or other suitable belt-tensioning provisions.
14. Motor Shaft Grounding: Motors shall be controlled through variable-frequency controllers with shaft grounding system to protect motor bearings from induced voltage. Drag on motor shaft due to shaft ground system shall be less than 0.5 percent of motor nameplate horsepower.

F. Hardware: Galvanized or stainless steel.

2.13 AIR DISCHARGE

A. Discharge Hood:

1. Hood Configuration: Tapered or Straight; totally surrounding heat exchanger; pressurized distribution system and drift eliminators; constructed of same material as casing; and having factory-installed insulation and access doors.
2. Discharge Dampers: Positive-closure, automatic, isolation dampers constructed of aluminum or galvanized steel with corrosion-resistant linkages and electric actuators with NEMA 250, Type 4X enclosure.

    a. If not provided with factory controls, field-connect provisions for electrical power and controls to open dampers when pump is energized, and close dampers when pump is de-energized.

3. Capacity-Control Dampers: Aluminum or Galvanized-steel dampers, with corrosion-resistant linkages, electric operator, controller, limit switches, transformer, and weatherproof enclosure.

a. If not provided with factory controls, provide field power and controls to operate dampers when pump is energized, and close dampers when pump and fan is de-energized.

B. Hardware: Galvanized or stainless steel.

2.14 ELECTRICAL POWER

A. Factory Furnish for Field Installation: A disconnect switch, motor controller or variable-frequency controller for each fan motor.

B. Factory Install: A disconnect switch, motor controller or variable-frequency controller for each fan motor.

1. Locate in a convenient and field-accessible location within sight of motor.
2. Installation shall comply with NFPA 70.
3. Wire, Conduit, and Enclosures:

a. Minimum Conduit Size: 0.75 inch (20 mm).
b. Materials: Corrosion resistant and constructed of stainless steel or PVC-coated steel.
c. Motor Termination: Liquidtight conduit, not to exceed 36 inches (900 mm) long.
d. Supports: Support, conduits boxes, and enclosures using corrosion-resistant fastening hardware constructed of stainless steel.
e. Wire:

1) Copper rated for 600-V solid wire for size No. 10 AWG and smaller and stranded wire for larger sizes.
2) Minimum Wire Size: No. 12 AWG.
3) Each circuit shall have a ground wire.
4) Install wire in conduit.

f. Boxes, Condulets, and Enclosures: NEMA 250, Type 3R, Type 4 or Type 4X.

C. Disconnect Switches:

1. Specification Grade; "Heavy-Duty Type," "quick-make," "quick-break" construction.
2. Three pole fused or nonfused.
3. 600-V rated.
4. Minimum SCCR: As required by electrical power distribution system, but not less than 42,000 - 65,000 A.
5. Enclosure: NEMA 250, Type 3R, Type 4, Type 4X or Type 4X stainless steel.
6. Operating handle shall be of box-mounted type that directly drives switch mechanism.
7. Disconnect switch shall use a flange-operated visible blade that is close coupled to a vertical-lift-type handle that achieves a positive visible indication of disconnect with cover open or closed.
8. Disconnect switch shall have a defeatable, front-accessible, mechanical interlock to prevent opening of cover when switch is in "ON" position, and to prevent turning switch "ON" when the door is open.
9. Include a solid neutral as required by authorities having jurisdiction.

10. Include a ground lug for ground wire termination.
11. Operating handle shall be lockable in open position.
12. Horsepower rated.
13. Feed through or double lugged.

D. Motor Controllers:

1. NEMA ICS 2, Class A, full-voltage, non-reversing motor-rated controller.
2. Configured for control of single- or multi-speed motors.
3. Enclosure: NEMA 250, Type 3R, Type 4, Type 4X or Type 4X stainless steel, with hinged full-front access door with lock and key.
4. Externally Operated, Door-Interlocked Disconnect: Fused disconnect switch, Nonfused disconnect switch or Circuit breaker with lockable handle.
5. SCCR: As required by electrical power distribution system, but not less than 42,000 - 65,000 A.
6. Hand-Off-Auto Switch: Mounted on face of enclosure.
7. Push-to-Test Run Status Pilot Lights: NEMA ICS 2, heavy-duty type.
8. Control Relays: Time-delay relays.
9. Phase-Failure, Phase-Reversal, Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hardwired connection.
10. Elapsed-Time Meters: Numerical readout in hours on face of enclosure.
11. Number-of-Starts Counter: Numerical readout on face of enclosure.

E. Variable-Frequency Controllers:

1. Description: NEMA ICS 2; arranged to achieve motor variable speed by adjusting output voltage and frequency.
2. Enclosure: Unit mounted, NEMA 250, Type 3R, Type 4, Type 4X or Type 4X stainless steel with hinged full-front access door with lock and key.
3. Externally Operated, Door-Interlocked Disconnect: Fused disconnect switch, Nonfused disconnect switch or Circuit breaker with lockable handle.
4. Minimum SCCR: As required by electrical power distribution system, but not less than 42,000 - 65,000 A.
5. Technology: Pulse-width-modulated (PWM) output with insulated gate bipolar transistors (IGBTs); suitable for variable-torque loads.
6. Controller shall consist of a rectifier converter section, a digital/analog driver regulator section, and an inverter output section.
7. Output Rating: Three phase; with voltage proportional to frequency throughout voltage range.
8. Output signal shall be programmed to not cause mechanical vibration issues with fan drive assembly.
9. Operating Requirements:

    a. Input AC Voltage Tolerance: 10 percent.
    b. Input frequency tolerance of 60 Hz, plus or minus 2 Hz.
    c. Capable of driving full motor load, without derating.
    d. Minimum Efficiency: 96 percent at 60 Hz, full load.
    e. Minimum Displacement Primary-Side Power Factor: 95 percent.
    f. Overload Capability: 1.05 times the full-load current for seven seconds.
    g. Starting Torque: As required by fan and motor drive assembly.
    h. Speed Regulation: 1 percent.

i. Speed Range: 10:1 speed range.
j. To avoid equipment resonant vibrations, include critical speed lockout circuitry to allow bands of operating frequency at which controller shall not operate continuously.
k. Capable of being restarted into a motor, coasting in either the forward or reverse direction without tripping.

10. Controller Adjustability Capabilities: Minimum and maximum output frequency, acceleration and deceleration, and current limit.
11. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions shall not result in component failure or the need for replacement:

a. Overtemperature.
b. Short circuit at controller output.
c. Ground fault at controller output. Variable-frequency controller shall be able to start a grounded motor.
d. Open circuit at controller output.
e. Input undervoltage.
f. Input overvoltage.
g. Loss of input phase.
h. Reverse phase.
i. AC line-switching transients.
j. Instantaneous overload, line to line or line to ground.
k. Sustained overload exceeding 100 percent of controller-rated current.
l. Starting a rotating motor.

12. Motor Protection: Controller shall protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.
13. Automatic Reset and Restart:

a. Capable of multiple restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction.
b. Capable of automatic restart on phase-loss and overvoltage and undervoltage trips.

14. Visual Indication: On face of controller; indicating the following conditions:

a. Power on.
b. Run.
c. Overcurrent and overvoltage.
d. Motor speed (percent).
e. Various faults with alarm status.
f. Input kilovolt amperes.
g. Power factor.
h. Input kilowatts and kilowatt-hours.
i. Three-phase input and output voltage.
j. Three-phase input and output current.
k. Output frequency.
l. Elapsed operating time (hours).
m. Diagnostic and service parameters.

15. Operator Interface: Start-stop and auto-manual selector with manual-speed-control potentiometer.
16. Control Signal Interface: A minimum of two analog inputs (0 to 10 V or 0/4 to 20 mA) and four programmable digital inputs.
17. Bypass Controller:

    a. Integrated NEMA ICS 2, Class A, full-voltage, non-reversing, motor-rated controller to operate fan motor if variable-frequency controller is not operational.
    b. Configure power supply to bypass controller and variable-frequency controller to completely isolate power to variable-frequency controller while operating fan motor through bypass controller, for safe servicing of variable-frequency controller.
    c. Include "Bypass/VFC" manual selector switch on face of enclosure to provide for local operator control of preferred controller.
    d. Include fail-safe control logic to automatically transfer fan motor operation from failed variable-frequency controller to bypass controller.
    e. Install bypass controller in same enclosure as variable-frequency controller.

2.15 CONTROLS

A. Vibration Switch: For each fan drive.

1. Enclosure: NEMA 250, Type 4 or Type 4X.
2. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
3. Switch shall have manual-reset button with hardwired connection to fan motor electrical circuit.
4. Switch shall have field connection for hardwired connection to control system.
5. Switch shall, on sensing excessive vibration, signal an alarm for connection to control system and shut down the fan.

2.16 SERVICE ACCESS

A. Doors:

1. Large enough for personnel to access cooling tower internal components.
2. Doors shall be hinged with handles operable from both sides of the door.
3. Door materials shall match casing.
4. Hinges and handles shall be corrosion resistant or stainless steel.

B. External Ladders with Safety Cages: Aluminum, galvanized-steel or stainless-steel fixed ladders, with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.

C. External Platforms with Handrails: Aluminum or galvanized-steel or stainless-steel bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.

D. Handrail: Aluminum, galvanized steel or stainless steel complete with kneerail and toeboard, around external platforms and top of cooling tower. Comply with 29 CFR 1910.23.

E. Hardware: Galvanized steel when connecting galvanized-steel components and stainless steel when connecting other materials.

2.17 CAPACITIES AND CHARACTERISTICS

A. Number of Cells: As directed.

B. Air-Inlet Arrangement: One side or bottom.

C. Maximum Drift Loss: 0.001 percent of design water flow.

D. Waterside:

1. Design Water Flow per Cell: As directed, gpm (L/s).
2. Minimum Water Flow per Cell: As directed, gpm (L/s).
3. Water Pressure Drop: As directed, psig (kPa).
4. Entering-Water Temperature: As directed, deg F (deg C).
5. Leaving-Water Temperature: As directed, deg F (deg C).

E. Airside:

1. Entering-Air, Wet-Bulb Temperature: As directed, deg F (deg C).
2. Altitude: As directed.
3. Air Flow per Cell: As directed, cfm (L/s).

F. Economizer Mode Performance:

1. Fluid Flow per Cell: As directed, gpm (L/s).
2. Entering-Fluid Temperature: As directed, deg F (deg C).
3. Leaving-Fluid Temperature: As directed, deg F (deg C).
4. Entering-Air, Wet-Bulb Temperature: As directed, deg F (deg C).

G. Fan Drive Assembly:

1. Type: Belt or direct.
2. Fan Motor:

a. Type: Single speed, Two speed, single winding, Two speed, two winding or Variable speed.
b. Motor Size per Cell: As directed, hp.
c. Full-Load Ampacity: As directed, A.
d. Minimum Circuit Ampacity: As directed, A.
e. Maximum Overcurrent Protection Device: As directed, A.
f. Electrical Characteristics: 208, 240 or 480 V ac, 3 phase, 60 Hz, as directed.

H. Sound Pressure Level dBA at distance in feet (m) when measured according to CTI ATC 128, as directed.

I. Collection Basin Heater:

1. Basin Water Temperature: 40 deg F (5 deg C).
2. Outdoor Ambient Temperature: 0 deg F (minus 18 deg C) or Minus 20 deg F (Minus 29 deg C), as directed.
3. Capacity per Cell: As directed, kW.
4. Full-Load Ampacity: As directed, A.
5. Minimum Circuit Ampacity: As directed, A.
6. Maximum Overcurrent Protection Device: As directed, A.
7. Electrical Characteristics: 208, 240 or 480 V ac, 3 phase, 60 Hz, as directed.
8. Capacity/Cell: As directed, MBtu/h (kW).
9. Coil fluid Type: Water.
10. Entering-Fluid Temperature: As directed, deg F (deg C).
11. Leaving-Fluid Temperature: As directed, deg F (deg C).
12. Fluid Flow Rate: As directed, gpm (L/s).
13. Fluid Pressure Drop: As directed, psig (kPa).
14. Capacity/Cell: As directed, MBtu/h (kW).
15. Steam Flow: As directed, lb/h (L/s).
16. Steam Pressure: As directed, psig (kPa).

2.18 SOURCE QUALITY CONTROL

A. Performance Test: Factory test and certify cooling tower performance according to CTI STD 201RS.

B. Seismic Performance Testing: Shake table tested by an independent or a factory-certified laboratory to certify performance complies with seismic requirements indicated.

C. Factory Functional Tests:

1. Test collection and distribution basins after assembly, and prove free of leaks.
2. Test factory-installed electric/electronic water-level controls for proper operation.
3. Test factory-installed electric basin heaters for proper operation.
4. Test factory-installed fan and drive assemblies for proper operation.
5. Test factory-installed control package for proper operation.
6. Test access doors to ensure smooth operation and proper fit.
7. Submit report documenting tests performed and results within one week of test date.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Examine cooling towers before installation. Reject cooling towers that are damaged.

B. Install cooling towers on support structure.

C. Equipment Mounting:

1. Install cooling towers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." Or Section 033053 "Miscellaneous Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

D. Install anchor bolts to elevations required for proper attachment to supported equipment.

E. Maintain manufacturer's recommended clearances for service and maintenance.

F. Maintain clearances required by governing code.

3.2 DUCT CONNECTIONS

A. Duct installation requirements are specified in other Sections. Drawings indicate general arrangement of ductwork and accessories.

B. Where installing duct adjacent to cooling towers, allow space for service and maintenance.

C. Install flexible connectors at duct connections to cooling towers.

3.3 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to cooling towers, allow space for service and maintenance.

C. Install flexible pipe connectors at pipe connections of cooling towers mounted on vibration isolators.

D. Connect cooling tower overflows and drains, and piping drains to sanitary sewage system.

E. Makeup-Water Piping:

1. Comply with applicable requirements in Section 221116 "Domestic Water Piping."
2. Connect to makeup-water connections with shutoff valve, plugged tee with pressure gage, flow meter, and drain connection with valve and union.

F. Supply and Return Piping:

1. Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
2. Connect to entering-cooling-tower connections with shutoff valve, strainer, balancing valve, thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve.

3. Connect to leaving-cooling-tower connection with shutoff valve thermometer, plugged tee with full port ball valve for portable field instruments, and drain connection with valve.
4. Make connections to cooling tower with a flange.

G. Equalizer Piping:

1. Piping requirements to match supply and return piping.
2. Connect an equalizer pipe, full size of cooling tower connection, between tower cells.
3. Connect to cooling tower with shutoff valve and drain connection with valve.
4. Make connections to cooling tower with a flange.

H. Basin Heater Hot-Water Piping:

1. Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
2. Connect to supply connections with shutoff valve, strainer, control valve thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve.
3. Connect to return connections with shutoff valve, balancing valve, thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve.
4. Make connections with a flange, union, or mechanical coupling.

I. Basin Heater Steam and Condensate Piping:

1. Comply with applicable requirements in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties."
2. Connect steam supply connection with shutoff valve, strainer, control valve, pressure gage, and flow meter.
3. Connect to condensate connection with shutoff valve, strainer, and an appropriate steam trap assembly.
4. Make connections with a flange or union.

J. Basin Sweeper Piping:

1. Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
2. Connect to supply connections with shutoff valve, flow meter, and drain connection with valve.
3. Connect to return connections with shutoff valve, balancing valve, flow meter, and drain connection with valve.
4. Make connections with a flange or union.

3.4 ELECTRICAL POWER CONNECTIONS

A. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

B. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding connections.

C. Install nameplate for each electrical connection indicating electrical equipment designation and circuit number feeding connection. Nameplate shall be laminated phenolic layers of black with engraved white letters at least 1/2 inch (13 mm) high. Locate nameplate where easily visible.

3.5 CONTROLS CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between cooling towers and other equipment to interlock operation as required to achieve a complete and functioning system.

3.6 FIELD-TESTING PROVISIONS

A. Include provisions for cooling tower future field performance testing complying with ASME PTC 23 or CTI ATC 105.

B. Include provisions in field piping for future field performance testing complying with ASME PTC 23 or CTI ATC 105.

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. Tests and Inspections: Comply with ASME PTC 23 or CTI ATC 105.

C. Cooling towers will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.8 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform or Perform startup service.

B. Inspect field-assembled components, equipment installation, and piping; controls; and electrical connections for proper assemblies, installations, and connections.

C. Obtain performance data from manufacturer.

1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

    a. Clean entire unit, including basins.
    b. Verify that accessories are properly installed.
    c. Verify clearances for airflow and for cooling tower servicing.
    d. Check for vibration isolation and structural support.
    e. Lubricate bearings.

f. Verify fan rotation for correct direction and for vibration or binding, and correct problems.
g. Adjust belts to proper alignment and tension.
h. Operate variable-speed fans through entire operating range and check for harmonic vibration imbalance. Set motor controller to skip speeds resulting in abnormal vibration.
i. Check vibration switch setting. Verify operation.
j. Verify water level in tower basin. Fill to proper startup level. Check makeup-water-level control and valve.
k. Verify operation of basin heater and control.
l. Verify that cooling tower air discharge is not recirculating air into tower or HVAC air intakes. Recommend corrective action.
m. Replace defective and malfunctioning units.

D. Start cooling tower and associated water pumps. Follow manufacturer's written starting procedures.

E. Prepare a written startup report that records the results of tests and inspections.

3.9 ADJUSTING

A. Set and balance water flow to each tower inlet.

B. Adjust water-level control for proper operating level.

C. Adjust basin heater control for proper operating set point.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train or train Owner's maintenance personnel to adjust, operate, and maintain cooling towers.

END OF SECTION 236513.13

SECTION 236513.16 – CLOSED-CIRCUIT, FORCED-DRAFT COOLING TOWERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes factory-assembled, closed-circuit, forced-draft cooling towers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Manufacturer's drawings of assembled cooling towers, control panels, sections, and elevations.
2. Assembled unit dimensions.
3. Diagram showing each separate piece requiring field assembly.
4. Shipped sub-assembly dimensions and weights for field assembly.
5. Operating weight and load distribution.
6. Unit vibration isolation and seismic controls.
7. Required clearances for maintenance and operation.
8. Sizes and dimensioned locations of piping and wiring connections.
9. Diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal: For cooling tower support structure indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of support structure.
2. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment.
3. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and wind restraints and for designing vibration isolation bases.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:

1. Drawings on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
2. Each view to show screened background with the following:

a. Structural grids.
b. Adjacent walls, floors, and roofs.

c. Equipment and products of other trades that are located in vicinity of cooling towers and are part of final installation, such as controls, power, lighting, fire suppression systems, and plumbing systems.

B. Product Certificates: For certification required in "Quality Assurance" Article.

C. Seismic Qualification Data: Certificates, for cooling towers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Source quality-control reports.

E. Field quality-control reports.

F. Field Test Reports: Include startup service reports.

G. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Certified by CTI or An NRTL.

B. ASME Compliance: Fabricate and label heat-exchanger coils to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

C. CTI Certification: Cooling tower thermal performance according to CTI STD 201RS.

D. FM Global: Approval and listing in the latest edition of FM Global's "Approval Guide."

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace the following components of cooling towers that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design cooling tower support structure and seismic restraints and wind restraints, including comprehensive engineering analysis.

B. Structural Performance: Cooling tower and support structure shall withstand the effects of loads and stresses within limits and under conditions indicated according to ASCE/SEI 7, IBC or governing code, as directed.

C. Seismic Performance: Cooling towers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 - 1.0.
3. Component Amplification Factor: As directed.
4. Component Response Modification Factor: As directed.

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

F. Operation Following Loss of Normal Power:

1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to back-up power system shall automatically return equipment and associated controls to the operating state occurring immediately before loss of normal power without need for manual intervention by an operator when power is restored either through a backup power source, or through normal power if restored before backup power is brought online.
2. Include means and methods required to satisfy requirement even if not explicitly indicated.

G. Vibration:

1. Rotating assemblies shall be dynamically balanced to achieve a balance level of "good" while complying with industry-standard requirements for cooling towers.
2. Critical speed shall be at least 115 percent of design speed.

2.3 DESIGN ARRANGEMENT

A. Counterflow pattern with inlet airflow from one side and forced-draft, bottom-mounted, axial fans; and with pressurized pipe distribution near top.

B. Counterflow pattern with inlet airflow from one side and forced-draft, bottom-mounted, centrifugal fans; and with pressurized pipe distribution near top.

C. Low-profile design with counterflow pattern, with inlet airflow from one side and forced-draft, side-mounted, centrifugal fans to reduce overall height; and with pressurized pipe distribution near top.

2.4 CASING AND FRAME

A. Casing Material: Galvanized steel, ASTM A653/A653M, G235 (Z700) coating or polymer-coated galvanized steel.

B. Frame Material: Galvanized steel, ASTM A653/A653M, G235 (Z700) coating, polymer-coated galvanized steel or materials to match casing.

C. Hardware: Galvanized or stainless steel.

D. Joints and Seams: Sealed watertight.

E. Welded Connections: Sealed watertight by continuous welds.

2.5 COLLECTION BASIN

A. Factory-Assembled Collection Basin:

1. Material: Galvanized steel, ASTM A653/A653M, G235 (Z700) coating or Polymer-coated galvanized steel.
2. Hardware: Galvanized or stainless steel.
3. Joints and Seams: Sealed watertight.
4. Welded Connections: Sealed watertight by continuous welds.
5. Removable stainless-steel strainer with openings smaller than nozzle orifices.
6. Overflow and drain connections.
7. Makeup-water connection.
8. Outlet Connection: Configured to mate to ASME B16.5, Class 150 flange.

2.6 COLLECTION BASIN MAKEUP-WATER ASSEMBLY

A. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.

B. Electric/Electronic, Collection Basin Water-Level Controller with Makeup-Water Valve:

1. Enclosures: NEMA 250, Type 4 or Type 4X.

2. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to control makeup-water valve, control makeup-water valve and low-level alarm, control water makeup valve and low- and high-level alarms or control makeup-water valve, low- and high-level alarms, and output for shutoff of pump on low level.
3. Electrode Probes: Stainless steel.
4. Water-Stilling Chamber: Corrosion-resistant material, FRP, galvanized steel, PVC pipe or stainless steel, Grade 304, stainless steel, Grade 316.
5. Makeup Water Valve:

    a. Slow-closing with stainless-steel body.
    b. Valve actuator controlled and powered through level controller in response to water-level set point.
    c. Actuator Enclosure: NEMA 250, Type 4 or Type 4X.
    d. Fail Position: Closed, Open or Last.
    e. Action: Two position or modulating.

6. Electrical Connection Requirements: 120-V ac, single phase, 60 Hz.

2.7 COLLECTION BASIN HEATER

A. Electric Heater:

1. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
2. Heater Control Panel: Mounted on the side of each cooling tower cell.
3. Enclosure: NEMA 250, Type 3R, Type 4 or Type 4X.
4. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
5. Control-circuit transformer with primary and secondary side fuses.
6. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
7. Single-point, field-power connection to a fused disconnect switch, nonfused disconnect switch or circuit breaker and heater branch circuiting complying with NFPA 70.
8. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures; except, connections to each electric basin heater shall be liquidtight conduit.

    a. Raceway shall be corrosion-resistant stainless steel or PVC-coated steel.

2.8 PRESSURIZED DISTRIBUTION NETWORK

A. Main header and lateral branch piping designed for even distribution over fill and heat-exchanger coils throughout the entire flow range without the need for balancing valves and for connecting individual, easily removable, nonclogging spray nozzles.

B. Pipe Material: Schedule 40 PVC.

C. Spray Nozzle Material: Plastic, Polypropylene or PVC.

D. Piping Supports: Corrosion-resistant hangers and supports to resist movement during operation and shipment.

2.9 HEAT-EXCHANGER COILS

A. Tube and Tube Sheet Materials: Copper tube with stainless-steel tube sheet, stainless-steel tube and tube sheet or carbon-steel tube and sheet with outer surface of tube and sheet hot-dip galvanized after fabrication.

B. Heat-Exchanger Arrangement:

1. Serpentine tubes, serpentine tubes with removable cover plate on inlet and outlet headers or straight tubes with removable header cover plate on both ends of heat exchanger for straight-through access to each tube; and sloped for complete drainage of fluid by gravity.
2. Tubes with extended surface fins if required to achieve performance indicated.
3. Multiple Separate Circuits: Separate circuits to achieve multiple isolated loops as required by application.

C. ASME Compliance: Designed, manufactured, and tested according to ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 and bearing ASME "U" stamp; and sloped for complete drainage of fluid by gravity.

D. Field Piping Connections: Vent, supply, and return suitable for mating to ASME B16.5, Class 150 flange.

2.10 DRIFT ELIMINATORS

A. Material: PVC with maximum flame-spread index of 5 – 25 according to ASTM E84.

B. UV Treatment: Inhibitors to protect against damage caused by UV radiation.

C. Arrangement: Multiple, easily removable sections.

D. Configuration: Multipass, designed and tested to reduce water carryover to 0.001 percent of design flow rate indicated.

E. Hardware: Galvanized or stainless steel.

2.11 AIR INLET

A. Removable Air-Intake Screens:

1. Galvanized, Polymer-coated, galvanized or Stainless steel wire mesh, with openings of size sufficient to not restrict airflow or impact performance.
2. Segmented into manageable individual sections arranged to facilitate independent removal of each section without disturbing adjoining sections.

B. Hardware: Galvanized or stainless steel.

2.12 FAN AND DRIVE ASSEMBLY

A. Axial Fans: Factory balanced after assembly.

1. Blade Material: Aluminum or galvanized steel.
2. Hub Material: Aluminum or galvanized steel.
3. Fan Shaft: Steel, coated to resist corrosion.
4. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C). Bearings designed for an L-10 life of 40,000, 50,000 or 100,000 hours, as directed
5. Bearing Grease Fittings: Extended lubrication lines to an easily accessible location.

B. Centrifugal Fans: Double-width, double-inlet, forward-curved blades; statically and dynamically balanced at the factory after assembly.

1. Cooling Tower Cell Fan Assembly: Each cooling tower cell shall have a single fan or multiple fans connected to a common shaft.
2. Fan Wheel and Housing Materials: Hot-dip galvanized steel.
3. Fan Shaft: Steel, coated to resist corrosion.
4. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C). Bearings designed for an L-10 life of 40,000, 50,000 or 100,000 hours, as directed.
5. Bearing Grease Fittings: Extended lubrication lines to an easily accessible location.
6. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens complying with OSHA regulations.

C. Belt Drives:

1. Service Factor: 1.5 based on motor nameplate horsepower.
2. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
3. Belt: Multiple V-belt design with a matched set of cogged belts.
4. Belt: One-piece, multigrooved, solid-back belt.
5. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
6. Belt-Drive Guard: Comply with OSHA regulations.
7. Two-Motor, Single-Fan Drive:

    a. Two single-speed motors per cooling tower cell fan assembly; one sized for full speed and load and the other sized for 67 – 100 percent of full-load speed.
    b. Each motor shall have belt drive and be configured for operation when other motor fails.
    c. Controls and wiring same as two-speed, two-winding motor.

D. Fan Motors:

1. Comply with NEMA MG 1 unless otherwise indicated.
2. Description: NEMA MG 1, Design B as required to comply with capacity and torque characteristics; medium induction motor.

3. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
4. Motor Enclosure: Totally enclosed, totally enclosed air-over (TEAO) or totally enclosed fan cooled (TEFC) and with epoxy or polyurethane finish.
5. Rotor: Random wound, squirrel cage.
6. Energy Efficiency: Comply with ASHRAE/IES 90.1 or NEMA Premium Efficient.
7. Service Factor: 1.15.
8. Temperature Rise: Match or One class lower than insulation rating.
9. Insulation: Class F or Class H.
10. Variable-Speed Motors: Inverter-duty rated according to NEMA MG 1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
11. Motor Location: Mounted outside of cooling tower airstream.
12. Severe-Duty Rating:

    a. Rotor and stator protected with corrosion-inhibiting epoxy resin.
    b. Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C.).
    c. Internal Heater: Automatically energized when motor is de-energized.
    d. Complying with IEEE 841.

13. Motor Base: Adjustable, or other suitable belt-tensioning provisions.
14. Motor Shaft Grounding: Motors shall be controlled through variable-frequency controllers with shaft grounding system to protect motor bearings from induced voltage. Drag on motor shaft due to shaft ground system shall be less than 0.5 percent of motor nameplate horsepower.

E. Hardware: Galvanized or stainless steel.

2.13 AIR DISCHARGE

A. Discharge Hood:

1. Hood Configuration: Tapered or Straight; totally surrounding heat exchanger; pressurized distribution system and drift eliminators; constructed of same material as casing; and having factory-installed insulation and access doors.
2. Discharge Dampers: Positive-closure, automatic, isolation dampers constructed of aluminum, galvanized steel or stainless steel, with corrosion-resistant linkages and electric actuators with NEMA 250, Type 4X enclosure.

    a. If not provided with factory controls, field-connect provisions for electrical power and controls to open dampers when pump is energized, and close dampers when pump is de-energized.

3. Capacity-Control Dampers: Aluminum, Galvanized-steel or Stainless-steel dampers, with corrosion-resistant linkages, electric operator, controller, limit switches, transformer, and weatherproof enclosure.

a. If not provided with factory controls, provide field power and controls to operate dampers when pump is energized, and close dampers when pump and fan is de-energized.

B. Hardware: Galvanized or stainless steel.

2.14 RECIRCULATING-WATER DISTRIBUTION SYSTEM

A. Pump: Close-coupled, single-stage, bronze-fitted centrifugal pump with mechanical seal; suitable for outdoor service. Factory install pump with following:

1. Redundant Pump: Same performance as required for primary pump; easily switched and maintained while cooling tower remains operating.
2. Flanges at pump connections to piping.
3. Strainer, with blowdown isolation valve, installed in piping on suction side of pump.
4. Flow-balancing valve in piping on discharge side of pump.

B. Pump Motor:

1. Comply with NEMA MG 1 unless otherwise indicated.
2. Description: NEMA MG 1, Design B, as required to comply with capacity and torque characteristics; medium induction motor.
3. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
4. Motor Enclosure: Open drip proof or totally enclosed and with epoxy or polyurethane finish, as directed.
5. Rotor: Random wound, squirrel cage.
6. Energy Efficiency: Comply with ASHRAE/IES 90.1 or NEMA Premium Efficient.
7. Service Factor: 1.15.
8. Temperature Rise: Match or One class lower than insulation rating, as directed.
9. Insulation: Class F or Class H.
10. Severe-Duty Rating:

    a. Rotor and stator protected with corrosion-inhibiting epoxy resin.
    b. Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C).
    c. Internal Heater: Automatically energized when motor is de-energized.
    d. Complying with IEEE 841.

C. Piping: Interconnecting collection basin to pump and pressurization distribution system.

1. Design delegated to manufacturer.
2. External to and supported from cooling tower casing and frame.
3. Material: Corrosion-resistant or PVC.
4. Install flanges at connections to collection basin and pressurized distribution system.
5. Drain connection with isolation valve at piping low point if piping does not drain directly into collection basin.

D. Piping: Field installed for connection to remotely installed pump and water storage that are not furnished with cooling tower.

2.15 ELECTRICAL POWER

A. Factory Furnish for Field Installation: A disconnect switch, motor controller or variable-frequency controller for each fan motor and a disconnect switch or motor controller for each pump motor.

B. Factory Install: A disconnect switch, motor controller or variable-frequency controller for each fan motor and a disconnect switch or motor controller for each pump motor.

1. Locate in a convenient and field-accessible location within sight of motor.
2. Installation shall comply with NFPA 70.
3. Wire, Conduit, and Enclosures:

    a. Minimum Conduit Size: 0.75 inch (20 mm).
    b. Materials: Corrosion resistant and constructed of stainless steel or PVC coated steel.
    c. Motor Termination: Liquidtight conduit, not to exceed 36 inches (900 mm) long.
    d. Supports: Support, conduits boxes, and enclosures using corrosion-resistant fastening hardware constructed of stainless steel.
    e. Wire:

        1) Copper, rated for 600-V, solid wire for size No. 10 AWG and smaller and stranded wire for larger sizes.
        2) Minimum Wire Size: No. 12 AWG.
        3) Each circuit shall have a ground wire.
        4) Install wire in conduit.

    f. Boxes, Condulets, and Enclosures: NEMA 250, Type 3R, Type 4 or Type 4X.

C. Disconnect Switches:

1. Specification Grade; "Heavy-Duty Type," "quick make," "quick break" construction.
2. Three pole fused or nonfused.
3. 600-V rated.
4. Minimum SCCR: As required by electrical power distribution system, but not less than 42,000 - 65,000 A.
5. Enclosure: NEMA 250, Type 3R, Type 4, Type 4X or Type 4X stainless steel.
6. Operating handle shall be of box-mounted type that directly drives switch mechanism.
7. Disconnect switch shall use a flange-operated visible blade that is close coupled to a vertical-lift-type handle that achieves a positive visible indication of disconnect with cover open or closed.
8. Disconnect switch shall have a defeatable, front-accessible, mechanical interlock to prevent opening of cover when switch is in "ON" position, and to prevent turning switch "ON" when the door is open.
9. Include a solid neutral as required by authorities having jurisdiction.
10. Include a ground lug for ground wire termination.
11. Operating handle shall be lockable in open position.

12. Horsepower rated.
13. Feed through or double lugged.

D. Motor Controllers:

1. NEMA ICS 2, Class A, full-voltage, non-reversing motor-rated controller.
2. Configured for control of single- or multi-speed motors.
3. Enclosure: NEMA 250, Type 3R, Type 4, Type 4X or Type 4X stainless steel, with hinged full-front access door with lock and key.
4. Externally Operated, Door-Interlocked Disconnect: Fused disconnect switch, Nonfused disconnect switch or Circuit breaker with lockable handle.
5. SCCR: As required by electrical power distribution system, but not less than 42,000 - 65,000 A.
6. Hand-Off-Auto Switch: Mounted on face of enclosure.
7. Push-to-Test Run Status Pilot Lights: NEMA ICS 2, heavy-duty type.
8. Control Relays: Time-delay relays.
9. Phase-Failure, Phase-Reversal, Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hardwired connection.
10. Elapsed-Time Meters: Numerical readout in hours on face of enclosure.
11. Number-of-Starts Counter: Numerical readout on face of enclosure.

E. Variable-Frequency Controllers:

1. Description: NEMA ICS 2; arranged to achieve motor variable speed by adjusting output voltage and frequency.
2. Enclosure: Unit mounted, NEMA 250, Type 3R, Type 4, Type 4X or Type 4X stainless steel, with hinged full-front access door with lock and key.
3. Externally Operated, Door-Interlocked Disconnect: Fused disconnect switch, Nonfused disconnect switch or Circuit breaker with lockable handle.
4. SCCR: As required by electrical power distribution system, but not less than 42,000 - 65,000 A.
5. Technology: Pulse-width-modulated (PWM) output with insulated gate bipolar transistors (IGBTs); suitable for variable-torque loads.
6. Controller shall consist of a rectifier converter section, a digital/analog driver regulator section, and an inverter output section.
7. Output Rating: Three phase; with voltage proportional to frequency throughout voltage range.
8. Output signal shall be programmed to not cause mechanical vibration issues with fan drive assembly.
9. Operating Requirements:

    a. Input AC Voltage Tolerance: 10 percent.
    b. Input frequency tolerance of 60 Hz, plus or minus 2 Hz.
    c. Capable of driving full motor load, without derating.
    d. Minimum Efficiency: 96 percent at 60 Hz, full load.
    e. Minimum Displacement Primary-Side Power Factor: 95 percent.
    f. Overload Capability: 1.05 times the full-load current for seven seconds.
    g. Starting Torque: As required by fan and motor drive assembly.
    h. Speed Regulation: 1 percent.
    i. Speed Range: 10:1 speed range.

j. To avoid equipment resonant vibrations, include critical speed lockout circuitry to allow bands of operating frequency at which controller shall not operate continuously.
k. Capable of being restarted into a motor, coasting in either the forward or reverse direction without tripping.

10. Controller Adjustability Capabilities: Minimum and maximum output frequency, acceleration and deceleration, and current limit.
11. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions shall not result in component failure or the need for replacement:

    a. Overtemperature.
    b. Short circuit at controller output.
    c. Ground fault at controller output. Variable-frequency controller shall be able to start a grounded motor.
    d. Open circuit at controller output.
    e. Input undervoltage.
    f. Input overvoltage.
    g. Loss of input phase.
    h. Reverse phase.
    i. AC line-switching transients.
    j. Instantaneous overload, line to line or line to ground.
    k. Sustained overload exceeding 100 percent of controller rated current.
    l. Starting a rotating motor.

12. Motor Protection: Controller shall protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.
13. Automatic Reset and Restart:

    a. Capable of multiple restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction.
    b. Capable of automatic restart on phase-loss and overvoltage and undervoltage trips.

14. Visual Indication: On face of controller; indicating the following conditions:

    a. Power on.
    b. Run.
    c. Overcurrent and overvoltage.
    d. Motor speed (percent).
    e. Various faults with alarm status.
    f. Input kilovolt amperes.
    g. Power factor.
    h. Input kilowatts and kilowatt-hours.
    i. Three-phase input and output voltage.
    j. Three-phase input and output current.
    k. Output frequency.
    l. Elapsed operating time (hours).
    m. Diagnostic and service parameters.

15. Operator Interface: Start-stop and auto-manual selector with manual-speed-control potentiometer.

16. Control Signal Interface: A minimum of two analog inputs (0 to 10 V or 0/4 to 20 mA) and four programmable digital inputs.
17. Bypass Controller:

    a. Integrated NEMA ICS 2, Class A, full-voltage, non-reversing, motor-rated controller to operate fan motor if variable-frequency controller is not operational.
    b. Configure power supply to bypass controller and variable-frequency controller to completely isolate power to variable-frequency controller while operating fan motor through bypass controller, for safe servicing of variable-frequency controller.
    c. Include "Bypass/VFC" manual selector switch on face of enclosure to provide for local operator control of preferred controller.
    d. Include fail-safe control logic to automatically transfer fan motor operation from failed variable-frequency controller to bypass controller.
    e. Install bypass controller in same enclosure as variable-frequency controller.

2.16 CONTROLS

A. Vibration Switch: For each fan drive.

1. Enclosure: NEMA 250, Type 4 or Type 4X.
2. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
3. Switch shall have manual-reset button with hardwired connection to fan motor electrical circuit.
4. Switch shall have field connection for hardwired connection to control system.
5. Switch shall, on sensing excessive vibration, signal an alarm for connection to control system and shut down the fan.

2.17 SERVICE ACCESS

A. Doors:

1. Large enough for personnel to access cooling tower internal components.
2. Doors shall be hinged with handles operable from both sides of the door.
3. Door materials shall match casing.
4. Hinges and handles shall be corrosion-resistant or stainless steel.

B. External Ladders with Safety Cages: Aluminum, galvanized steel or stainless-steel fixed ladders, with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.

C. External Platforms with Handrails: Aluminum, galvanized steel or stainless-steel bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.

D. Handrail: Aluminum, galvanized steel or stainless steel complete with kneerail and toeboard, around external platforms and top of cooling tower. Comply with 29 CFR 1910.23.

E. Hardware: Galvanized steel when connecting galvanized-steel components and stainless steel when connecting other materials.

2.18 CAPACITIES AND CHARACTERISTICS

A. Number of Cells: As directed.

B. Air-Inlet Arrangement: One side.

C. Maximum Drift Loss: 0.001 percent of design water flow.

D. Heat Exchanger:

1. Fluid Type: Water.
2. Design Fluid Flow per Cell: As directed, gpm (L/s).
3. Minimum Fluid Flow per Cell: As directed, gpm (L/s).
4. Fluid Pressure Drop: As directed, psig (kPa).
5. Fluid Pressure Rating: As directed, psig (kPa).
6. Entering-Fluid Temperature: As directed, deg F (deg C).
7. Leaving-Fluid Temperature: As directed, deg F (deg C).
8. Entering-Air Wet-Bulb Temperature: As directed, deg F (deg C).
9. Air Flow per Cell: As directed, cfm (L/s).

E. Economizer Mode Performance:

1. Fluid Flow per Cell: As directed, gpm (L/s).
2. Entering-Fluid Temperature: As directed, deg F (deg C).
3. Leaving-Fluid Temperature: As directed, deg F (deg C).
4. Entering-Air, Wet-Bulb Temperature: As directed, deg F (deg C).

F. Fan Drive Assembly:

1. Type: Belt.
2. Fan Motor:

    a. Type: Single speed, two speed, single winding, two-speed, two winding or variable speed, as directed.
    b. Motor Size per Cell: As directed, hp.
    c. Full-Load Ampacity: As directed, A.
    d. Minimum Circuit Ampacity: As directed, A.
    e. Maximum Overcurrent Protection Device: As directed, A.
    f. Electrical Characteristics: 208, 240 or 480 V ac, 3 phase, 60 Hz, as directed.

G. Pump and Motor:

1. Water Flow per Cell: As directed, gpm (L/s).
2. Motor Size per Cell: As directed, hp.
3. Full-Load Ampacity: As directed, A.
4. Minimum Circuit Ampacity: As directed, A.
5. Maximum Overcurrent Protection Device: As directed, A.

6. Electrical Characteristics: 120, 208, 240, 277 or 480 V ac, single or 3 phase, 60 Hz.

H. Sound Pressure Level: dBA (As directed) in feet (m) when measured according to CTI ATC 128.

I. Collection Basin Heater:

1. Basin Water Temperature: 40 deg F (5 deg C).
2. Outdoor Ambient Temperature: 0 deg F (minus 18 deg C) or Minus 20 deg F (Minus 29 deg C).
3. Capacity per Cell: As directed, kW.
4. Full-Load Ampacity: As directed, A.
5. Minimum Circuit Ampacity: As directed, A.
6. Maximum Overcurrent Protection Device: As directed, A.
7. Electrical Characteristics: 208, 240 or 480 V ac, 3 phase, 60 Hz, as directed.

2.19 SOURCE QUALITY CONTROL

A. Performance Test: Factory test and certify cooling tower performance according to CTI STD 201RS.

B. Seismic Performance Testing: Shake table tested by an independent or a factory-certified laboratory to certify performance complies with seismic requirements indicated.

C. Factory Functional Tests:

1. Test collection and distribution basins after assembly and prove free of leaks.
2. Test factory-installed electric/electronic water-level controls for proper operation.
3. Test factory-installed electric basin heaters for proper operation.
4. Test factory-installed fan and drive assemblies for proper operation.
5. Test factory-installed control package for proper operation.
6. Test access doors to ensure smooth operation and proper fit.

D. Heat-Exchanger Factory Pressure and Leak Tests:

1. Pneumatically test heat-exchanger assembly while submerged under water and prove to be free of leaks.
2. Test pressure equal to 1.5 times rated pressured, but not less than, as directed, psig (kPa).
3. Submit report documenting test and results.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Examine cooling towers before installation. Reject cooling towers that are damaged.

B. Install cooling towers on support structure.

C. Equipment Mounting:

1. Install cooling towers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." Or Section 033053 "Miscellaneous Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

D. Install anchor bolts to elevations required for proper attachment to supported equipment.

E. Maintain manufacturer's recommended clearances for service and maintenance.

F. Maintain clearances required by governing code.

3.2 DUCT CONNECTIONS

A. Duct installation requirements are specified in other Sections. Drawings indicate general arrangement of ductwork and accessories.

B. Where installing duct adjacent to cooling towers, allow space for service and maintenance.

C. Install flexible connectors at duct connections to cooling towers.

3.3 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to cooling towers, allow space for service and maintenance.

C. Install flexible pipe connectors at pipe connections of cooling towers mounted on vibration isolators.

D. Connect cooling tower overflows and drains, and piping drains to sanitary sewage system.

E. Makeup-Water Piping:

1. Comply with applicable requirements in Section 221116 "Domestic Water Piping."
2. Connect to makeup-water connections with shutoff valve, plugged tee with pressure gage, flow meter, and drain connection with valve and union.

F. Supply and Return Piping:

1. Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
2. Connect to entering-cooling-tower connections with shutoff valve, strainer, balancing valve, thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve.

3. Connect to leaving-cooling-tower connection with shutoff valve thermometer, plugged tee with full port ball valve for portable field instruments, and drain connection with valve.
4. Make connections to cooling tower with a flange.

G. Basin Heater Hot-Water Piping:

1. Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
2. Connect to supply connections with shutoff valve, strainer, control valve thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve.
3. Connect to return connections with shutoff valve, balancing valve, thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve.
4. Make connections with a flange, union, or mechanical coupling.

H. Basin Heater Steam and Condensate Piping:

1. Comply with applicable requirements in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties."
2. Connect steam supply connection with shutoff valve, strainer, control valve, pressure gage and flow meter.
3. Connect to condensate connection with shutoff valve, strainer, and an appropriate steam trap assembly.
4. Make connections with a flange or union.

I. Basin Sweeper Piping:

1. Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
2. Connect to supply connections with shutoff valve, flow meter, and drain connection with valve.
3. Connect to return connections with shutoff valve, balancing valve, flow meter, and drain connection with valve.
4. Make connections with a flange or union.

3.4 ELECTRICAL POWER CONNECTIONS

A. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

B. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding connections.

C. Install nameplate for each electrical connection indicating electrical equipment designation and circuit number feeding connection. Nameplate shall be laminated phenolic layers of black with engraved white letters at least 1/2 inch (13 mm) high. Locate nameplate where easily visible.

3.5 CONTROLS CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between cooling towers and other equipment to interlock operation as required to achieve a complete and functioning system.

3.6 FIELD TESTING PROVISIONS

A. Include provisions for cooling tower future field performance testing complying with ASME PTC 23 or CTI ATC 105.

B. Include provisions in field piping for future field performance testing complying with ASME PTC 23 or CTI ATC 105.

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. Tests and Inspections: Comply with ASME PTC 23 or CTI ATC 105.

C. Cooling towers will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.8 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform or Perform startup service.

B. Inspect field-assembled components, equipment installation, and piping; controls; and electrical connections for proper assemblies, installations, and connections.

C. Obtain performance data from manufacturer.

1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

    a. Clean entire unit, including basins.
    b. Verify that accessories are properly installed.
    c. Verify clearances for airflow and for cooling tower servicing.
    d. Check for vibration isolation and structural support.
    e. Lubricate bearings.
    f. Verify fan rotation for correct direction and for vibration or binding and correct problems.
    g. Verify pump rotation for correct direction, vibration, cavitation, and flow, and correct problems.
    h. Adjust belts to proper alignment and tension.

i. Operate variable-speed fans through entire operating range and check for harmonic vibration imbalance. Set motor controller to skip speeds resulting in abnormal vibration.
j. Check vibration switch setting. Verify operation.
k. Verify water level in tower basin. Fill to proper startup level. Check makeup-water-level control and valve.
l. Verify operation of basin heater and control.
m. Verify that cooling tower air discharge is not recirculating air into tower or HVAC air intakes. Recommend corrective action.
n. Replace defective and malfunctioning units.

D. Start cooling tower and associated water pumps. Follow manufacturer's written starting procedures.

E. Prepare a written startup report that records the results of tests and inspections.

3.9 ADJUSTING

A. Set and balance water flow to each tower inlet.

B. Adjust water-level control for proper operating level.

C. Adjust basin heater control for proper operating setpoint.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train or train Owner's maintenance personnel to adjust, operate, and maintain cooling towers.

END OF SECTION 236513.16

SECTION 236514.13 – OPEN-CIRCUIT, INDUCED-DRAFT, COUNTERFLOW COOLING TOWERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes factory-assembled, open-circuit, induced-draft, counterflow cooling towers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Manufacturer's drawings of assembled cooling towers, control panels, sections, and elevations.
2. Diagram showing each separate piece requiring field assembly.
3. Shipped sub-assembly dimensions and weights for field assembly.
4. Operating weight and load distribution.
5. Unit vibration isolation and seismic controls.
6. Required clearances for maintenance and operation.
7. Sizes and dimensioned locations of piping and wiring connections.
8. Diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal: For cooling tower support structure indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of support structure.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
3. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and wind restraints and for designing vibration isolation bases.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:

1. Drawings on which items are shown and coordinated with each other, using input from installers of the items involved.
2. Each view to show screened background with the following:

a. Structural grids.
b. Adjacent walls, floors, and roofs.

c. Equipment and products of other trades that are located in vicinity of cooling towers and are part of final installation, such as, controls, power, lighting, fire-suppression systems, and plumbing systems.

B. Seismic Qualification Data: Certificates, for cooling towers, accessories, and components, from manufacturer.

C. Product Certificates: For certification required in "Quality Assurance" Article.

D. Field test reports.

E. Source quality-control reports.

F. Field quality-control reports.

G. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Certified by CTI or An NRTL.

B. CTI Certification: Cooling tower thermal performance according to CTI STD 201RS.

C. FM Global: Approval and listing in the latest edition of FM Global's "Approval Guide."

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of cooling towers that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design cooling tower support structure and seismic restraint and wind restraints, including comprehensive engineering analysis.

B. Structural Performance: Cooling tower and support structure shall withstand the effects of loads and stresses within limits and under conditions indicated according to ASCE/SEI 7, the IBC or governing code, as directed.

C. Seismic Performance: Cooling towers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 - 1.0.
3. Component Amplification Factor: As directed.
4. Component Response Modification Factor: Insert value.

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

F. Operation Following Loss of Normal Power:

1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to backup power system shall automatically return equipment and associated controls to the operating state occurring immediately before loss of normal power without need for manual intervention by an operator when power is restored either through a backup power source, or through normal power if restored before backup power is brought on-line.
2. Include means and methods required to satisfy requirement even if not explicitly indicated.

G. Vibration:

1. Rotating assemblies shall be dynamically balanced to achieve a balance level of "good" while complying with industry-standard requirements for cooling towers.
2. Critical speed shall be at least 115 percent of design speed.

2.3 DESIGN ARRANGEMENT

A. Counterflow design with airflow from all sides and induced-draft, top-mounted axial fan and pressurized pipe distribution.

2.4 CASING AND FRAME

A. Casing Material: FRP with UV inhibitors, HDPE with UV inhibitors, Galvanized steel, ASTM A653/A653M, G210 (Z600) coating, Galvanized steel, ASTM A653/A653M, G235 (Z700) coating or Polymer-coated galvanized steel, as directed.

B. Frame Material: FRP with UV inhibitors, HDPE with UV inhibitors, galvanized steel, ASTM A653/A653M, G210 (Z600) coating, galvanized steel, ASTM A653/A653M, G235 (Z700) coating, polymer-coated galvanized steel or materials to match casing.

C. Hardware: Galvanized or stainless steel.

D. Joints and Seams: Sealed watertight.

E. Welded Connections: Sealed watertight by continuous welds.

2.5 COLLECTION BASIN

A. Field-Constructed Collection Basin: Configure tower without a factory-assembled collection basin for installation and operation with a field-constructed collection basin.

B. Factory-Assembled Collection Basin:

1. Material: FRP with UV inhibitors, HDPE with UV inhibitors, Galvanized steel, ASTM A653/A653M, G210 (Z600) coating, Galvanized steel, ASTM A653/A653M, G235 (Z700) coating, Polymer-coated galvanized steel, Stainless steel, Grade 304, Stainless steel, Grade 316, as directed.
2. Hardware: Galvanized or stainless steel.
3. Joints and Seams: Sealed watertight.
4. Welded Connections: Sealed watertight by continuous welds.
5. Removable stainless-steel strainer with openings smaller than nozzle orifices.
6. Overflow and drain connections.
7. Makeup-water connection.
8. Outlet Connection: Configured to mate to ASME B16.5, Class 150 flange.
9. Removable equalization flume plate between adjacent cells of multiple-cell towers.
10. Equalizer connection for field-installed equalizer piping configured to mate to ASME B16.5, Class 150 flange.

2.6 COLLECTION BASIN MAKEUP-WATER ASSEMBLY

A. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.

B. Electric/Electronic, Collection Basin Water-Level Controller with Makeup-Water Valve:

1. Enclosures: NEMA 250, Type 4 or Type 4X.
2. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to control makeup-water valve, control makeup-water valve and low-level alarm, control makeup-water valve and low- and high-level alarms, control makeup-water valve, low- and high-level alarms, and output for shutoff of pump on low level.
3. Electrode Probes: Stainless steel.
4. Water Stilling Chamber: Corrosion-resistant material, FRP, Galvanized steel, PVC pipe, Stainless steel, Grade 304 or Stainless steel, Grade 316.
5. Makeup-Water Valve:

a. Slow closing with stainless-steel body.
b. Valve actuator controlled and powered through level controller in response to water-level set point.
c. Actuator Enclosure: NEMA 250, Type 4 or Type 4X.
d. Fail Position: Closed, Open or Last.
e. Action: Two position or modulating.

6. Electrical Connection Requirements: 120-V ac, single phase, 60 Hz.

2.7 COLLECTION BASIN HEATER

A. Electric Heater:

1. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
2. Heater Control Panel: Mounted on the side of each cooling tower cell.
3. Enclosure: NEMA 250, Type 3R, Type 4 or Type 4X, Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
4. Control-circuit transformer with primary and secondary side fuses.
5. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
6. Single-point, field-power connection to a fused disconnect switch, nonfused disconnect switch or circuit breaker and heater branch circuiting complying with NFPA 70.
7. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except connections to each electric basin heater shall be liquid tight conduit.

a. Raceway shall be corrosion-resistant stainless steel or PVC coated steel.

2.8 PRESSURIZED DISTRIBUTION NETWORK

A. Main header and lateral branch piping designed for even distribution over fill throughout the entire flow range without the need for balancing valves and for connecting individual, easily removable, non-clogging spray nozzles.

B. Pipe Material: Fiberglass, Schedule 40 PVC or galvanized steel.

C. Spray Nozzle Material: Plastic, polypropylene or PVC.

D. Piping Supports: Corrosion-resistant hangers and supports to resist movement during operation and shipment.

2.9 FILL

A. Materials: PVC, with maximum flame-spread index of 5 - 25 according to ASTM E84.

B. Minimum Thickness: 15 mils (0.4 mm) - 20 mils (0.5 mm), before forming.

C. Fabrication: Fill-type sheets, fabricated, formed, and bonded together after forming into removable assemblies that are factory installed by manufacturer.

D. Fill Material Operating Temperature: Suitable for entering-water temperatures up through 120 deg F (49 deg C).

E. Hardware: Galvanized or stainless steel.

2.10 DRIFT ELIMINATORS

A. Material: FRP, PVC, FRP or PVC; with maximum flame-spread index of 5 - 25 according to ASTM E84.

B. UV Treatment: Inhibitors to protect against damage caused by UV radiation.

C. Configuration: Multipass, designed and tested to reduce water carryover to 0.001 - 0.005 percent of design flow rate indicated.

D. Hardware: Galvanized or stainless steel.

2.11 AIR INLET

A. Air-Intake Louvers:

1. Material: FRP, PVC or Matching casing.
2. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
3. Multiple, easily removable sections arranged to uniformly direct air into cooling tower, to minimize air resistance, to block direct sunlight, and to prevent water from splashing out of tower during all modes of operation including operation with fans off.

B. Removable Air-Intake Screens:

1. Galvanized, Polymer-coated, galvanized or stainless steel wire mesh with openings of size sufficient to not restrict airflow or impact performance.
2. Segmented into manageable individual sections arranged to facilitate independent removal of each section without disturbing adjoining sections.

C. Hardware: Galvanized or stainless steel.

2.12 FAN AND DRIVE ASSEMBLY

A. Axial Fan: Balanced at the factory after assembly.

1. Blade Material: Aluminum, FRP or galvanized steel.
2. Hub Material: Aluminum, FRP or galvanized steel.
3. Blade Pitch: Field adjustable.
4. Fan Shaft: Corrosion resistant or Stainless steel.
5. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus

300 deg F (minus 29 and plus 149 deg C). Bearings designed for an L-10 life of 40,000, 50,000 or 100,000 hours, as directed.

6. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.

B. Belt Drive:

1. Service Factor: 1.5 based on motor nameplate horsepower.
2. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
3. Belt: Multiple V-belt design with a matched set of cogged belts.
4. Belt: One-piece, multi-grooved, solid-back belt.
5. Belt Material: Oil resistant, non-static conducting, and constructed of neoprene polyester cord.
6. Belt-Drive Guard: Comply with OSHA regulations.
7. Two-Motor, Single-Fan Drive:

    a. Two single-speed motors per fan, one sized for full speed and load and the other sized for 67 percent of full-load speed.
    b. Each motor shall have belt drive and be configured for operation when other motor fails.
    c. Controls and wiring same as two-speed, two-winding motor.

C. Direct Drive: Fan hub directly connected, and properly secured, to motor shaft.

D. Gear Drive: Right angle, reduced speed, and designed for cooling tower applications according to CTI STD 111. Motor and gear drive shall be aligned before shipment.

1. Gear Drive and Coupling Service Factor: 2.0 based on motor nameplate horsepower.
2. Housing: Cast iron, with epoxy or polyurethane finish, beveled high-strength steel gears continuously bathed in oil, and with lubrication to other internal parts at all operating speeds.
3. Mounting: Directly mounted to fan hub and connected to motor so motor shaft is in horizontal position.
4. Operation: Able to operate both forward and in reverse. Able to operate throughout entire speed range from design speed indicated down to 10 -20 of design speed.
5. Drive-to-Motor Connection: Close coupled to motor using a flexible coupling.
6. Drive-to-Motor Connection: Connected to motor located outside of cooling tower casing by a full-floating drive shaft.
7. Drive Shaft Material: Corrosion resistant or Stainless steel and fitted with flexible couplings on both ends.
8. Drive Guards: Exposed shaft and couplings shall have guards according to OSHA regulations.
9. Extend oil fill, drain, and vent to outside of cooling tower casing using galvanized-steel or stainless-steel piping. Include oil-level sight glass.

E. Fan Motor:

1. Comply with NEMA MG 1 unless otherwise indicated.
2. Description: NEMA MG 1, Design B as required to comply with capacity and torque characteristics; medium induction motor.

3. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
4. Motor Enclosure: Totally enclosed, totally enclosed air-over (TEAO), Totally enclosed fan-cooled (TEFC) and with epoxy or polyurethane finish, as directed.
5. Rotor: Random-wound, squirrel cage.
6. Energy Efficiency: Comply with ASHRAE/IES 90.1 or NEMA Premium Efficient.
7. Service Factor: 1.15
8. Temperature Rise: Match or One class lower than insulation rating, as directed.
9. Insulation: Class F or Class H as directed.
10. Variable-Speed Motors: Inverter-duty rated per NEMA MG 1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
11. Motor Location: Mounted outside of cooling tower casing and cooling tower discharge airstream.
12. Severe-Duty Rating:

    a. Rotor and stator protected with corrosion-inhibiting epoxy resin.
    b. Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C).
    c. Internal Heater: Automatically energized when motor is de-energized.
    d. Complying with IEEE 841.

13. Motor Base: Adjustable, or other suitable belt-tensioning provisions.
14. Motor Shaft Grounding: Motors shall be controlled through variable-frequency controllers with shaft grounding system to protect motor bearings from induced voltage. Drag on motor shaft due to shaft ground system shall be less than 0.5 percent of motor nameplate horsepower.

F. Hardware: Galvanized or stainless steel.

2.13 AIR DISCHARGE

A. Low-Profile Fan Discharge Stack:

1. Manufacturer's standard low-profile design.
2. Material: Material to match casing, FRP, Galvanized steel, Polymer-coated, galvanized steel or Stainless steel, as directed.
3. Stack Extension: Fabricated to extend above fan deck, as directed.
4. Stack Termination: Wire-mesh, galvanized-steel, polymer-coated, galvanized-steel or stainless-steel screens; segmented into multiple removable pie sections and complying with OSHA regulations.

B. Velocity Recovery Fan Discharge Stack:

1. Design: Tapered and expanded for velocity recovery and improved energy efficiency.
2. Material: FRP or material matching casing.

3. Stack Height: Fabricated to extend above fan deck at least 5 feet (1.5 m) unless otherwise indicated.
4. Service Access: Fabricated of multiple segments to facilitate removal of fan and drive components from overhead.
5. Stack Termination: Wire-mesh, galvanized-steel, polymer-coated, galvanized-steel or stainless-steel screens; segmented into multiple removable pie sections and complying with OSHA regulations.

C. Hardware: Galvanized or stainless steel.

2.14 ELECTRICAL POWER

A. Factory Furnish for Field Installation: A disconnect switch, motor controller or variable-frequency controller for each fan motor, as directed.

B. Factory Install: A disconnect switch, motor controller or variable-frequency controller for each fan motor, as directed.

1. Locate in a convenient and field-accessible location within sight of motor.
2. Installation shall comply with NFPA 70.
3. Wire, Conduit, and Enclosures:

    a. Minimum Conduit Size: 0.75 inch (20 mm).
    b. Materials: Corrosion resistant and constructed of 300L series stainless steel or PVC coated steel.
    c. Motor Termination: Liquidtight conduit, not to exceed 36 inches (900 mm) long.
    d. Supports: Support conduits, boxes, and enclosures using corrosion-resistant fastening hardware constructed of stainless steel.
    e. Wire:

        1) Copper, rated for 600-V, solid wire for size No. 10 AWG and smaller and stranded wire for larger sizes.
        2) Minimum Wire Size: No. 12 AWG.
        3) Each circuit shall have a ground wire.
        4) Install wire in conduit.

    f. Boxes, Condulets, and Enclosures: NEMA 250, Type 3R, Type 4 or Type 4X, as directed.

C. Disconnect Switches:

1. Specification Grade; "Heavy Duty Type"; "quick-make," "quick-break" construction.
2. Three pole, fused or nonfused.
3. 600-V rated.
4. Minimum SCCR: As required by electrical power distribution system, but not less than 42,000 - 65,000 A, as directed.
5. Enclosure: NEMA 250, Type 3R, Type 4, Type 4X or Type 4X stainless steel.
6. Operating handle shall be of box-mounted type that directly drives switch mechanism.

7. Disconnect switch shall use a flange-operated visible blade that is close coupled to a vertical-lift-type handle that achieves a positive visible indication of disconnect with cover open or closed.
8. Disconnect switch shall have a defeatable, front-accessible, mechanical interlock to prevent opening of cover when switch is in "ON" position, and to prevent turning switch "ON" when the door is open.
9. Include a solid neutral as required by authorities having jurisdiction.
10. Disconnect switch shall have a ground lug for ground wire termination.
11. Operating handle shall be lockable in open position.
12. Horsepower rated.
13. Feed through or double lugged.

D. Motor Controllers:

1. NEMA ICS 2, Class A, full-voltage, non-reversing, motor-rated controller.
2. Configured for control of single- or multispeed motors.
3. Enclosure: NEMA 250, Type 3R, Type 4, Type 4X or Type 4X stainless steel, with hinged full-front access door with lock and key.
4. Externally Operated, Door-Interlocked Disconnect: Fused disconnect switch, Nonfused disconnect switch or Circuit breaker with lockable handle.
5. SCCR: As required by electrical power distribution system, but not less than 42,000 - 65,000A, as directed.
6. Hand-Off-Auto Switch: Mounted on face of enclosure.
7. Push-to-Test Run Status Pilot Lights: NEMA ICS 2, heavy-duty type.
8. Control Relays: Time-delay relays.
9. Phase-Failure, Phase-Reversal, Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hardwired connection.
10. Elapsed-Time Meters: Numerical readout in hours on face of enclosure.
11. Number-of-Starts Counter: Numerical readout on face of enclosure.

E. Variable-Frequency Controllers:

1. Description: NEMA ICS 2; arranged to achieve motor variable speed by adjusting output voltage and frequency.
2. Enclosure: Unit mounted, NEMA 250, Type 3R, Type 4, Type 4X, or Type 4X stainless steel, with hinged full-front access door with lock and key.
3. Externally Operated, Door-Interlocked Disconnect: Fused disconnect switch, Nonfused disconnect switch or Circuit breaker with lockable handle.
4. Minimum SCCR: As required by electrical power distribution system, but not less than 42,000 - 65,000 A, as directed.
5. Technology: Pulse-width-modulated (PWM) output with insulated gate bipolar transistors (IGBT); suitable for variable torque loads.
6. Controller shall consist of a rectifier converter section, a digital/analog driver regulator section, and an inverter output section.
7. Output Rating: Three phase; with voltage proportional to frequency throughout voltage range.
8. Output signal shall be programmed to not cause mechanical vibration issues with fan drive assembly.
9. Operating Requirements:

    a. Input AC Voltage Tolerance: 10 percent.

b. Input frequency tolerance of 60 Hz, plus or minus 2 Hz.
c. Capable of driving full motor load, without derating.
d. Minimum Efficiency: 96 percent at 60 Hz, full load.
e. Minimum Displacement Primary-Side Power Factor: 95 percent.
f. Overload Capability: 1.05 times the full-load current for 7 seconds.
g. Starting Torque: As required by fan and motor drive assembly.
h. Speed Regulation: 1 percent.
i. Speed Range: 10:1 speed range.
j. To avoid equipment resonant vibrations, include critical speed lockout circuitry to allow bands of operating frequency at which controller shall not operate continuously.
k. Capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.

10. Controller Adjustability Capabilities: Minimum and maximum output frequency, acceleration and deceleration, and current limit.
11. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions shall not result in component failure or the need for replacement:

    a. Overtemperature.
    b. Short circuit at controller output.
    c. Ground fault at controller output. Variable-frequency controller shall be able to start a grounded motor.
    d. Open circuit at controller output.
    e. Input undervoltage.
    f. Input overvoltage.
    g. Loss of input phase.
    h. Reverse phase.
    i. AC line switching transients.
    j. Instantaneous overload, line to line or line to ground.
    k. Sustained overload exceeding 100 percent of controller rated current.
    l. Starting a rotating motor.

12. Motor Protection: Controller shall protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.
13. Automatic Reset and Restart:

    a. Capable of multiple restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction.
    b. Capable of automatic restart on phase-loss and overvoltage and undervoltage trips.

14. Visual Indication: On face of controller; indicating the following conditions:

    a. Power on.
    b. Run.
    c. Overcurrent and overvoltage.
    d. Motor speed (percent).
    e. Various faults with alarm status.
    f. Input kilovolt amperes.
    g. Power factor.
    h. Input kilowatts and kilowatt-hours.

i. Three-phase input and output voltage.
j. Three-phase input and output current.
k. Output frequency.
l. Elapsed operating time (hours).
m. Diagnostic and service parameters.

15. Operator Interface: Start-stop and auto-manual selector with manual-speed-control potentiometer.
16. Control Signal Interface: A minimum of two analog inputs (0 to 10 V or 0/4 to 20 mA) and four programmable digital inputs.

2.15 CONTROLS

A. Vibration Switch: For each fan drive.

1. Enclosure: NEMA 250, Type 4 or Type 4X, as directed.
2. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
3. Switch shall have manual-reset button hardwired connection to fan motor electrical circuit.
4. Switch shall have field connection to a control system hardwired connection to fan motor electrical circuit.
5. Switch shall, on sensing excessive vibration, signal an alarm for connection to control system and shut down the fan.

B. Vibration Transmitter with Switch: For each fan drive.

1. Enclosure: NEMA 250, Type 4X.
2. Display: Local display of measured value, power, and alarm.
3. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point.

    a. Cooling tower manufacturer shall select range that is suitable for cooling tower and recommend switch set point for proper operation and protection.

4. Transmitter: Continuous vibration level indication through a 4- to 20-mA signal for connection to control system.
5. Switch:

    a. Relay and switch with manual-reset button for field connection to control system and hardwired connection to fan motor electrical circuit.
    b. Switch shall, on sensing excessive vibration, signal an alarm to control system and shut down the fan.

6. Mounting: Locate out of cooling tower discharge airstream and mount in a location that is accessible and where display is easily viewable.
7. Field Electrical Connection Requirements: 120 V, single phase, 60 Hz.

C. Gear-Drive, Oil-Level Switch: Low-oil-level warning switch for connection to control system.

1. Switch shall, on reaching a low-oil-level set point recommended by cooling tower manufacturer, signal an alarm through control system.

2.16 HOISTING ASSEMBLY

A. Hoisting assembly consisting of pedestal base, davit arm, and winch to accommodate lowering and raising cooling tower components from their installed location to the base of cooling tower supports.

1. Cooling tower components serviceable by hoisting assembly shall include, but not be limited to, fan stack, fan, fan drive, and fan motor.
2. Hoisting assembly shall be designed to accommodate heaviest single component plus a safety factor of 1.5.
3. Construct cooling tower structural supports and reinforcing to accommodate lifting heaviest load with safety factor.

B. Pedestal Base:

1. Equip each cooling tower cell with a pedestal base to accommodate an easily removable davit arm and winch assembly.
2. Position pedestal base at a location on cooling tower for hoisting assembly coverage to fan, fan motor, and fan drive assembly.
3. Pedestal base design shall be open-socket, or comparable, design that is configured to accept and secure an inserted portable davit arm.
4. Fit each pedestal base with an easily removable cap or plug designed to seal the open top of the base when the davit arm is not installed.
5. Fasten pedestal base to cooling tower using threaded hardware.
6. Construct pedestal base of hot-dip galvanized steel or 300L series stainless steel.

C. Davit Arm:

1. Each cooling tower cell shall have a davit arm.
2. Davit arm shall be an adjustable telescoping design with angular adjustment to accommodate varying lifting conditions required by the application.
3. Davit arm assembly shall be portable and capable of being relocated to any cooling tower cell pedestal base.
4. Construct davit arm of hot-dip galvanized steel or 300L series stainless steel.

D. Winch:

1. Each davit arm shall have an electric or a hand operated winch.

    a. Electric winch shall include a power cord and plug for connection to a field-installed, weatherproof, 20-A receptacle with 120-V, single-phase, 60-Hz field power supply.
    b. Hand-operated winch with gear mechanism to limit force on handle to not more than 80 lb (36 kg) when lifting the heaviest component.

2. Coat winch body and exposed components with corrosion-resistant finish that is rated for outdoor duty in a highly corrosive environment and exposed to direct sunlight.

3. Winch cable shall be stainless steel and terminated with a stainless-steel hook and quick disconnecting mechanism. Cable length shall be at least 1.5 times actual length required for application.

E. Hardware: 304 or 316 series stainless steel.

F. Nameplate:

1. Stamped or engraved aluminum or stainless-steel nameplate with rated load capacity on each davit arm and pedestal.
2. Letter size legible from a distance 60 inches (1500 mm) and not less than1/2 inch (13 mm).
3. Fasten nameplate at multiple points with stainless-steel rivets or screws.

2.17 CAPACITIES AND CHARACTERISTICS

A. Number of Cells: As directed.

B. Air-Inlet Arrangement: All sides.

C. Maximum Drift Loss: 0.005 percent of design water flow.

D. Waterside:

1. Design Water Flow per Cell: As directed, gpm (L/s).
2. Minimum Water Flow per Cell: As directed, gpm (L/s).
3. Water Pressure Drop: As directed, (kPa).
4. Entering-Water Temperature: As directed, deg F (deg C).
5. Leaving-Water Temperature: As directed, deg F (deg C).

E. Airside:

1. Entering-Air Wet-Bulb Temperature: As directed, deg F (deg C).
2. Altitude: As directed.
3. Airflow per Cell: As directed, cfm (L/s).

F. Economizer-Mode Performance:

1. Water Flow per Cell: As directed, gpm (L/s).
2. Entering-Water Temperature: As directed, deg F (deg C).
3. Leaving-Water Temperature: As directed, deg F (deg C).
4. Entering-Air Wet-Bulb Temperature: As directed, deg F (deg C).

G. Fan Drive Assembly:

1. Type: Belt, direct or gear.
2. Fan Motor:

a. Type: Single speed, two speed, single winding, Two speed, two winding or Variable speed.
b. Motor Size per Cell: As directed, hp.

c. Full-Load Ampacity: As directed, A.
d. Minimum Circuit Ampacity: As directed.
e. Maximum Overcurrent Protection Device: As directed.
f. Electrical Characteristics: 208, 240 or 480 V ac, 3 phase, 60 Hz.

H. Sound Pressure Level: dBA, distance in feet (m), when measured according to CTI ATC 128, as directed.

I. Collection Basin Heater:

1. Basin Water Temperature: 40 deg F (5 deg C).
2. Outdoor Ambient Temperature: 0 deg F (Minus 18 deg C) or Minus 20 deg F (Minus 29 deg C).
3. Capacity per Cell: As directed.
4. Full-Load Ampacity: As directed.
5. Minimum Circuit Ampacity: As directed.
6. Maximum Overcurrent Protection Device: As directed.
7. Electrical Characteristics: 208, 240 or 480 V ac, 3 phase, 60 Hz, as directed.
8. Capacity per Cell: As directed, MBtu/h (kW).
9. Coil Fluid Type: Water.
10. Entering-Fluid Temperature: As directed, deg F (deg C).
11. Leaving-Fluid Temperature: As directed, deg F (deg C).
12. Fluid Flow Rate: As directed, gpm (L/s).
13. Fluid Pressure Drop: As directed, psig (kPa).
14. Capacity per Cell: As directed, MBtu/h (kW).
15. Steam Flow: As directed, lb/h (L/s).
16. Steam Pressure: As directed, psig (kPa).

2.18 SOURCE QUALITY CONTROL

A. Performance Test: Factory test and certify cooling tower performance according to CTI STD 201RS, "Standard for the Certification of Water-Cooling Tower Thermal Performance."

B. Seismic Performance Testing: Shake table tested by an independent or a factory-certified laboratory to certify performance complies with seismic requirements indicated.

C. Factory Functional Tests:

1. Test collection and distribution basins after assembly, and prove free of leaks.
2. Test factory-installed electric/electronic water-level controls for proper operation.
3. Test factory-installed electric basin heaters for proper operation.
4. Test factory-installed fan and drive assemblies for proper operation.
5. Test factory-installed control package for proper operation.
6. Test access doors to ensure smooth operation and proper fit.
7. Allow Owner access to place where cooling towers are being tested. Notify Owner in writing at least 30 days in advance of testing.
8. Submit report documenting tests performed and results within one week of test date.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Examine cooling towers before installation. Reject cooling towers that are damaged.

B. Install cooling towers on support structure.

C. Equipment Mounting:

1. Install cooling towers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." Or Section 033053 "Miscellaneous Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

D. Install anchor bolts to elevations required for proper attachment to supported equipment.

E. Maintain manufacturer's recommended clearances for service and maintenance.

F. Maintain clearances required by governing code.

3.2 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to cooling towers, allow space for service and maintenance.

C. Install flexible pipe connectors at pipe connections of cooling towers mounted on vibration isolators.

D. Install drain piping with valve at cooling tower drain connections and at low points in piping.

E. Connect cooling tower overflows and drains, and piping drains, to sanitary sewage system.

F. Makeup-Water Piping:

1. Comply with applicable requirements in Section 221116 "Domestic Water Piping."
2. Connect to makeup-water connections with shutoff valve, plugged tee with pressure gage, flow meter, and drain connection with valve and union.

G. Supply and Return Piping:

1. Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."

2. Connect to entering cooling tower connections with shutoff valve, strainer, balancing valve, thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve.
3. Connect to leaving cooling tower connection with shutoff valve thermometer, plugged tee with full port ball valve for portable field instruments, and drain connection with valve.
4. Make connections to cooling tower with a flange.

H. Equalizer Piping:

1. Piping requirements to match supply and return piping.
2. Connect an equalizer pipe, full size of cooling tower connection, between tower cells.
3. Connect to cooling tower with shutoff valve and drain connection with valve.
4. Make connections to cooling tower with a flange.

I. Basin Heater Hot-Water Piping:

1. Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
2. Connect to supply connections with shutoff valve, strainer, control valve thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve.
3. Connect to return connections with shutoff valve, balancing valve, thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve.
4. Make connections with a flange, union, or mechanical coupling.

J. Basin Heater Steam and Condensate Piping:

1. Comply with applicable requirements in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties."
2. Connect steam supply connection with shutoff valve, strainer, control valve, pressure gage, and flow meter.
3. Connect to condensate connection with shutoff valve, strainer, and an appropriate steam trap assembly.
4. Make connections with a flange or union.

3.3 ELECTRICAL POWER CONNECTIONS

A. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems" for grounding connections.

C. Install nameplate for each electrical connection indicating electrical equipment designation and circuit number feeding connection. Nameplate shall be laminated phenolic layers of black with engraved white letters at least 1/2 inch (13 mm) high. Locate nameplate where easily visible.

3.4 CONTROLS CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between cooling towers and other equipment to interlock operation as required to achieve a complete and functioning system.

3.5 FIELD TESTING PROVISIONS

A. Include provisions for cooling tower future field-performance testing complying with ASME PTC 23 or CTI ATC 105.

B. Include provisions in field piping for future field-performance testing complying with ASME PTC 23 or CTI ATC 105.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Tests and Inspections: Comply with ASME PTC 23 or CTI ATC 105.

E. Cooling towers will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform or Perform startup service.

B. Inspect field-assembled components, equipment installation, and piping; controls; and electrical connections for proper assemblies, installations, and connections.

C. Obtain performance data from manufacturer.

1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

    a. Clean entire unit including basins.
    b. Verify that accessories are properly installed.
    c. Verify clearances for airflow and for cooling tower servicing.
    d. Check for vibration isolation and structural support.
    e. Lubricate bearings.
    f. Verify fan rotation for correct direction and for vibration or binding and correct problems.
    g. Adjust belts to proper alignment and tension.
    h. Verify proper oil level in gear-drive housing. Fill with oil to proper level.
    i. Operate variable-speed fans through entire operating range and check for harmonic vibration imbalance. Set motor controller to skip speeds resulting in abnormal vibration.

j. Check vibration switch setting. Verify operation.
k. Verify water level in tower basin. Fill to proper startup level. Check makeup-water-level control and valve.
l. Verify operation of basin heater and control.
m. Verify that cooling tower air discharge is not recirculating air into tower or HVAC air intakes. Recommend corrective action.
n. Replace defective and malfunctioning units.

D. Start cooling tower and associated water pumps. Follow manufacturer's written starting procedures.

E. Prepare a written startup report that records the results of tests and inspections.

3.8 ADJUSTING

A. Set and balance water flow to each tower inlet.

B. Adjust water-level control for proper operating level.

C. Adjust basin heater control for proper operating set point.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train or train Owner's maintenance personnel to adjust, operate, and maintain cooling towers.

END OF SECTION 236514.13

SECTION 236514.14 – OPEN-CIRCUIT, INDUCED-DRAFT, CROSSFLOW COOLING TOWERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes factory-assembled, open-circuit, induced-draft, crossflow cooling towers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Manufacturer's drawings of assembled cooling towers, control panels, sections, and elevations.
2. Diagram showing each separate piece requiring field assembly.
3. Shipped sub-assembly dimensions and weights for field assembly.
4. Operating weight and load distribution.
5. Unit vibration isolation and seismic controls.
6. Required clearances for maintenance and operation.
7. Sizes and dimensioned locations of piping and wiring connections.
8. Diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal: For cooling tower support structure indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of support structure.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
3. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and wind restraints and for designing vibration isolation bases.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:

1. Drawings on which items are shown and coordinated with each other, using input from installers of the items involved.
2. Each view to show screened background with the following:

a. Structural grids.
b. Adjacent walls, floors, and roofs.

c. Equipment and products of other trades that are located in vicinity of cooling towers and are part of final installation, such as, controls, power, lighting, fire-suppression systems, and plumbing systems.

B. Seismic Qualification Data: Certificates, for cooling towers, accessories, and components, from manufacturer.

C. Product Certificates: For certification required in "Quality Assurance" Article.

D. Field test reports.

E. Source quality-control reports.

F. Field quality-control reports.

G. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Certified by CTI or an NRTL.

B. CTI Certification: Cooling tower thermal performance according to CTI STD 201RS.

C. FM Global: Approval and listing in the latest edition of FM Global's "Approval Guide."

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of cooling towers that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design cooling tower support structure and seismic restraints and wind restraints, including comprehensive engineering analysis.

B. Structural Performance: Cooling tower and support structure shall withstand the effects of loads and stresses within limits and under conditions indicated according to ASCE/SEI 7, the IBC or governing codes.

C. Seismic Performance: Cooling towers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 - 1.0.
3. Component Amplification Factor: As directed.
4. Component Response Modification Factor: As directed.

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

F. Operation Following Loss of Normal Power:

1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to backup power system shall automatically return equipment and associated controls to the operating state occurring immediately before loss of normal power without need for manual intervention by an operator when power is restored either through a backup power source, or through normal power if restored before backup power is brought on-line.
2. Include means and methods required to satisfy requirement even if not explicitly indicated.

G. Vibration:

1. Rotating assemblies shall be dynamically balanced to achieve a balance level of "good" while complying with industry-standard requirements for cooling towers.
2. Critical speed shall be at least 115 percent of design speed.

2.3 DESIGN ARRANGEMENT

A. Crossflow design with airflow from two sides and induced-draft, top-mounted axial fan and gravity distribution basin.

B. Crossflow design with airflow from one side and induced-draft, top-mounted axial fan and gravity distribution basin.

C. Crossflow design with airflow from one side and induced-draft, side-mounted axial fan and gravity distribution basin.

2.4 CASING AND FRAME

A. Casing Material: FRP with UV inhibitors, Galvanized steel, ASTM A653/A653M, G235 (Z700) coating or Polymer-coated galvanized steel.

B. Frame Material: FRP with UV inhibitors, galvanized steel, ASTM A653/A653M, G235 (Z700) coating, polymer-coated galvanized steel or materials to match casing.

C. Hardware: Galvanized or stainless steel.

D. Joints and Seams: Sealed watertight.

E. Welded Connections: Sealed watertight by continuous welds.

2.5 COLLECTION BASIN

A. Factory-Assembled Collection Basin:

1. Material: FRP with UV inhibitors or Galvanized steel, ASTM A653/A653M, G235 (Z700) coating, Polymer-coated galvanized steel, Stainless steel, Grade 304 or Stainless steel, Grade 316.
2. Hardware: Galvanized or stainless steel.
3. Joints and Seams: Sealed watertight.
4. Welded Connections: Sealed watertight by continuous welds.
5. Removable stainless-steel strainer with openings smaller than nozzle orifices.
6. Overflow and drain connections.
7. Makeup-water connection.
8. Outlet Connection: Configured to mate to ASME B16.5, Class 150 flange.
9. Removable equalization flume plate between adjacent cells of multiple-cell towers.
10. Equalizer connection for field-installed equalizer piping configured to mate to ASME B16.5, Class 150 flange.

2.6 COLLECTION BASIN MAKEUP-WATER ASSEMBLY

A. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.

B. Electric/Electronic, Collection Basin Water-Level Controller with Makeup-Water Valve:

1. Enclosures: NEMA 250, Type 4 or Type 4X, as directed.
2. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to control makeup-water valve, control makeup-water valve and low-level alarm, control makeup-water valve and low- and high-level alarms, control makeup-water valve, low- and high-level alarms, and output for shutoff of pump on low level.
3. Electrode Probes: Stainless steel.
4. Water Stilling Chamber: Corrosion-resistant material, FRP, Galvanized steel, PVC pipe, Stainless steel, Grade 304 or Stainless steel, Grade 316.
5. Makeup-Water Valve:

a. Slow closing with stainless-steel body.
b. Actuator controlled and powered through level controller in response to water-level set point.
c. Actuator Enclosure: NEMA 250, Type 4 or Type 4X.
d. Fail Position: Closed, Open or Last, as directed.
e. Action: Two position or modulating.

6. Electrical Connection Requirements: 120-V ac, single phase, 60 Hz.

2.7 COLLECTION BASIN HEATER

A. Electric Heater:

1. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
2. Heater Control Panel: Mounted on the side of each cooling tower cell.
3. Enclosure: NEMA 250, Type 3R, Type 4 or Type 4X, as directed.
4. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
5. Control-circuit transformer with primary and secondary side fuses.
6. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
7. Single-point, field-power connection to a fused disconnect switch, nonfused disconnect switch or circuit breaker and heater branch circuiting complying with NFPA 70.
8. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except connections to each electric basin heater shall be liquidtight conduit.

a. Raceway shall be corrosion-resistant stainless steel or PVC coated steel.

2.8 GRAVITY WATER DISTRIBUTION BASIN

A. Design: Non-pressurized design with head of water level in basin adequate to overcome spray nozzle losses and designed to evenly distribute water over fill throughout the flow range indicated.

1. Material: FRP with UV inhibitors, galvanized steel, ASTM A653/A653M, G235 (Z700) coating, polymer-coated galvanized steel or stainless steel.
2. Location: Over each bank of fill with easily replaceable plastic spray nozzles mounted in bottom of basin.
3. Inlet Connection: Configured to mate to ASME B16.5, Class 150 flange.
4. Fasteners: Galvanized or stainless steel.
5. Joints and Seams: Sealed watertight.
6. Welded Connections: Sealed watertight by continuous welds.
7. Partitioning Dams: Same material as basin to distribute water over the fill to minimize icing and achieve proper operation while operating throughout the flow range indicated.

a. Manufacturer has option to use individual nozzle cups in lieu of partitioning dams to achieve operation within flow range (design to minimum) indicated.

8. Removable Panels: Same material as basin to completely cover top of basin. Secure panels to basin with removable corrosion-resistant or stainless-steel hardware. Panels reinforced to accommodate service personnel walking on the panels without resulting in permanent deflection and damage.
9. Valves: Manufacturer's standard valve installed at each inlet connection and arranged to balance or shut off flow to each gravity distribution basin.
10. Single-Inlet, Field Pipe Connection: Galvanized-steel or PVC pipe arranged to achieve balancing of flow within cooling tower cell without the need for additional balancing valves. Pipe each cooling tower cell internally to a single, field connection suitable for mating to ASME B16.5, Class 150 flange and located on the bottom or side unless otherwise indicated.

2.9 FILL

A. Materials: PVC, with maximum flame-spread index of 5 - 25 according to ASTM E84.

B. Minimum Thickness: 15 mils (0.4 mm) - 20 mils (0.5 mm), before forming.

C. Fabrication: Fill-type sheets, fabricated, formed, and bonded together after forming into removable assemblies that are factory installed by manufacturer.

D. Fill Material Operating Temperature: Suitable for entering-water temperatures up through 120 deg F (49 deg C).

E. Hardware: Galvanized or stainless steel.

2.10 DRIFT ELIMINATORS

A. Material: FRP, PVC, FRP or PVC with maximum flame-spread index of 5 – 25 according to ASTM E84.

B. UV Treatment: Inhibitors to protect against damage caused by UV radiation.

C. Configuration: Multipass, designed and tested to reduce water carryover to 0.005 percent of design flow rate indicated.

D. Location: Integral to Separate and removable from fill.

E. Hardware: Galvanized or stainless steel.

2.11 AIR INLET

A. Air-Intake Louvers:

1. Material: FRP, PVC or Matching casing, as directed.
2. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
3. Louver Blades: Arranged to uniformly direct air into cooling tower, to minimize air resistance, and to prevent water from splashing out of tower during all modes of operation including operation with fans off.

4. Location: Integral to Separate from fill.

B. Removable Air-Intake Screens:

1. Galvanized, Polymer-coated, galvanized or stainless steel wire mesh with openings of size sufficient to not restrict airflow or impact performance.
2. Segmented into manageable individual sections arranged to facilitate independent removal of each section without disturbing adjoining sections.

C. Hardware: Galvanized or stainless steel.

2.12 FAN AND DRIVE ASSEMBLY

A. Axial Fan: Balanced at the factory after assembly.

1. Blade Material: Aluminum, FRP or galvanized steel, as directed.
2. Hub Material: Aluminum, FRP or galvanized steel, as directed.
3. Blade Pitch: Field adjustable.
4. Fan Shaft: Corrosion resistant or Stainless steel.
5. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C). Bearings designed for an L-10 life of 40,000, 50,000 or 100,000 hours, as directed.
6. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.

B. Belt Drive:

1. Service Factor: 1.5 based on motor nameplate horsepower.
2. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
3. Belt: Multiple V-belt design with a matched set of cogged belts.
4. Belt: One-piece, multi-grooved, solid-back belt.
5. Belt Material: Oil resistant, non-static conducting, and constructed of neoprene polyester cord.
6. Belt-Drive Guard: Comply with OSHA regulations.
7. Two-Motor, Single-Fan Drive:

a. Two single-speed motors per fan, one sized for full speed and load and the other sized for 67 percent of full-load speed.
b. Each motor shall have belt drive and be configured for operation when other motor fails.
c. Controls and wiring same as two-speed, two-winding motor.

C. Direct Drive: Fan hub directly connected, and properly secured, to motor shaft.

D. Gear Drive: Right angle, reduced speed, and designed for cooling tower applications according to CTI STD 111. Motor and gear drive shall be aligned before shipment.

1. Gear Drive and Coupling Service Factor: 2.0 based on motor nameplate horsepower.

2. Housing: Cast iron, with epoxy or polyurethane finish, beveled high-strength steel gears continuously bathed in oil, and with lubrication to other internal parts at all operating speeds.
3. Mounting: Directly mounted to fan hub and connected to motor so motor shaft is in horizontal position.
4. Operation: Able to operate both forward and in reverse. Able to operate throughout entire speed range from design speed indicated down to 10 - 20 of design speed.
5. Drive-to-Motor Connection: Close coupled to motor using a flexible coupling.
6. Drive-to-Motor Connection: Connected to motor located outside of cooling tower casing by a full-floating drive shaft.
7. Drive Shaft Material: Corrosion resistant or Stainless steel, and fitted with flexible couplings on both ends.
8. Drive Guards: Exposed shaft and couplings shall have guards according to OSHA regulations.
9. Extend oil fill, drain, and vent to outside of cooling tower casing using galvanized-steel or stainless-steel piping. Include oil-level sight glass.

E. Fan Motor:

1. Comply with NEMA MG 1 unless otherwise indicated.
2. Description: NEMA MG 1, Design B as required to comply with capacity and torque characteristics; medium induction motor.
3. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
4. Motor Enclosure: Totally enclosed, totally enclosed air-over (TEAO), Totally enclosed fan-cooled (TEFC) and with epoxy or polyurethane finish, as directed.
5. Rotor: Random-wound, squirrel cage.
6. Energy Efficiency: Comply with ASHRAE/IES 90.1 or NEMA Premium Efficient.
7. Service Factor: 1.15.
8. Temperature Rise: Match or One class lower than insulation rating, as directed.
9. Insulation: Class F or Class H,
10. Variable-Speed Motors: Inverter-duty rated per NEMA MG 1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
11. Motor Location: Mounted outside of cooling tower casing and cooling tower discharge airstream.
12. Severe-Duty Rating:

    a. Rotor and stator protected with corrosion-inhibiting epoxy resin.
    b. Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C.).
    c. Internal Heater: Automatically energized when motor is de-energized.
    d. Complying with IEEE 841.

13. Motor Base: Adjustable, or other suitable provision for adjusting belt tension.
14. Motor Shaft Grounding: Motors shall be controlled through variable-frequency controllers with shaft grounding system to protect motor bearings from induced voltage. Drag on motor shaft due to shaft ground system shall be less than 0.5 percent of motor nameplate horsepower.

F. Hardware: Galvanized or stainless steel.

2.13 AIR DISCHARGE

A. Low-Profile Fan Discharge Stack:

1. Manufacturer's standard low-profile design.
2. Material: Material to match casing, FRP, Galvanized steel, Polymer-coated, galvanized steel or Stainless steel.
3. Stack Extension: Fabricated to extend above fan deck, as directed.
4. Stack Termination: Wire-mesh, galvanized-steel, polymer-coated, galvanized-steel or stainless-steel screens; segmented into multiple removable pie sections and complying with OSHA regulations.

B. Velocity Recovery Fan Discharge Stack:

1. Design: Tapered and expanded for velocity recovery and improved energy efficiency.
2. Material: FRP or material matching casing.
3. Stack Height: Fabricated to extend above fan deck at least 5 feet (1.5 m) unless otherwise indicated.
4. Service Access: Fabricated of multiple segments to facilitate removal of fan and drive components from overhead.
5. Stack Termination: Wire-mesh, galvanized-steel, polymer-coated, galvanized-steel or stainless-steel screens; segmented into multiple removable pie sections and complying with OSHA regulations.

C. Hardware: Galvanized or stainless steel.

2.14 ELECTRICAL POWER

A. Factory Furnish for Field Installation: A disconnect switch, motor controller or variable-frequency controller for each fan motor, as directed.

B. Factory Install: A disconnect switch, motor controller or variable-frequency controller for each fan motor, as directed.

1. Locate in a convenient and field-accessible location within sight of motor.
2. Installation shall comply with NFPA 70.
3. Wire, Conduit, and Enclosures:

    a. Minimum Conduit Size: 0.75 inch (20 mm).
    b. Materials: Corrosion resistant and constructed of stainless steel or PVC coated steel.
    c. Motor Termination: Liquidtight conduit, not to exceed 36 inches (900 mm) long.
    d. Supports: Support conduits, boxes, and enclosures using corrosion-resistant fastening hardware constructed of stainless steel.
    e. Wire:

1) Copper, rated for 600-V, solid wire for size No. 10 AWG and smaller and stranded wire for larger sizes.
2) Minimum Wire Size: No. 12 AWG.
3) Each circuit shall have a ground wire.
4) Install wire in conduit.

f. Boxes, Condulets, and Enclosures: NEMA 250, Type 3R, Type 4 or Type 4X.

C. Disconnect Switches:

1. Specification Grade; "Heavy Duty Type"; "quick-make," "quick-break" construction.
2. Three pole, fused or nonfused.
3. 600 V rated.
4. Minimum SCCR: As required by electrical power distribution system, but not less than 42,000 - 65,000 A, as directed.
5. Enclosure: NEMA 250, Type 3R, Type 4 or Type 4X or Type 4X stainless steel, as directed.
6. Operating handle shall be of box-mounted type that directly drives switch mechanism.
7. Disconnect switch shall use a flange-operated visible blade that is close coupled to a vertical-lift-type handle that achieves a positive visible indication of disconnect with cover open or closed.
8. Disconnect switch shall have a defeatable, front-accessible, mechanical interlock to prevent opening of cover when switch is in "ON" position, and to prevent turning switch "ON" when the door is open.
9. Include a solid neutral as required by authorities having jurisdiction.
10. Disconnect switch shall have a ground lug for ground wire termination.
11. Operating handle shall be lockable in open position.
12. Horsepower rated.
13. Feed through or double lugged.

D. Motor Controllers:

1. NEMA ICS 2, Class A, full-voltage, non-reversing, motor-rated controller.
2. Configured for control of single- or multispeed motors as indicated.
3. Enclosure: NEMA 250, Type 3R, Type 4or Type 4X or Type 4X stainless steel, as directed, with hinged full-front access door with lock and key.
4. Externally Operated, Door-Interlocked Disconnect: Fused disconnect switch, Nonfused disconnect switch or Circuit breaker with lockable handle, as directed.
5. SCCR: As required by electrical power distribution system, but not less than 42,000 - 65,000 A, as directed.
6. Hand-Off-Auto Switch: Mounted on face of enclosure.
7. Push-to-Test Run Status Pilot Lights: NEMA ICS 2, heavy-duty type.
8. Control Relays: Time-delay relays.
9. Phase-Failure, Phase-Reversal, Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hardwired connection.
10. Elapsed-Time Meters: Numerical readout in hours on face of enclosure.
11. Number-of-Starts Counter: Numerical readout on face of enclosure.

E. Variable-Frequency Controllers:

1. Description: NEMA ICS 2; arranged to achieve motor variable speed by adjusting output voltage and frequency.
2. Enclosure: Unit mounted, NEMA 250, Type 3R, Type 4 or Type 4X or Type 4X stainless steel with hinged full-front access door with lock and key, as directed.
3. Externally Operated, Door-Interlocked Disconnect: Fused disconnect switch, Nonfused disconnect switch or Circuit breaker with lockable handle, as directed.
4. Minimum SCCR: As required by electrical power distribution system, but not less than 42,000 - 65,000 A, as directed.
5. Technology: Pulse-width-modulated (PWM) output with insulated gate bipolar transistors (IGBT); suitable for variable torque loads.
6. Controller shall consist of a rectifier converter section, a digital/analog driver regulator section, and an inverter output section.
7. Output Rating: Three phase; with voltage proportional to frequency throughout voltage range.
8. Output signal shall be programmed to not cause mechanical vibration issues with fan drive assembly.
9. Operating Requirements:

    a. Input AC Voltage Tolerance: 10 percent.
    b. Input frequency tolerance of 60 Hz, plus or minus 2 Hz.
    c. Capable of driving full motor load, without derating.
    d. Minimum Efficiency: 96 percent at 60 Hz, full load.
    e. Minimum Displacement Primary-Side Power Factor: 95 percent.
    f. Overload Capability: 1.05 times the full-load current for 7 seconds.
    g. Starting Torque: As required by fan and motor drive assembly.
    h. Speed Regulation: 1 percent.
    i. Speed Range: 10:1 speed range.
    j. To avoid equipment resonant vibrations, include critical speed lockout circuitry to allow bands of operating frequency at which controller shall not operate continuously.
    k. Capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.

10. Controller Adjustability Capabilities: Minimum and maximum output frequency, acceleration and deceleration, and current limit.
11. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions shall not result in component failure or the need for replacement:

    a. Overtemperature.
    b. Short circuit at controller output.
    c. Ground fault at controller output. Variable-frequency controller shall be able to start a grounded motor.
    d. Open circuit at controller output.
    e. Input undervoltage.
    f. Input overvoltage.
    g. Loss of input phase.
    h. Reverse phase.
    i. AC line switching transients.
    j. Instantaneous overload, line to line or line to ground.
    k. Sustained overload exceeding 100 percent of controller rated current.
    l. Starting a rotating motor.

12. Motor Protection: Controller shall protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.
13. Automatic Reset and Restart:

    a. Capable of multiple restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction.
    b. Capable of automatic restart on phase-loss and overvoltage and undervoltage trips.

14. Visual Indication: On face of controller; indicating the following conditions:

    a. Power on.
    b. Run.
    c. Overcurrent and overvoltage.
    d. Motor speed (percent).
    e. Various faults with alarm status.
    f. Input kilovolt amperes.
    g. Power factor.
    h. Input kilowatts and kilowatt-hours.
    i. Three-phase input and output voltage.
    j. Three-phase input and output current.
    k. Output frequency.
    l. Elapsed operating time (hours).
    m. Diagnostic and service parameters.

15. Operator Interface: Start-stop and auto-manual selector with manual-speed-control potentiometer.
16. Control Signal Interface: A minimum of two analog inputs (0 to 10 V or 0/4 to 20 mA) and four programmable digital inputs.

2.15 CONTROLS

A. Vibration Switch: For each fan drive.

1. Enclosure: NEMA 250, Type 4 or Type 4X, as directed.
2. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
3. Switch shall have manual-reset button hardwired connection to fan motor electrical circuit.
4. Switch shall have field connection to a control system hardwired connection to fan motor electrical circuit.
5. Switch shall, on sensing excessive vibration, signal an alarm for connection to control system and shut down the fan.

B. Vibration Transmitter with Switch: For each fan drive.

1. Enclosure: NEMA 250, Type 4X.
2. Display: Local display of measured value, power, and alarm.
3. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point.

a. Cooling tower manufacturer shall select range that is suitable for cooling tower and recommend switch set point for proper operation and protection.

4. Transmitter: Continuous vibration level indication through a 4- to 20-mA signal for connection to control system.
5. Switch:

a. Relay and switch with manual-reset button for field connection to control system and hardwired connection to fan motor electrical circuit.
b. Switch shall, on sensing excessive vibration, signal an alarm to control system and shut down the fan.

6. Mounting: Locate out of cooling tower discharge airstream and mount in a location that is accessible and where display is easily viewable.
7. Field Electrical Connection Requirements: 120 V, single phase, 60 Hz.

C. Gear-Drive, Oil-Level Switch: Low-oil-level warning switch for connection to control system.

1. Switch shall, on reaching a low-oil-level set point recommended by cooling tower manufacturer, signal an alarm through control system.

2.16 HOISTING ASSEMBLY

A. Hoisting assembly consisting of pedestal base, davit arm, and winch to accommodate lowering and raising cooling tower components from their installed location to the base of cooling tower supports.

1. Cooling tower components serviceable by hoisting assembly shall include, but not be limited to, fan stack, fan, fan drive, and fan motor.
2. Hoisting assembly shall be designed to accommodate heaviest single component plus a safety factor of 1.5.
3. Construct cooling tower structural supports and reinforcing to accommodate lifting heaviest load with safety factor.

B. Pedestal Base:

1. Equip each cooling tower cell with a pedestal base to accommodate an easily removable davit arm and winch assembly.
2. Position pedestal base at a location on cooling tower fan (top) deck for hoisting assembly coverage to fan, fan motor, and fan drive assembly.
3. Pedestal base design shall be open-socket, or comparable, design that is configured to accept and secure an inserted portable davit arm.
4. Fit each pedestal base with an easily removable cap or plug designed to seal the open top of the base when the davit arm is not installed.
5. Fasten pedestal base to cooling tower using threaded hardware.
6. Construct pedestal base of hot-dip galvanized steel or 300L series stainless steel.

C. Davit Arm:

1. Each cooling tower cell shall have a davit arm.

2. Davit arm shall be an adjustable telescoping design with angular adjustment to accommodate varying lifting conditions required by the application.
3. Davit arm assembly shall be portable and capable of being relocated to any cooling tower cell pedestal base.
4. Construct davit arm of hot-dip galvanized steel or 300L series stainless steel.

D. Winch:

1. Each davit arm shall have an electric or a hand operated winch.

   a. Electric winch shall include a power cord and plug for connection to a field-installed, weatherproof, 20-A receptacle with 120-V, single-phase, 60-Hz field power supply.
   b. Hand-operated winch with gear mechanism to limit force on handle to not more than 80 lb (36 kg) when lifting the heaviest component.

2. Coat winch body and exposed components with corrosion-resistant finish that is rated for outdoor duty in a highly corrosive environment and exposed to direct sunlight.
3. Winch cable shall be stainless steel and terminated with a stainless-steel hook and quick disconnecting mechanism. Cable length shall be at least 1.5 times actual length required for application.

E. Hardware: 304 or 316 series stainless steel.

F. Nameplate:

1. Stamped or engraved aluminum or stainless-steel nameplate with rated load capacity on each davit arm and pedestal.
2. Letter size legible from a distance of 60 inches (1500 mm) and not less than 1/2 inch (13 mm).
3. Fasten nameplate at multiple points with stainless-steel rivets or screws.

2.17 CAPACITIES AND CHARACTERISTICS

A. Number of Cells: As directed.

B. Air-Inlet Arrangement: Single side or Two sides, as directed.

C. Maximum Drift Loss: 0.005 percent of design water flow.

D. Waterside:

1. Design Water Flow per Cell: As directed, gpm (L/s).
2. Minimum Water Flow per Cell: As directed, gpm (L/s).
3. Water Pressure Drop: As directed, psig (kPa).
4. Entering-Water Temperature: As directed, deg F (deg C).
5. Leaving-Water Temperature: As directed, deg F (deg C).

E. Airside:

1. Entering-Air Wet-Bulb Temperature: As directed, deg F (deg C).

2. Altitude: As directed.
3. Airflow per Cell: As directed, (L/s).

F. Economizer-Mode Performance:

1. Water Flow per Cell: As directed, gpm (L/s.
2. Entering-Water Temperature: As directed, deg F (deg C).
3. Leaving-Water Temperature: As directed, deg F (deg C).
4. Entering-Air Wet-Bulb Temperature: As directed, deg F (deg C).

G. Fan Drive Assembly:

1. Type: Belt, direct or gear.
2. Fan Motor:

a. Type: Single speed, two speed, single winding, two speed, two winding or variable speed.
b. Motor Size per Cell: As directed, hp.
c. Full-Load Ampacity: As directed, A
d. Minimum Circuit Ampacity: As directed.
e. Maximum Overcurrent Protection Device: As directed.
f. Electrical Characteristics: 208, 240 or 480 V ac, 3 phase, 60 Hz, as directed

H. Sound Pressure Level: dBA at distance in feet (m), when measured according to CTI ATC 128.

I. Collection Basin Heater:

1. Basin Water Temperature: 40 deg F (5 deg C)
2. Outdoor Ambient Temperature: 0 deg F (Minus 18 deg C) or Minus 20 deg F (Minus 29 deg C), as directed.
3. Capacity per Cell: As directed.
4. Full-Load Ampacity: As directed.
5. Minimum Circuit Ampacity: As directed.
6. Maximum Overcurrent Protection Device: As directed.
7. Electrical Characteristics: 208, 240 or 480 V ac, 3 phase, 60 Hz, as directed.
8. Capacity/Cell: As directed, MBtu/h (kW).
9. Coil Fluid Type: Water.
10. Entering-Fluid Temperature: As directed, deg F (deg C).
11. Leaving-Fluid Temperature: As directed, deg F (deg C).
12. Fluid Flow Rate: As directed, gpm (L/s).
13. Fluid Pressure Drop: As directed, psig (kPa).
14. Capacity/Cell: As directed, MBtu/h (kW).
15. Steam Flow: As directed, lb/h (L/s).
16. Steam Pressure: As directed, psig (kPa).

2.18 SOURCE QUALITY CONTROL

A. Performance Test: Factory test and certify cooling tower performance according to CTI STD 201RS, "Standard for the Certification of Water-Cooling Tower Thermal Performance."

B. Seismic Performance Testing: Shake table tested by an independent or a factory-certified laboratory to certify performance complies with seismic requirements indicated.

C. Factory Functional Tests:

1. Test collection and distribution basins after assembly, and prove free of leaks.
2. Test factory-installed electric/electronic water-level controls for proper operation.
3. Test factory-installed electric basin heaters for proper operation.
4. Test factory-installed fan and drive assemblies for proper operation.
5. Test factory-installed control package for proper operation.
6. Test access doors to ensure smooth operation and proper fit.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Examine cooling towers before installation. Reject cooling towers that are damaged.

B. Install cooling towers on support structure.

C. Equipment Mounting:

1. Install cooling towers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." Or Section 033053 "Miscellaneous Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

D. Install anchor bolts to elevations required for proper attachment to supported equipment.

E. Maintain manufacturer's recommended clearances for service and maintenance.

F. Maintain clearances required by governing code.

3.2 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to cooling towers, allow space for service and maintenance.

C. Install flexible pipe connectors at pipe connections of cooling towers mounted on vibration isolators.

D. Install drain piping with valve at cooling tower drain connections and at low points in piping.

E. Connect cooling tower overflows and drains, and piping drains, to sanitary sewage system.

F. Makeup-Water Piping:

1. Comply with applicable requirements in Section 221116 "Domestic Water Piping."
2. Connect to makeup-water connections with shutoff valve, plugged tee with pressure gage, flow meter, and drain connection with valve and union.

G. Supply and Return Piping:

1. Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
2. Connect to entering cooling tower connections with shutoff valve, strainer, balancing valve, thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve.
3. Connect to leaving cooling tower connection with shutoff valve thermometer, plugged tee with full port ball valve for portable field instruments, and drain connection with valve.
4. Make connections to cooling tower with a flange.

H. Equalizer Piping:

1. Piping requirements to match supply and return piping.
2. Connect an equalizer pipe, full size of cooling tower connection, between tower cells.
3. Connect to cooling tower with shutoff valve and drain connection with valve.
4. Make connections to cooling tower with a flange.

I. Basin Heater Hot-Water Piping:

1. Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
2. Connect to supply connections with shutoff valve, strainer, control valve thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve.
3. Connect to return connections with shutoff valve, balancing valve, thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve.
4. Make connections with a flange, union, or mechanical coupling.

J. Basin Heater Steam and Condensate Piping:

1. Comply with applicable requirements in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties."
2. Connect steam supply connection with shutoff valve, strainer, control valve, pressure gage, and flow meter.
3. Connect to condensate connection with shutoff valve, strainer, and an appropriate steam trap assembly.
4. Make connections with a flange or union.

3.3 ELECTRICAL POWER CONNECTIONS

A. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

B. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding connections.

C. Install nameplate for each electrical connection indicating electrical equipment designation and circuit number feeding connection. Nameplate shall be laminated phenolic layers of black with engraved white letters at least 1/2 inch (13 mm) high. Locate nameplate where easily visible.

3.4 CONTROLS CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between cooling towers and other equipment to interlock operation as required to achieve a complete and functioning system.

3.5 FIELD TESTING PROVISIONS

A. Include provisions for cooling tower future field-performance testing complying with ASME PTC 23 or CTI ATC 105, as directed.

B. Include provisions in field piping for future field-performance testing complying with ASME PTC 23 or CTI ATC 105, as directed.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Tests and Inspections: Comply with ASME PTC 23 or CTI ATC 105, as directed.

E. Cooling towers will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform or Perform startup service.

B. Inspect field-assembled components, equipment installation, and piping; controls; and electrical connections for proper assemblies, installations, and connections.

C. Obtain performance data from manufacturer.

1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

a. Clean entire unit including basins.
b. Verify that accessories are properly installed.
c. Verify clearances for airflow and for cooling tower servicing.
d. Check for vibration isolation and structural support.
e. Lubricate bearings.
f. Verify fan rotation for correct direction and for vibration or binding and correct problems.
g. Adjust belts to proper alignment and tension.
h. Verify proper oil level in gear-drive housing. Fill with oil to proper level.
i. Operate variable-speed fans through entire operating range and check for harmonic vibration imbalance. Set motor controller to skip speeds resulting in abnormal vibration.
j. Check vibration switch setting. Verify operation.
k. Verify water level in tower basin. Fill to proper startup level. Check makeup-water-level control and valve.
l. Verify operation of basin heater and control.
m. Verify that cooling tower air discharge is not recirculating air into tower or HVAC air intakes. Recommend corrective action.
n. Replace defective and malfunctioning units.

D. Start cooling tower and associated water pumps. Follow manufacturer's written starting procedures.

E. Prepare a written startup report that records the results of tests and inspections.

3.8 ADJUSTING

A. Set and balance water flow to each tower inlet.

B. Adjust water-level control for proper operating level.

C. Adjust basin heater control for proper operating set point.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train or train Owner's maintenance personnel to adjust, operate, and maintain cooling towers.

END OF SECTION 236514.14

SECTION 236514.16 – CLOSED-CIRCUIT, INDUCED-DRAFT, COUNTERFLOW COOLING TOWERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes factory-assembled, closed-circuit, induced-draft, counterflow cooling towers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Manufacturer's drawings of assembled cooling towers, control panels, sections, and elevations.
2. Diagram showing each separate piece requiring field assembly.
3. Shipped sub-assembly dimensions and weights for field assembly.
4. Operating weight and load distribution.
5. Unit vibration isolation and seismic controls.
6. Required clearances for maintenance and operation.
7. Sizes and dimensioned locations of piping and wiring connections.
8. Diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal: For cooling tower support structure indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of support structure.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
3. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and wind restraints and for designing vibration isolation bases.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:

1. Drawings on which items are shown and coordinated with each other, using input from installers of the items involved.
2. Each view to show screened background with the following:

a. Structural grids.
b. Adjacent walls, floors, and roofs.

c. Equipment and products of other trades that are located in vicinity of cooling towers and are part of final installation, such as controls, power, lighting, fire-suppression systems, and plumbing systems.

B. Seismic Qualification Data: Certificates, for cooling towers, accessories, and components, from manufacturer.

C. Product Certificates: For certification required in "Quality Assurance" Article.

D. Field test reports.

E. Source quality-control reports.

F. Field quality-control reports.

G. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Certified by CTI or an NRTL.

B. ASME Compliance: Fabricate and label heat-exchanger coils to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

C. CTI Certification: Cooling tower thermal performance according to CTI STD 201RS.

D. FM Global: Approval and listing in the latest edition of FM Global's "Approval Guide."

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of cooling towers that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design cooling tower support structure and seismic restraints and wind restraints, including comprehensive engineering analysis.

B. Structural Performance: Cooling tower and support structure shall withstand the effects of loads and stresses within limits and under conditions indicated according to ASCE/SEI 7, the IBC or governing code, as directed.

C. Seismic Performance: Cooling towers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 - 1.0.
3. Component Amplification Factor: As directed.
4. Component Response Modification Factor: As directed.

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

F. Operation Following Loss of Normal Power:

1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to backup power system shall automatically return equipment and associated controls to the operating state occurring immediately before loss of normal power without need for manual intervention by an operator when power is restored either through a backup power source, or through normal power if restored before backup power is brought on-line.
2. Include means and methods required to satisfy requirement even if not explicitly indicated.

G. Vibration:

1. Rotating assemblies shall be dynamically balanced to achieve a balance level of "good" while complying with industry standard requirements for cooling towers.
2. Critical speed shall be at least 115 percent of design speed.

2.3 DESIGN ARRANGEMENT

A. Counterflow design with airflow from all sides and induced-draft, top-mounted axial fan and pressurized pipe distribution.

2.4 CASING AND FRAME

A. Casing Material: Galvanized steel, ASTM A653/A653M, G235 (Z700) coating or Polymer-coated galvanized steel.

B. Frame Material: Galvanized steel, ASTM A653/A653M, G235 (Z700) coating, polymer-coated galvanized steel or materials to match casing.

C. Hardware: Galvanized or stainless steel.

D. Joints and Seams: Sealed watertight.

E. Welded Connections: Sealed watertight by continuous welds.

2.5 COLLECTION BASIN

A. Factory-Assembled Collection Basin:

1. Material: Galvanized steel, ASTM A653/A653M, G235 (Z700) coating, Polymer-coated galvanized steel.
2. Hardware: Galvanized or stainless steel.
3. Joints and Seams: Sealed watertight.
4. Welded Connections: Sealed watertight by continuous welds.
5. Removable stainless-steel strainer with openings smaller than nozzle orifices.
6. Overflow and drain connections.
7. Makeup-water connection.
8. Outlet Connection: Configured to mate to ASME B16.5, Class 150 flange.

2.6 COLLECTION BASIN MAKEUP-WATER ASSEMBLY

A. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.

B. Electric/Electronic, Collection Basin Water-Level Controller with Makeup-Water Valve:

1. Enclosures: NEMA 250, Type 4 or Type 4X.
2. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to control makeup-water valve, control makeup-water valve and low-level alarm, control makeup-water valve and low- and high-level alarms or control makeup-water valve, low- and high-level alarms, and output for shutoff of pump on low level.
3. Electrode Probes: Stainless steel.
4. Water Stilling Chamber: Corrosion-resistant material, FRP, Galvanized steel, PVC pipe, Stainless steel, Grade 304 or Stainless steel, Grade 316.
5. Makeup-Water Valve:

a. Slow closing with stainless-steel body.
b. Valve actuator controlled and powered through level controller in response to water-level set point.
c. Actuator Enclosure: NEMA 250, Type 4 or Type 4X.
d. Fail Position: Closed, Open or Last.
e. Action: Two position or modulating.

6. Electrical Connection Requirements: 120-V ac, single phase, 60 Hz.

2.7 COLLECTION BASIN HEATER

A. Electric Heater:

1. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
2. Heater Control Panel: Mounted on the side of each cooling tower cell.
3. Enclosure: NEMA 250, Type 3R, Type 4 or Type 4X.
4. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
5. Control-circuit transformer with primary and secondary side fuses.
6. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
7. Single-point, field-power connection to a fused disconnect switch, nonfused disconnect switch or circuit breaker and heater branch circuiting complying with NFPA 70, as directed.
8. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except make connections to each electric basin heater with liquidtight conduit.

a. Raceway shall be corrosion-resistant stainless steel or PVC coated steel.

2.8 PRESSURIZED DISTRIBUTION NETWORK

A. Main header and lateral branch piping designed for even distribution over heat-exchanger coils throughout the entire flow range without the need for balancing valves and for connecting individual, easily removable, nonclogging spray nozzles.

B. Pipe Material: Schedule 40 PVC.

C. Spray Nozzle Material: Plastic, Polypropylene or PVC.

D. Piping Supports: Corrosion-resistant hangers and supports to resist movement during operation and shipment.

2.9 HEAT-EXCHANGER COILS

A. Tube and Tube Sheet Materials: Copper tube with stainless-steel tube sheet, stainless-steel tube and tube sheet or carbon-steel tube and sheet with outer surface of tube and sheet hot-dip galvanized after fabrication.

B. Heat-Exchanger Arrangement:

1. Serpentine tubes, Serpentine tubes with removable cover plate on inlet and outlet headers or straight tubes with removable header cover plate on both ends of heat exchanger for straight-through access to each tube; sloped for complete drainage of fluid by gravity.
2. Tubes with extended surface fins if required to achieve performance indicated.
3. Multiple Separate Circuits: Separate circuits to achieve multiple isolated loops as required by application.

C. ASME Compliance: Designed, manufactured, and tested according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, and bearing ASME "U" stamp; sloped for complete drainage of fluid by gravity.

D. Field Piping Connections: Vent, supply, and return suitable for mating to ASME B16.5, Class 150 flange.

2.10 DRIFT ELIMINATORS

A. Material: PVC with maximum flame-spread index of 5 - 25 according to ASTM E84.

B. UV Treatment: Inhibitors to protect against damage caused by UV radiation.

C. Arrangement: Multiple, easily removable sections.

D. Configuration: Multipass, designed and tested to reduce water carryover to 0.001 percent of design flow rate indicated.

E. Hardware: Galvanized or stainless steel.

2.11 AIR INLET

A. Air-Intake Louvers:

1. Material: PVC.
2. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
3. Multiple, easily removable sections arranged to uniformly direct air into cooling tower, to minimize air resistance, to block direct sunlight, and to prevent water from splashing out of tower during all modes of operation including operation with fans off.

B. Hardware: Galvanized or stainless steel.

2.12 FAN AND DRIVE ASSEMBLY

A. Axial Fan: Balanced at the factory after assembly.

1. Blade Material: Aluminum, FRP or galvanized steel.
2. Hub Material: Aluminum, FRP or galvanized steel.
3. Blade Pitch: Field adjustable.

4. Fan Shaft: Corrosion resistant or Stainless steel.
5. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C). Bearings designed for an L-10 life of 40,000, 50,000 or 100,000 hours, as directed.
6. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.
7. Automatic Bearing Greasing System:

    a. Manufacturer designed system to provide an as needed supply of new grease to bearings while reducing the need for periodic bearing maintenance and associated greasing problems.
    b. Easily replaceable storage container filled with recommended grease and located in an easily accessible location on cooling tower exterior. Container capacity of sufficient size to provide grease for one year.

B. Belt Drive:

1. Service Factor: 1.5 based on motor nameplate horsepower.
2. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
3. Belt: Multiple V-belt design with a matched set of cogged belts.
4. Belt: One-piece, multigrooved, solid-back belt.
5. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
6. Belt-Drive Guard: Comply with OSHA regulations.
7. Two-Motor, Single-Fan Drive:

    a. Two single-speed motors per fan, one sized for full speed and load and the other sized for 67 percent of full-load speed.
    b. Each motor shall have belt drive and be configured for operation when other motor fails.
    c. Controls and wiring same as two-speed, two-winding motor.

C. Direct Drive: Fan hub directly connected, and properly secured, to motor shaft.

D. Fan Motor:

1. Comply with NEMA MG 1 unless otherwise indicated.
2. Description: NEMA MG 1, Design B as required to comply with capacity and torque characteristics; medium induction motor.
3. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
4. Motor Enclosure: Open dripproof with weather protective cover, totally enclosed, totally enclosed air-over (TEAO) or totally enclosed fan-cooled (TEFC) with epoxy or polyurethane finish, as directed.
5. Rotor: Random-wound, squirrel cage.
6. Energy Efficiency: Comply with ASHRAE/IES 90.1 or NEMA Premium Efficient.
7. Service Factor: 1.15.
8. Temperature Rise: Match or One class lower than insulation rating.
9. Insulation: Class F or Class H.

10. Variable-Speed Motors: Inverter-duty rated per NEMA MG 1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
11. Motor Location: Mounted outside of cooling tower casing and cooling tower discharge airstream.
12. Severe-Duty Rating:

    a. Rotor and stator protected with corrosion-inhibiting epoxy resin.
    b. Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C).
    c. Internal Heater: Automatically energized when motor is de-energized.
    d. Complying with IEEE 841.

13. Motor Base: Adjustable, or other suitable provision for adjusting belt tension.
14. Motor Shaft Grounding: Motors shall be controlled through variable-frequency controllers with shaft grounding system to protect motor bearings from induced voltage. Drag on motor shaft due to shaft ground system shall be less than 0.5 percent of motor nameplate horsepower.

E. Hardware: Galvanized or stainless steel.

2.13 AIR DISCHARGE

A. Fan Discharge Stack:

1. Manufacturer's standard low-profile design.
2. Material: Material to match casing.
3. Stack Extension: Fabricated to extend above fan deck unless otherwise indicated.
4. Stack Termination: Wire-mesh, galvanized-steel, polymer-coated, galvanized-steel or stainless-steel screens; segmented into multiple removable pie sections and complying with OSHA regulations.

B. Discharge Hood:

1. Hood Configuration: Tapered or Straight; totally surrounding heat exchanger, pressurized distribution system and drift eliminators; constructed of same material as casing; and having factory-installed insulation and access doors.
2. Discharge Dampers: Positive-closure, automatic, isolation dampers constructed of aluminum, galvanized steel or stainless steel with corrosion-resistant linkages and electric actuators with NEMA 250, Type 4X enclosure.

    a. If not provided with factory controls, field-connect provisions for electrical power and controls to open dampers when pump is energized and close dampers when pump is de-energized.

3. Capacity-Control Dampers: Aluminum, Galvanized-steel or Stainless-steel dampers, with corrosion-resistant linkages, electric operator, controller, limit switches, transformer, and weatherproof enclosure.

a. If not provided with factory controls, provide field power and controls to operate dampers when pump is energized and close dampers when pump and fan is de-energized.

C. Hardware: Galvanized or stainless steel.

2.14 RECIRCULATING WATER DISTRIBUTION SYSTEM

A. Pump: Close-coupled, single-stage, bronze-fitted centrifugal pump; with mechanical seal and suitable for outdoor service. Factory install pump with following:

1. Redundant Pump: Same performance as required for primary pump; easily switched and maintained while cooling tower remains operating.
2. Flanges at pump connections to piping.
3. Strainer, with blowdown isolation valve, installed in piping on suction side of pump.
4. Flow balancing valve in piping on discharge side of pump.

B. Pump Motor:

1. Comply with NEMA MG 1 unless otherwise indicated.
2. Description: NEMA MG 1, Design B as required to comply with capacity and torque characteristics; medium induction motor.
3. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
4. Motor Enclosure: Open dripproof or totally enclosed and with epoxy or polyurethane finish.
5. Rotor: Random-wound, squirrel cage.
6. Energy Efficiency: Comply with ASHRAE/IES 90.1 or NEMA Premium Efficient.
7. Service Factor: 1.15.
8. Temperature Rise: Match or One class lower than insulation rating.
9. Insulation: Class F or Class H.
10. Severe-Duty Rating:

    a. Rotor and stator protected with corrosion-inhibiting epoxy resin.
    b. Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C).
    c. Internal Heater: Automatically energized when motor is de-energized.
    d. Complying with IEEE 841.

C. Piping: Interconnecting collection basin to pump and pressurization distribution system.

1. Design delegated to manufacturer.
2. External to and supported from cooling tower casing and frame.
3. Material: Corrosion resistant or PVC.
4. Install flanges at connections to collection basin and pressurized distribution system.
5. Drain connection with isolation valve at piping low point if piping does not drain directly into collection basin.

D. Piping: Field installed for connection to remotely installed pump and water storage that are not furnished with cooling tower.

2.15 ELECTRICAL POWER

A. Factory Furnish for Field Installation: A disconnect switch, motor controller or variable-frequency controller for each fan motor and a disconnect switch or motor controller for each pump motor.

B. Factory Install: A disconnect switch, motor controller or variable-frequency controller for each fan motor and a disconnect switch or motor controller for each pump motor.

1. Locate in a convenient and field-accessible location within sight of motor.
2. Installation shall comply with NFPA 70.
3. Wire, Conduit, and Enclosures:

    a. Minimum Conduit Size: 0.75 inch (20 mm).
    b. Materials: Corrosion resistant and constructed of stainless steel or PVC coated steel.
    c. Motor Termination: Liquidtight conduit, not to exceed 36 inches (900 mm) long.
    d. Supports: Support conduits, boxes, and enclosures using corrosion-resistant fastening hardware constructed of stainless steel.
    e. Wire:

        1) Copper, rated for 600-V, solid wire for size No. 10 AWG and smaller and stranded wire for larger sizes.
        2) Minimum Wire Size: No. 12 AWG.
        3) Each circuit shall have a ground wire.
        4) Install wire in conduit.

    f. Boxes, Condulets, and Enclosures: NEMA 250, Type 3R, Type 4 or Type 4X.

C. Disconnect Switches:

1. Specification Grade; "Heavy Duty Type"; "quick-make," "quick-break" construction.
2. Three pole, fused or nonfused.
3. 600 V rated.
4. Minimum SCCR: As required by electrical power distribution system, but not less than 42,000 - 65,000 A.
5. Enclosure: NEMA 250, Type 3R, Type 4, Type 4X or Type 4X stainless steel.
6. Operating handle shall be of box-mounted type that directly drives switch mechanism.
7. Disconnect switch shall use a flange-operated visible blade that is close coupled to a vertical-lift-type handle that achieves a positive visible indication of disconnect with cover open or closed.
8. Disconnect switch shall have a defeatable, front-accessible, mechanical interlock to prevent opening of cover when switch is in "ON" position, and to prevent turning switch "ON" when the door is open.
9. Include a solid neutral as required by authorities having jurisdiction.
10. Provide a ground lug for ground wire termination.
11. Operating handle shall be lockable in open position.

12. Horsepower rated.
13. Feed through or double lugged.

D. Motor Controllers:

1. NEMA ICS 2, Class A, full-voltage, non-reversing, motor-rated controller.
2. Configured for control of single- or multispeed motors as indicated.
3. Enclosure: NEMA 250, Type 3R, Type 4, Type 4X or Type 4X stainless steel, with hinged full-front access door with lock and key.
4. Externally Operated, Door-Interlocked Disconnect: Fused disconnect switch, Nonfused disconnect switch or Circuit breaker with lockable handle.
5. SCCR shall be as required by electrical power distribution system, but not less than 42,000 or 65,000 A.
6. Hand-Off-Auto Switch: Mounted on face of enclosure.
7. Push-to-Test Run Status Pilot Lights: NEMA ICS 2, heavy-duty type.
8. Control Relays: Time-delay relays.
9. Phase-Failure, Phase-Reversal, Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hardwired connection.
10. Elapsed-Time Meters: Numerical readout in hours on face of enclosure.
11. Number-of-Starts Counter: Numerical readout on face of enclosure.

E. Variable-Frequency Controllers:

1. Description: NEMA ICS 2; arranged to achieve motor variable speed by adjusting output voltage and frequency.
2. Enclosure: Unit mounted, NEMA 250, Type 3R, Type 4, Type 4X or Type 4X stainless steel, with hinged full-front access door with lock and key, as directed.
3. Externally Operated, Door-Interlocked Disconnect: Fused disconnect switch, Nonfused disconnect switch or Circuit breaker with lockable handle.
4. Minimum SCCR shall be as required by electrical power distribution system, but not less than 42,000 or 65,000 A.
5. Technology: Pulse-width-modulated (PWM) output with insulated gate bipolar transistors (IGBT); suitable for variable torque loads.
6. Controller shall consist of a rectifier converter section, a digital/analog driver regulator section, and an inverter output section.
7. Output Rating: Three phase; with voltage proportional to frequency throughout voltage range.
8. Output signal shall be programmed to not cause mechanical vibration issues with fan drive assembly.
9. Operating Requirements:

    a. Input AC Voltage Tolerance: 10 percent.
    b. Input frequency tolerance of 60 Hz, plus or minus 2 Hz.
    c. Capable of driving full motor load, without derating.
    d. Minimum Efficiency: 96 percent at 60 Hz, full load.
    e. Minimum Displacement Primary-Side Power Factor: 95 percent.
    f. Overload Capability: 1.05 times the full-load current for 7 seconds.
    g. Starting Torque: As required by fan and motor drive assembly.
    h. Speed Regulation: 1 percent.
    i. Speed Range: 10:1 speed range.

j. To avoid equipment resonant vibrations, include critical speed lockout circuitry to allow bands of operating frequency at which controller shall not operate continuously.
k. Capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.

10. Controller Adjustability Capabilities: Minimum and maximum output frequency, acceleration and deceleration, and current limit.
11. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions shall not result in component failure or the need for replacement:

    a. Overtemperature.
    b. Short circuit at controller output.
    c. Ground fault at controller output. Variable-frequency controller shall be able to start a grounded motor.
    d. Open circuit at controller output.
    e. Input undervoltage.
    f. Input overvoltage.
    g. Loss of input phase.
    h. Reverse phase.
    i. AC line switching transients.
    j. Instantaneous overload, line to line or line to ground.
    k. Sustained overload exceeding 100 percent of controller rated current.
    l. Starting a rotating motor.

12. Motor Protection: Controller shall protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.
13. Automatic Reset and Restart:

    a. Capable of multiple restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction.
    b. Capable of automatic restart on phase-loss and overvoltage and undervoltage trips.

14. Visual Indication: On face of controller; indicating the following conditions:

    a. Power on.
    b. Run.
    c. Overcurrent and overvoltage.
    d. Motor speed (percent).
    e. Various faults with alarm status.
    f. Input kilovolt amperes.
    g. Power factor.
    h. Input kilowatts and kilowatt-hours.
    i. Three-phase input and output voltage.
    j. Three-phase input and output current.
    k. Output frequency.
    l. Elapsed operating time (hours).
    m. Diagnostic and service parameters.

15. Operator Interface: Start-stop and auto-manual selector with manual-speed-control potentiometer.

16. Control Signal Interface: A minimum of two analog inputs (0 to 10 V or 0/4 to 20 mA) and four programmable digital inputs.
17. Bypass Controller:

    a. Integrated NEMA ICS 2, Class A, full-voltage, non-reversing, motor-rated controller to operate fan motor if variable-frequency controller is not operational.
    b. Configure power supply to bypass controller and variable-frequency controller to completely isolate power to variable-frequency controller while operating fan motor through bypass controller for safe servicing of variable-frequency controller.
    c. Include "Bypass/VFC" manual selector switch on face of enclosure for local operator control of preferred controller.
    d. Include fail-safe control logic to automatically transfer fan motor operation from failed variable-frequency controller to bypass controller.
    e. Install bypass controller in same enclosure as variable-frequency controller.

2.16 CONTROLS

A. Vibration Switch: For each fan drive.

1. Enclosure: NEMA 250, Type 4 or Type 4X.
2. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
3. Switch shall have manual-reset button hardwired connection to fan motor electrical circuit.
4. Switch shall have field connection to a control system hardwired connection to fan motor electrical circuit.
5. Switch shall, on sensing excessive vibration, signal an alarm for connection to control system and shut down the fan.

2.17 WATER TREATMENT

A. Chemical-Free Water Treatment System: Complete factory-installed system consisting of the following:

1. Pulsed-power technology emitting high-frequency bursts of low energy electromagnetic fields to the recirculated water to control corrosion, bacteria, and scale.
2. Conductivity control of electrically operated valve designed to control totally dissolved solids levels and bleed rates.
3. Piping associated with system.
4. Interconnecting power and control wiring installed in corrosion-resistant metal raceway.

B. Chemical Water Treatment System: Complete factory-installed system consisting of the following:

1. Microprocessor-controlled conductivity controller housed in NEMA 250, Type 4X enclosure.
2. Chemical metering pump housed in NEMA 250, Type 4X enclosure.

3. Electrically operated valve designed to control totally dissolved solids levels and bleed rates.
4. Piping associated with system.
5. Interconnecting power and control wiring installed in corrosion-resistant metal raceway.

2.18 SERVICE ACCESS

A. Doors:

1. Large enough for personnel to access cooling tower internal components.
2. Doors shall be hinged with handles operable from both sides of the door.
3. Door materials shall match casing.
4. Hinges and handles shall be corrosion resistant or stainless steel.

B. External Ladders with Safety Cages: Aluminum, galvanized-steel or stainless-steel fixed ladders with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.

C. External Platforms with Handrails: Aluminum, galvanized-steel or stainless-steel bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.

D. External Motor Platforms with Handrails: Aluminum, galvanized-steel or stainless-steel bar grating.

E. Fan Deck Floor between Cooling Tower Cells:

1. Factory furnish reinforced fan deck floor panels between cooling tower cells for field installation.
2. Floor materials shall match adjacent cooling tower cell fan deck.
3. Fan deck floor shall fasten to and be supported by framing that is attached to cooling tower cells.
4. Frame shall be constructed of same materials as cooling tower frame.

F. Handrail: Aluminum, galvanized steel or stainless steel complete with kneerail and toeboard, around external platforms and top of cooling tower. Comply with 29 CFR 1910.23.

G. Internal Platforms: Aluminum, galvanized-steel or, stainless-steelbar grating.

1. Spanning the collection basin from one end of cooling tower to the other and positioned to form a path between. Platform shall be elevated so that all parts are above the high water level of the collection basin.
2. Elevated internal platforms with handrails accessible from fixed vertical ladders to access the fan drive assembly when out of reach.

H. Hardware: Galvanized steel when connecting galvanized-steel components; stainless steel when connecting other materials.

2.19 CAPACITIES AND CHARACTERISTICS

A. Number of Cells: As directed.

B. Air-Inlet Arrangement: All sides.

C. Maximum Drift Loss: 0.001 percent of design water flow.

D. Heat Exchanger:

1. Fluid Type: Water.
2. Design Fluid Flow per Cell: As directed, gpm (L/s).
3. Minimum Fluid Flow per Cell: As directed, gpm (L/s).
4. Fluid Pressure Drop: As directed, psig (kPa).
5. Fluid Pressure Rating: As directed, psig (kPa).
6. Entering-Fluid Temperature: As directed, deg F (deg C).
7. Leaving-Fluid Temperature: As directed, deg F (deg C).
8. Entering-Air Wet-Bulb Temperature: As directed, deg F (deg C).
9. Airflow per Cell: As directed, cfm (L/s).

E. Economizer-Mode Performance:

1. Fluid Flow per Cell: As directed, gpm (L/s).
2. Entering-Fluid Temperature: As directed, deg F (deg C).
3. Leaving-Fluid Temperature: As directed, deg F (deg C).
4. Entering-Air Wet-Bulb Temperature: As directed, deg F (deg C).

F. Fan Drive Assembly:

1. Type: Belt or direct.
2. Fan Motor:

    a. Type: Single speed, Two speed, single winding, Two speed, two winding or Variable speed.
    b. Motor Size per Cell: As directed, hp.
    c. Full-Load Ampacity: As directed.
    d. Minimum Circuit Ampacity: As directed.
    e. Maximum Overcurrent Protection Device: As directed.
    f. Electrical Characteristics: 208, 240 or 480V ac, 3 phase, 60 Hz.

G. Pump and Motor:

1. Water Flow per Cell: As directed, gpm (L/s).
2. Motor Size per Cell: As directed, hp.
3. Full-Load Ampacity: As directed.
4. Minimum Circuit Ampacity: As directed, A.
5. Maximum Overcurrent Protection Device: As directed.
6. Electrical Characteristics: 120, 208, 240, 277 and 480V ac, single or 3 phase, 60 Hz.

H. Sound Pressure Level: dBA at distance in feet (m) when measured according to CTI ATC 128.

I. Collection Basin Heater:

1. Basin Water Temperature: 40 deg F (5 deg C).

2. Outdoor Ambient Temperature: 0 deg F (Minus 18 deg C) or Minus 20 deg F (Minus 29 deg C).
3. Capacity/Cell: As directed.
4. Full-Load Ampacity: As directed.
5. Minimum Circuit Ampacity: As directed.
6. Maximum Overcurrent Protection Device: As directed.
7. Electrical Characteristics: 208, 240 or 480V ac, 3 phase, 60 Hz.

2.20 SOURCE QUALITY CONTROL

A. Performance Test: Factory test and certify cooling tower performance according to CTI STD 201RS, "Standard for the Certification of Water-Cooling Tower Thermal Performance."

B. Seismic Performance Testing: Shake table tested by an independent or a factory-certified laboratory to certify performance complies with seismic requirements indicated.

C. Factory Functional Tests:

1. Test collection and distribution basins after assembly, and prove free of leaks.
2. Test factory-installed electric/electronic water-level controls for proper operation.
3. Test factory-installed electric basin heaters for proper operation.
4. Test factory-installed fan and drive assemblies for proper operation.
5. Test factory-installed control package for proper operation.
6. Test access doors to ensure smooth operation and proper fit.

D. Heat-Exchanger Factory Pressure and Leak Tests:

1. Pneumatically test heat-exchanger assembly while submerged underwater and prove to be free of leaks.
2. Test pressure equal to 1.5 times rated pressured, but not less than psig (kPa), as directed.
3. Submit report documenting test and results.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Examine cooling towers before installation. Reject cooling towers that are damaged.

B. Install cooling towers on support structure.

C. Equipment Mounting:

1. Install cooling towers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." Or Section 033053 "Miscellaneous Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

D. Install anchor bolts to elevations required for proper attachment to supported equipment.

E. Maintain manufacturer's recommended clearances for service and maintenance.

F. Maintain clearances required by governing code.

3.2 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to cooling towers, allow space for service and maintenance.

C. Install flexible pipe connectors at pipe connections of cooling towers mounted on vibration isolators.

D. Install drain piping with valve at cooling tower drain connections and at low points in piping.

E. Connect cooling tower overflows and drains, and piping drains to sanitary sewage system.

F. Makeup-Water Piping:

1. Comply with applicable requirements in Section 221116 "Domestic Water Piping."
2. Connect to makeup-water connections with shutoff valve, plugged tee with pressure gage, flow meter, and drain connection with valve and union.

G. Supply and Return Piping:

1. Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
2. Connect to entering cooling tower connections with shutoff valve, strainer, balancing valve, thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve.
3. Connect to leaving cooling tower connection with shutoff valve thermometer, plugged tee with full port ball valve for portable field instruments, and drain connection with valve.
4. Make connections to cooling tower with a flange.

3.3 ELECTRICAL POWER CONNECTIONS

A. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

B. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding connections.

C. Install nameplate for each electrical connection indicating electrical equipment designation and circuit number feeding connection. Nameplate shall be laminated phenolic layers of black with engraved white letters at least 1/2 inch (13 mm) high. Locate nameplate where easily visible.

3.4 CONTROLS CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between cooling towers and other equipment to interlock operation as required to achieve a complete and functioning system.

3.5 FIELD TESTING PROVISIONS

A. Include provisions for cooling tower future field-performance testing complying with ASME PTC 23 or CTI ATC 105.

B. Include provisions in field piping for future field-performance testing complying with ASME PTC 23 or CTI ATC 105.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Tests and Inspections: Comply with ASME PTC 23 or CTI ATC 105.

E. Cooling towers will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform or perform startup service.

B. Inspect field-assembled components, equipment installation, and piping; controls; and electrical connections for proper assemblies, installations, and connections.

C. Obtain performance data from manufacturer.

1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

    a. Clean entire unit including basins.
    b. Verify that accessories are properly installed.

c. Verify clearances for airflow and for cooling tower servicing.
d. Check for vibration isolation and structural support.
e. Lubricate bearings.
f. Verify fan rotation for correct direction and for vibration or binding and correct problems.
g. Verify pump rotation for correct direction, vibration, cavitation, and flow and correct problems.
h. Adjust belts to proper alignment and tension.
i. Operate variable-speed fans through entire operating range and check for harmonic vibration imbalance. Set motor controller to skip speeds resulting in abnormal vibration.
j. Check vibration switch setting. Verify operation.
k. Verify water level in tower basin. Fill to proper startup level. Check makeup-water-level control and valve.
l. Verify operation of basin heater and control.
m. Verify that cooling tower air discharge is not recirculating air into tower or HVAC air intakes. Recommend corrective action.
n. Replace defective and malfunctioning units.

D. Start cooling tower and associated water pumps. Follow manufacturer's written starting procedures.

E. Prepare a written startup report that records the results of tests and inspections.

3.8 ADJUSTING

A. Set and balance water flow to each tower inlet.

B. Adjust water-level control for proper operating level.

C. Adjust basin heater control for proper operating set point.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train or train Owner's maintenance personnel to adjust, operate, and maintain cooling towers.

END OF SECTION 236514.16

SECTION 236514.17 – CLOSED-CIRCUIT, INDUCED-DRAFT, COMBINED-FLOW COOLING TOWERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes factory-assembled, closed-circuit, induced-draft, combined-flow cooling towers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Manufacturer's drawings of assembled cooling towers, control panels, sections, and elevations.
2. Diagram showing each separate piece requiring field assembly.
3. Shipped sub-assembly dimensions and weights for field assembly.
4. Operating weight and load distribution.
5. Unit vibration isolation and seismic controls.
6. Required clearances for maintenance and operation.
7. Sizes and dimensioned locations of piping and wiring connections.
8. Diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal: For cooling tower support structure indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of support structure.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
3. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and wind restraints and for designing vibration isolation bases.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:

1. Drawings on which items are shown and coordinated with each other, using input from installers of the items involved.
2. Each view to show screened background with the following:

    a. Structural grids.
    b. Adjacent walls, floors, and roofs.

c. Equipment and products of other trades that are located in vicinity of cooling towers and are part of final installation, such as controls, power, lighting, fire-suppression systems, and plumbing systems.

B. Seismic Qualification Data: Certificates, for cooling towers, accessories, and components, from manufacturer.

C. Product Certificates: For certification required in "Quality Assurance" Article.

D. Field test reports.

E. Source quality-control reports.

F. Field quality-control reports.

G. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Certified by CTI or an NRTL.

B. ASME Compliance: Fabricate and label heat-exchanger coils to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

C. CTI Certification: Cooling tower thermal performance according to CTI STD 201RS.

D. FM Global: Approval and listing in the latest edition of FM Global's "Approval Guide."

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of cooling towers that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design cooling tower support structure and seismic restraints and wind restraints, including comprehensive engineering analysis.

B. Structural Performance: Cooling tower and support structure shall withstand the effects of loads and stresses within limits and under conditions indicated according to ASCE/SEI 7, the IBC or governing code.

C. Seismic Performance: Cooling towers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 - 1.0.
3. Component Amplification Factor: As directed.
4. Component Response Modification Factor: As directed.

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

F. Operation Following Loss of Normal Power:

1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to backup power system shall automatically return equipment and associated controls to the operating state occurring immediately before loss of normal power without need for manual intervention by an operator when power is restored either through a backup power source, or through normal power if restored before backup power is brought on-line.
2. Include means and methods required to satisfy requirement even if not explicitly indicated.

G. Vibration:

1. Rotating assemblies shall be dynamically balanced to achieve a balance level of "good" while complying with industry standard requirements for cooling towers.
2. Critical speed shall be at least 115 percent of design speed.

2.3 DESIGN ARRANGEMENT

A. Combined flow with airflow from one side and induced-draft, top-mounted, axial fan; and with pressurized pipe distribution.

B. Combined flow with airflow from two sides and induced-draft, top-mounted, axial fan; and with pressurized pipe distribution.

C. Combined flow with airflow from all (four) sides and induced-draft, top-mounted, axial fan; and with pressurized pipe distribution.

2.4 CASING AND FRAME

A. Casing Material: Galvanized steel, ASTM A653/A653M, G235 (Z700) coating or Polymer-coated galvanized steel.

B. Frame Material: Galvanized steel, ASTM A653/A653M, G235 (Z700) coating, polymer-coated galvanized steel or materials to match casing.

C. Hardware: Galvanized or stainless steel.

D. Joints and Seams: Sealed watertight.

E. Welded Connections: Sealed watertight by continuous welds.

2.5 COLLECTION BASIN

A. Field-Constructed Collection Basin: Configure tower without a factory-assembled collection basin for installation and operation with a field-constructed collection basin.

B. Factory-Assembled Collection Basin:

1. Material: Galvanized steel, ASTM A653/A653M, G235 (Z700) coating or Polymer-coated galvanized steel.
2. Hardware: Galvanized or stainless steel.
3. Joints and Seams: Sealed watertight.
4. Welded Connections: Sealed watertight by continuous welds.
5. Removable stainless-steel strainer with openings smaller than nozzle orifices.
6. Overflow and drain connections.
7. Makeup-water connection.
8. Outlet Connection: Configured to mate to ASME B16.5, Class 150 flange.

2.6 COLLECTION BASIN MAKEUP-WATER ASSEMBLY

A. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.

B. Electric/Electronic, Collection Basin Water-Level Controller with Makeup-Water Valve:

1. Enclosures: NEMA 250, Type 4 or Type 4X.
2. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to control makeup-water valve, control makeup-water valve and low-level alarm, control makeup-water valve and low- and high-level alarms or control makeup-water valve, low- and high-level alarms, and output for shutoff of pump on low level.
3. Electrode Probes: Stainless steel.
4. Water Stilling Chamber: Corrosion-resistant material, FRP, Galvanized steel, PVC pipe, Stainless steel, Grade 304 or Stainless steel, Grade 316.
5. Makeup-Water Valve:

    a. Slow closing with stainless-steel body.
    b. Valve actuator controlled and powered through level controller in response to water-level set point.
    c. Actuator Enclosure: NEMA 250, Type 4 or Type 4X.
    d. Fail Position: Closed, Open or Last.
    e. Action: Two position or modulating.

6. Electrical Connection Requirements: 120-V ac, single phase, 60 Hz.

2.7 COLLECTION BASIN HEATER

A. Electric Heater:

1. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
2. Heater Control Panel: Mounted on the side of each cooling tower cell.
3. Enclosure: NEMA 250, Type 3R, Type 4 or Type 4X.
4. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
5. Control-circuit transformer with primary and secondary side fuses.
6. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
7. Single-point, field-power connection to a fused disconnect switch, nonfused disconnect switch or circuit breaker and heater branch circuiting complying with NFPA 70.
8. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except make connections to each electric basin heater with liquidtight conduit.

    a. Raceway shall be corrosion-resistant stainless steel or PVC coated steel.

2.8 PRESSURIZED DISTRIBUTION NETWORK

A. Main header and lateral branch piping designed for even distribution over fill and heat-exchanger coils throughout the entire flow range without the need for balancing valves and for connecting individual, easily removable, nonclogging spray nozzles.

B. Pipe Material: Schedule 40 PVC.

C. Spray Nozzle Material: Plastic, Polypropylene or PVC.

D. Piping Supports: Corrosion-resistant hangers and supports to resist movement during operation and shipment.

2.9 FILL

A. Materials: PVC, with maximum flame-spread index of 5 - 25 according to ASTM E84.

B. Minimum Thickness: 15 mils (0.4 mm) or 20 mils (0.5 mm) before forming.

C. Fabrication: Fill-type sheets, fabricated, formed, and bonded together after forming into removable assemblies that are factory installed by manufacturer.

D. Fill Material Operating Temperature: Suitable for entering-water temperatures up through 120 deg F (49 deg C).

E. Hardware: Galvanized or stainless steel.

2.10 HEAT-EXCHANGER COILS

A. Tube and Tube Sheet Materials: Copper tube with stainless-steel tube sheet, stainless-steel tube and tube sheet or carbon-steel tube and sheet with outer surface of tube and sheet hot-dip galvanized after fabrication.

B. Heat-Exchanger Arrangement:

1. Serpentine tubes, serpentine tubes with removable cover plate on inlet and outlet headers or straight tubes with removable header cover plate on both ends of heat exchanger for straight-through access to each tube; sloped for complete drainage of fluid by gravity.
2. Tubes with extended surface fins if required to achieve performance indicated.
3. Multiple Separate Circuits: Separate circuits to achieve multiple isolated loops as required by application.

C. ASME Compliance: Designed, manufactured, and tested according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, and bearing ASME "U" stamp; sloped for complete drainage of fluid by gravity.

D. Field Piping Connections: Vent, supply, and return suitable for mating to ASME B16.5, Class 150 flange.

2.11 DRIFT ELIMINATORS

A. Material: PVC with maximum flame-spread index of 5 - 25 according to ASTM E84.

B. UV Treatment: Inhibitors to protect against damage caused by UV radiation.

C. Arrangement: Multiple, easily removable sections.

D. Configuration: Multipass, designed and tested to reduce water carryover to 0.001 percent of design flow rate indicated.

E. Hardware: Galvanized or stainless steel.

2.12 AIR INLET

A. Air-Intake Louvers:

1. Material: PVC.
2. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
3. Multiple, easily removable sections arranged to uniformly direct air into cooling tower, to minimize air resistance, to block direct sunlight, and to prevent water from splashing out of tower during all modes of operation including operation with fans off.

B. Removable Air-Intake Screens:

1. Galvanized, Polymer-coated, galvanized or Stainless steel wire mesh with openings of size sufficient to not restrict airflow or impact performance.
2. Segmented into manageable individual sections arranged to facilitate independent removal of each section without disturbing adjoining sections.

C. Hardware: Galvanized or stainless steel.

2.13 FAN AND DRIVE ASSEMBLY

A. Axial Fan: Balanced at the factory after assembly.

1. Blade Material: Aluminum, FRP or galvanized steel.
2. Hub Material: Aluminum, FRP or galvanized steel.
3. Blade Pitch: Field adjustable.
4. Fan Shaft: Corrosion resistant or Stainless steel.
5. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C). Bearings designed for an L-10 life of 40,000, 50,000 or 100,000 hours, as directed.
6. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.
7. Automatic Bearing Greasing System:

    a. Manufacturer-designed system to provide an as-needed supply of new grease to bearings while reducing the need for periodic bearing maintenance and associated greasing problems.
    b. Easily replaceable storage container filled with recommended grease and located in an easily accessible location on cooling tower exterior. Container capacity of sufficient size to provide grease for one year.

B. Belt Drive:

1. Service Factor: 1.5 based on motor nameplate horsepower.
2. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
3. Belt: Multiple V-belt design with a matched set of cogged belts.

4. Belt: One-piece, multigrooved, solid-back belt.
5. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
6. Belt-Drive Guard: Comply with OSHA regulations.
7. Two-Motor, Single-Fan Drive:

    a. Two single-speed motors per fan, one sized for full speed and load and the other sized for 67 percent of full-load speed.
    b. Each motor shall have belt drive and be configured for operation when other motor fails.
    c. Controls and wiring same as two-speed, two-winding motor.

C. Direct Drive: Fan hub directly connected, and properly secured, to motor shaft.

D. Gear Drive: Right angle, reduced speed, and designed for cooling tower applications according to CTI STD 111. Motor and gear drive shall be aligned before shipment.

1. Gear Drive and Coupling Service Factor: 2.0 based on motor nameplate horsepower.
2. Housing: Cast iron, with epoxy or polyurethane finish, beveled high-strength steel gears continuously bathed in oil, and with lubrication to other internal parts at all operating speeds.
3. Mounting: Directly mounted to fan hub and connected to motor so motor shaft is in horizontal position.
4. Operation: Able to operate both forward and in reverse. Able to operate throughout entire speed range from design speed indicated down to 10 - 20 of design speed.
5. Drive-to-Motor Connection: Close coupled to motor using a flexible coupling.
6. Drive-to-Motor Connection: Connected to motor located outside of cooling tower casing by a full-floating drive shaft.
7. Drive Shaft Material: Corrosion resistant or Stainless steel and fitted with flexible couplings on both ends.
8. Drive Guards: Provide exposed shaft and couplings with guards according to OSHA regulations.
9. Extend oil fill, drain, and vent to outside of cooling tower casing using galvanized-steel or stainless-steel piping. Provide installation with oil-level sight glass.

E. Fan Motor:

1. Comply with NEMA MG 1 unless otherwise indicated.
2. Description: NEMA MG 1, Design B as required to comply with capacity and torque characteristics; medium induction motor.
3. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
4. Motor Enclosure: Totally enclosed, Totally enclosed air-over (TEAO), Totally enclosed fan-cooled (TEFC) and with epoxy or polyurethane finish.
5. Rotor: Random-wound, squirrel cage.
6. Energy Efficiency: Comply with ASHRAE/IES 90.1 or NEMA Premium Efficient.
7. Service Factor: 1.15.
8. Temperature Rise: Match or One class lower than insulation rating.
9. Insulation: Class F or Class H.

10. Variable-Speed Motors: Inverter-duty rated per NEMA MG 1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
11. Motor Location: Mounted outside of cooling tower casing and cooling tower discharge airstream.
12. Severe-Duty Rating:

    a. Rotor and stator protected with corrosion-inhibiting epoxy resin.
    b. Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C).
    c. Internal Heater: Automatically energized when motor is de-energized.
    d. Complying with IEEE 841.

13. Motor Base: Adjustable, or other suitable provision for adjusting belt tension.
14. Motor Shaft Grounding: Motors shall be controlled through variable-frequency controllers with shaft grounding system to protect motor bearings from induced voltage. Drag on motor shaft due to shaft ground system shall be less than 0.5 percent of motor nameplate horsepower.

F. Hardware: Galvanized or stainless steel.

2.14 AIR DISCHARGE

A. Fan Discharge Stack:

1. Manufacturer's standard low-profile design.
2. Material: Material to match casing.
3. Stack Extension: Fabricated to extend above fan deck unless otherwise indicated.
4. Stack Termination: Wire-mesh, galvanized-steel, polymer-coated, galvanized-steel or stainless-steel screens; segmented into multiple removable pie sections and complying with OSHA regulations.

B. Discharge Hood:

1. Hood Configuration: Tapered or Straight; totally surrounding heat exchanger, pressurized distribution system and drift eliminators; constructed of same material as casing; and having factory-installed insulation and access doors.
2. Discharge Dampers: Positive-closure, automatic, isolation dampers constructed of aluminum, galvanized-steel or stainless-steel with corrosion-resistant linkages and electric actuators with NEMA 250, Type 4X enclosure.

    a. If not provided with factory controls, provide field power and controls to open dampers when pump is energized and close dampers when pump is de-energized.

3. Capacity-Control Dampers: Aluminum, Galvanized-steel or Stainless-steel dampers, with corrosion-resistant linkages, electric operator, controller, limit switches, transformer, and weatherproof enclosure.

a. If not provided with factory controls, provide field power and controls to operate dampers when pump is energized and close dampers when pump and fan is de-energized.

C. Hardware: Galvanized or stainless steel.

2.15 RECIRCULATING WATER DISTRIBUTION SYSTEM

A. Pump: Close-coupled, single-stage, bronze-fitted centrifugal pump; with mechanical seal and suitable for outdoor service. Factory install pump with the following:

1. Redundant Pump: Same performance as required for primary pump; easily switched and maintained while cooling tower remains operating.
2. Flanges at pump connections to piping.
3. Strainer, with blowdown isolation valve, installed in piping on suction side of pump.
4. Flow balancing valve in piping on discharge side of pump.

B. Pump Motor:

1. Comply with NEMA MG 1 unless otherwise indicated.
2. Description: NEMA MG 1, Design B as required to comply with capacity and torque characteristics; medium induction motor.
3. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
4. Motor Enclosure: Totally enclosed with epoxy or polyurethane finish.
5. Rotor: Random-wound, squirrel cage.
6. Energy Efficiency: Comply with ASHRAE/IES 90.1 or NEMA Premium Efficient.
7. Service Factor: 1.15.
8. Temperature Rise: Match or One class lower than insulation rating.
9. Insulation: Class F or Class H.
10. Severe-Duty Rating:

    a. Rotor and stator protected with corrosion-inhibiting epoxy resin.
    b. Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C).
    c. Internal Heater: Automatically energized when motor is de-energized.
    d. Complying with IEEE 841.

C. Piping: Interconnecting collection basin to pump and pressurization distribution system.

1. Design delegated to manufacturer.
2. External to and supported from cooling tower casing and frame.
3. Material: Corrosion resistant or PVC.
4. Install flanges at connections to collection basin and pressurized distribution system.
5. Drain connection with isolation valve at piping low point if piping does not drain directly into collection basin.

D. Piping: Field installed for connection to remotely installed pump and water storage that are not furnished with cooling tower.

2.16 ELECTRICAL POWER

A. Factory Furnish for Field Installation: A disconnect switch, motor controller or variable-frequency controller for each fan motor and a disconnect switch or motor controller for each pump motor.

B. Factory Install: A disconnect switch, motor controller or variable-frequency controller for each fan motor and a disconnect switch or motor controller for each pump motor.

1. Locate in a convenient and field-accessible location within sight of motor.
2. Installation shall comply with NFPA 70.
3. Wire, Conduit, and Enclosures:

    a. Minimum Conduit Size: 0.75 inch (20 mm).
    b. Materials: Corrosion resistant and constructed of stainless steel or PVC coated steel.
    c. Motor Termination: Liquidtight conduit, not to exceed 36 inches (900 mm) long.
    d. Supports: Support conduits, boxes, and enclosures using corrosion-resistant fastening hardware constructed of stainless steel.
    e. Wire:

        1) Copper, rated for 600-V, solid wire for size No. 10 AWG size and smaller and stranded wire for larger sizes.
        2) Minimum Wire Size: No. 12 AWG.
        3) Each circuit shall have a ground wire.
        4) Install wire in conduit.

    f. Boxes, Condulets, and Enclosures: NEMA 250, Type 3R, Type 4 or Type 4X.

C. Disconnect Switches:

1. Specification Grade; "Heavy Duty Type"; "quick-make," "quick-break" construction.
2. Three pole, fused or nonfused.
3. 600-V rated.
4. Minimum short-circuit current rating (SCCR) shall be as required by electrical power distribution system, but not less than 42,000 - 65,000 A.
5. Enclosure: NEMA 250, Type 3R, Type 4 or Type 4X or Type 4X stainless steel.
6. Operating handle shall be of box-mounted type that directly drives switch mechanism.
7. Disconnect switch shall use a flange-operated visible blade that is close coupled to a vertical-lift-type handle that achieves a positive visible indication of disconnect with cover open or closed.
8. Disconnect switch shall have a defeatable, front-accessible, mechanical interlock to prevent opening of cover when switch is in "ON" position, and to prevent turning switch "ON" when the door is open.
9. Include a solid neutral as required by authorities having jurisdiction.
10. Include a ground lug for ground wire termination.
11. Operating handle shall be lockable in open position.

12. Horsepower rated.
13. Feed through or double lugged.

D. Motor Controllers:

1. NEMA ICS 2, Class A, full-voltage, non-reversing, motor-rated controller.
2. Configured for control of single- or multispeed motors as indicated.
3. Enclosure: NEMA 250, Type 3R, Type 4, Type 4X or Type 4X stainless steel Type, with hinged full-front access door with lock and key.
4. Externally Operated, Door-Interlocked Disconnect: Fused disconnect switch, Nonfused disconnect switch or Circuit breaker with lockable handle.
5. SCCR shall be as required by electrical power distribution system, but not less than 42,000 - 65,000 A.
6. Hand-Off-Auto Switch: Mounted on face of enclosure.
7. Push-to-Test Run Status Pilot Lights: NEMA ICS 2, heavy-duty type.
8. Control Relays: Time-delay relays.
9. Phase-Failure, Phase-Reversal, Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hardwired connection.
10. Elapsed-Time Meters: Numerical readout in hours on face of enclosure.
11. Number-of-Starts Counter: Numerical readout on face of enclosure.

E. Variable-Frequency Controllers:

1. Description: NEMA ICS 2; arranged to achieve motor variable speed by adjusting output voltage and frequency.
2. Enclosure: Unit mounted, NEMA 250, Type 3R, Type 4 or Type 4X or Type 4X stainless steel, with hinged full-front access door with lock and key.
3. Externally Operated, Door-Interlocked Disconnect: Fused disconnect switch, Nonfused disconnect switch or Circuit breaker with lockable handle.
4. Minimum SCCR: As required by electrical power distribution system, but not less than 42,000 - 65,000 A.
5. Technology: Pulse-width-modulated (PWM) output with insulated gate bipolar transistors (IGBT); suitable for variable torque loads.
6. Controller shall consist of a rectifier converter section, a digital/analog driver regulator section, and an inverter output section.
7. Output Rating: Three phase; with voltage proportional to frequency throughout voltage range.
8. Output signal shall be programmed to not cause mechanical vibration issues with fan drive assembly.
9. Operating Requirements:

    a. Input AC Voltage Tolerance: 10 percent.
    b. Input frequency tolerance of 60 Hz, plus or minus 2 Hz.
    c. Capable of driving full motor load, without derating.
    d. Minimum Efficiency: 96 percent at 60 Hz, full load.
    e. Minimum Displacement Primary-Side Power Factor: 95 percent.
    f. Overload Capability: 1.05 times the full-load current for 7 seconds.
    g. Starting Torque: As required by fan and motor drive assembly.
    h. Speed Regulation: 1 percent.
    i. Speed Range: 10:1 speed range.

j. To avoid equipment resonant vibrations, include critical speed lockout circuitry to allow bands of operating frequency at which controller shall not operate continuously.
k. Capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.

10. Controller Adjustability Capabilities: Minimum and maximum output frequency, acceleration and deceleration, and current limit.
11. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions shall not result in component failure or the need for replacement:

a. Overtemperature.
b. Short circuit at controller output.
c. Ground fault at controller output. Variable-frequency controller shall be able to start a grounded motor.
d. Open circuit at controller output.
e. Input undervoltage.
f. Input overvoltage.
g. Loss of input phase.
h. Reverse phase.
i. AC line switching transients.
j. Instantaneous overload, line to line or line to ground.
k. Sustained overload exceeding 100 percent of controller rated current.
l. Starting a rotating motor.

12. Motor Protection: Controller shall protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.
13. Automatic Reset and Restart:

a. Capable of multiple restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction.
b. Capable of automatic restart on phase-loss and overvoltage and undervoltage trips.

14. Visual Indication: On face of controller; indicating the following conditions:

a. Power on.
b. Run.
c. Overcurrent and overvoltage.
d. Motor speed (percent).
e. Various faults with alarm status.
f. Input kilovolt amperes.
g. Power factor.
h. Input kilowatts and kilowatt-hours.
i. Three-phase input and output voltage.
j. Three-phase input and output current.
k. Output frequency.
l. Elapsed operating time (hours).
m. Diagnostic and service parameters.

15. Operator Interface: Start-stop and auto-manual selector with manual-speed-control potentiometer.

16. Control Signal Interface: A minimum of two analog inputs (0 to 10 V or 0/4 to 20 mA) and four programmable digital inputs.

2.17 CONTROLS

A. Vibration Switch: For each fan drive.

1. Enclosure: NEMA 250, Type 4 or Type 4X.
2. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
3. Switch shall have manual-reset button with hardwired connection to fan motor electrical circuit.
4. Switch shall have field connection for hardwired connection to control system.
5. Switch shall, on sensing excessive vibration, signal an alarm for connection to control system and shut down the fan.

B. Vibration Transmitter with Switch: For each fan drive.

1. Enclosure: NEMA 250, Type 4X.
2. Display: Local display of measured value, power, and alarm.
3. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point.

    a. Cooling tower manufacturer shall select range that is suitable for cooling tower provided and recommend switch set point for proper operation and protection.

4. Transmitter: Continuous vibration level indication through a 4- to 20-mA signal for connection to control system.
5. Switch:

    a. Relay and switch with manual-reset button for field connection to control system and hardwired connection to fan motor electrical circuit.
    b. Switch shall, on sensing excessive vibration, signal an alarm to control system and shut down the fan.

6. Mounting: Locate out of cooling tower discharge airstream and mount in a location that is accessible and where display is easily viewable.
7. Field Electrical Connection Requirements: 120 V, single phase, 60 Hz.

C. Gear-Drive, Oil-Level Switch: Low-oil-level warning switch for connection to control system.

1. Switch shall, on reaching a low-oil-level set point recommended by cooling tower manufacturer, signal an alarm through control system.

2.18 WATER TREATMENT

A. Chemical-Free Water Treatment System: Complete factory-installed system consisting of the following:

1. Pulsed-power technology emitting high-frequency bursts of low energy electromagnetic fields to the recirculated water to control corrosion, bacteria, and scale.
2. Conductivity control of electrically operated valve designed to control totally dissolved solids levels and bleed rates.
3. Piping associated with system.
4. Interconnecting power and control wiring installed in corrosion-resistant metal raceway.

B. Chemical Water Treatment System: Complete factory-installed system consisting of the following:

1. Microprocessor-controlled conductivity controller housed in a NEMA 250, Type 4X enclosure.
2. Chemical metering pump housed in a NEMA 250, Type 4X enclosure.
3. Electrically operated valve designed to control totally dissolved solids levels and bleed rates.
4. Piping associated with system.
5. Interconnecting power and control wiring installed in corrosion-resistant metal raceway.

2.19 CAPACITIES AND CHARACTERISTICS

A. Number of Cells: As directed.

B. Air-Inlet Arrangement: One, two or all sides.

C. Maximum Drift Loss: 0.001 percent of design water flow.

D. Heat Exchanger:

1. Fluid Type: Water.
2. Fluid Flow per Cell: As directed, gpm (L/s).
3. Minimum Fluid Flow per Cell: As directed, gpm (L/s).
4. Fluid Pressure Drop: As directed, psig (kPa).
5. Fluid Pressure Rating: As directed, psig (kPa).
6. Entering-Fluid Temperature: As directed, deg F (deg C).
7. Leaving-Fluid Temperature: As directed, deg F (deg C).
8. Entering-Air Wet-Bulb Temperature: As directed, deg F (deg C).
9. Airflow per Cell: As directed, cfm (L/s).

E. Economizer-Mode Performance:

1. Fluid Flow per Cell: As directed, gpm (L/s).
2. Entering-Fluid Temperature: As directed, deg F (deg C).
3. Leaving-Fluid Temperature: As directed, deg F (deg C).
4. Entering-Air Wet-Bulb Temperature: As directed, deg F (deg C).

F. Fan Drive Assembly:

1. Type: Belt, direct or gear.
2. Fan Motor:

a. Type: Single speed, Two speed, single winding, Two speed, two winding or Variable speed.
b. Motor Size per Cell: As directed, hp.
c. Full-Load Ampacity: As directed.
d. Minimum Circuit Ampacity: As directed.
e. Maximum Overcurrent Protection Device: As directed.
f. Electrical Characteristics: 208, 240 or 480V ac, 3 phase, 60 Hz.

G. Pump and Motor:

1. Water Flow per Cell: As directed, gpm (L/s).
2. Motor Size per Cell: As directed, hp.
3. Full-Load Ampacity: As directed.
4. Minimum Circuit Ampacity: As directed.
5. Maximum Overcurrent Protection Device: As directed.
6. Electrical Characteristics: 120, 208, 240, 277 or 480V ac, single or 3 phase, 60 Hz.

H. Sound Pressure Level: dBA, as directed feet (m) when measured according to CTI ATC 128.

I. Collection Basin Heater:

1. Basin Water Temperature: 40 deg F (5 deg C).
2. Outdoor Ambient Temperature: 0 deg F (Minus 18 deg C) or Minus 20 deg F (Minus 29 deg C).
3. Capacity per Cell: As directed.
4. Full-Load Ampacity: As directed.
5. Minimum Circuit Ampacity: As directed.
6. Maximum Overcurrent Protection Device: As directed.
7. Electrical Characteristics: 208, 240 or 480V ac, 3 phase, 60 Hz.

2.20 SOURCE QUALITY CONTROL

A. Performance Test: Factory test and certify cooling tower performance according to CTI STD 201RS, "Standard for the Certification of Water-Cooling Tower Thermal Performance."

B. Seismic Performance Testing: Shake table tested by an independent or a factory-certified laboratory to certify performance complies with seismic requirements indicated.

C. Factory Functional Tests:

1. Test collection and distribution basins after assembly and prove free of leaks.
2. Test factory-installed electric/electronic water-level controls for proper operation.
3. Test factory-installed electric basin heaters for proper operation.
4. Test factory-installed fan and drive assemblies for proper operation.

D. Heat-Exchanger Factory Pressure and Leak Tests:

1. Pneumatically test heat-exchanger assembly while submerged underwater and prove to be free of leaks.

2. Test pressure equal to 1.5 times rated pressured, but not less than (As directed) psig (kPa).
3. Submit report documenting test and results.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Examine cooling towers before installation. Reject cooling towers that are damaged.

B. Install cooling towers on support structure.

C. Equipment Mounting:

1. Install cooling towers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." Or Section 033053 "Miscellaneous Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

D. Install anchor bolts to elevations required for proper attachment to supported equipment.

E. Maintain manufacturer's recommended clearances for service and maintenance.

F. Maintain clearances required by governing code.

3.2 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to cooling towers, allow space for service and maintenance.

C. Install flexible pipe connectors at pipe connections of cooling towers mounted on vibration isolators.

D. Connect cooling tower overflows and drains, and piping drains, to sanitary sewage system.

E. Makeup-Water Piping:

1. Comply with applicable requirements in Section 221116 "Domestic Water Piping."
2. Connect to makeup-water connections with shutoff valve, plugged tee with pressure gage, flow meter, and drain connection with valve and union.

F. Supply and Return Piping:

1. Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
2. Connect to entering cooling tower connections with shutoff valve, strainer, balancing valve, thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve.
3. Connect to leaving cooling tower connection with shutoff valve thermometer, plugged tee with full port ball valve for portable field instruments, and drain connection with valve.
4. Make connections to cooling tower with a flange.

3.3 ELECTRICAL POWER CONNECTIONS

A. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

B. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding connections.

C. Install nameplate for each electrical connection indicating electrical equipment designation and circuit number feeding connection. Nameplate shall be laminated phenolic layers of black with engraved white letters at least 1/2 inch (13 mm) high. Locate nameplate where easily visible.

3.4 CONTROLS CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between cooling towers and other equipment to interlock operation as required to achieve a complete and functioning system.

3.5 FIELD TESTING PROVISIONS

A. Include provisions for cooling tower future field-performance testing complying with ASME PTC 23 or CTI ATC 105.

B. Include provisions in field piping for future field-performance testing complying with ASME PTC 23 or CTI ATC 105.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Tests and Inspections: Comply with ASME PTC 23 or CTI ATC 105.

E. Cooling towers will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform or Perform startup service.

B. Inspect field-assembled components, equipment installation, and piping; controls; and electrical connections for proper assemblies, installations, and connections.

C. Obtain performance data from manufacturer.

1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

a. Clean entire unit including basins.
b. Verify that accessories are properly installed.
c. Verify clearances for airflow and for cooling tower servicing.
d. Check for vibration isolation and structural support.
e. Lubricate bearings.
f. Verify fan rotation for correct direction and for vibration or binding and correct problems.
g. Verify pump rotation for correct direction, vibration, cavitation and flow and correct problems.
h. Adjust belts to proper alignment and tension.
i. Operate variable-speed fans through entire operating range and check for harmonic vibration imbalance. Set motor controller to skip speeds resulting in abnormal vibration.
j. Check vibration switch setting. Verify operation.
k. Verify water level in tower basin. Fill to proper startup level. Check makeup-water-level control and valve.
l. Verify operation of basin heater and control.
m. Verify that cooling tower air discharge is not recirculating air into tower or HVAC air intakes. Recommend corrective action.
n. Replace defective and malfunctioning units.

D. Start cooling tower and associated water pumps. Follow manufacturer's written starting procedures.

E. Prepare a written startup report that records the results of tests and inspections.

3.8 ADJUSTING

A. Set and balance water flow to each tower inlet.

B. Adjust water-level control for proper operating level.

C. Adjust basin heater control for proper operating set point.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train or train Owner's maintenance personnel to adjust, operate, and maintain cooling towers.

END OF SECTION 236514.17

SECTION 237213 - HEAT WHEEL AIR-TO-AIR ENERGY RECOVERY UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes heat wheels.

B. Related Requirements:

1. Section 233119 "HVAC Casings" for customized housings used for air-to-air energy recovery units.
2. Section 237313.19 "Indoor, Custom Air-Handling Units" for custom housings used for air-to-air energy recovery units.
3. Section 237343.19 "Outdoor, Custom Air-Handling Units" for custom housings used for air-to-air energy recovery units.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: For air-to-air energy recovery equipment.

1. Include plans, elevations, sections, details, and mounting or attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

D. Delegated-Design Submittal: For air-to-air energy recovery equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, elevations, and other details, drawn to scale and coordinated with each other, using input from installers of the items involved.

B. Seismic Qualification Data: Certificates, for air-to-air energy recovery equipment, accessories, and components, from manufacturer.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of air-to-air energy recovery equipment that fail in materials or workmanship within specified warranty period.

1. As directed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of unit components.

C. ASHRAE Compliance:

1. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
2. Capacity ratings for air-to-air energy recovery equipment shall comply with ASHRAE 84, "Method of Testing Air-to-Air Heat/Energy Exchangers."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation and seismic restraints, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

F. Seismic Performance: Air-to-air energy recovery equipment shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 - 1.0.

2.2 CAPACITIES AND CHARACTERISTICS

A. Exhaust Air:

1. Airflow: As directed, cfm (L/s).
2. Face Velocity: As directed, fpm (m/s).
3. Summer:

    a. Entering-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    b. Entering-Air Temperature, Wet Bulb: As directed, deg F (deg C).
    c. Leaving-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    d. Leaving-Air Temperature, Wet Bulb: As directed, deg F (deg C).

4. Winter:

    a. Entering-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    b. Entering-Air Temperature, Wet Bulb: As directed, deg F (deg C).
    c. Leaving-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    d. Leaving-Air Temperature, Wet Bulb: As directed, deg F (deg C).

5. Air Pressure Drop: As directed, inches wg (Pa).

B. Supply Air:

1. Airflow: As directed, cfm (L/s).
2. Face Velocity: As directed, fpm (m/s).
3. Summer:

    a. Entering-Air Temperature, Dry Bulb:). As directed, deg F (deg C).
    b. Entering-Air Temperature, Wet Bulb:). As directed, deg F (deg C).
    c. Leaving-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    d. Leaving-Air Temperature, Wet Bulb: As directed, deg F (deg C).

4. Winter:

    a. Entering-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    b. Entering-Air Temperature, Wet Bulb: As directed, deg F (deg C).
    c. Leaving-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    d. Leaving-Air Temperature, Wet Bulb: As directed, deg F (deg C).

5. Air Pressure Drop: As directed, inches wg (Pa).

C. Wheel Drive:

1. Motor Size: As directed.
2. Motor Electrical Characteristics: As directed.

    a. Volts: 120, 208 or 230V.
    b. Phase: Single or Three.
    c. Hertz: 60 Hz.

D. Effectiveness: As directed.

2.3 MANUFACTURERS

2.4 HEAT WHEELS

A. Casing:

1. Galvanized steel, stainless steel, or aluminum with standard factory finish.
2. Integral purge section limiting carryover of exhaust air to between 0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg (0.05 percent at 400-Pa and 0.20 percent at 1000-Pa) differential pressure.
3. Casing seals on periphery of rotor and on duct divider and purge section.
4. Support vertical rotors on grease-lubricated ball bearings having extended grease fittings or permanently lubricated bearings with an L-10, 400,000 hours. Support horizontal rotors on tapered roller bearing.

B. Rotor: Aluminum or polymer segmented wheel strengthened with radial spokes, with nontoxic, noncorrosive, silica-gel desiccant coating.

C. Rotor: Aluminum, metallic, or polymer segmented wheel strengthened with radial spokes impregnated with nonmigrating, water-selective, 3-angstrom, molecular-sieve desiccant coating.

D. Drive: Fractional horsepower motor and gear reducer, with speed changed by variable-frequency controller and self-adjusting multilink belt around outside of rotor.

1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

E. Controls:

1. Starting relay, factory mounted and wired, and manual motor starter for field wiring.
2. Variable-Frequency Controller: Factory mounted and wired, permitting input of field-connected 4- to 20-mA or 1- to 10-V control signal.
3. Variable-Frequency Controller with Exhaust-Air Sensor: Factory mounted and wired, with exhaust-air sensor to vary rotor speed and maintain exhaust temperature above freezing.
4. Variable-Frequency Controller with Exhaust- and Outdoor-Air Sensors: Factory mounted and wired, with exhaust- and outdoor-air sensors, automatic changeover thermostat and set-point adjuster, to vary rotor speed and maintain exhaust temperature above freezing and air differential temperature above set point. Rotor speed shall increase to maximum when exhaust-air temperature is less than outdoor-air temperature.
5. Pilot-Light Indicator: Display rotor rotation and speed.
6. Speed Settings: Adjustable settings for maximum and minimum rotor speed limits.

2.5 SOURCE QUALITY CONTROL

A. AHRI 1060 Certification: Testing according to AHRI 1060 and listed and labeled by AHRI.

PART 3 - EXECUTION

3.1 INSTALLATION OF HEAT WHEELS

A. Examine roughing-in for electrical services to verify actual locations of connections before installation.

B. Install heat wheels so supply and exhaust airstreams flow in opposite directions and rotation is away from exhaust side to purge section to supply side.

1. Install access doors in both supply and exhaust ducts, both upstream and downstream, for access to wheel surfaces, drive motor, and seals.
2. Install removable panels or access doors between supply and exhaust ducts on building side for bypass during startup.
3. Access doors and panels are specified in Section 233300 "Air Duct Accessories."

C. Install floor-mounted units on 4-inch- (100-mm-) high concrete base designed to withstand, without damage to equipment, seismic force required by code.

D. Equipment Mounting:

1. Install air-to-air energy recovery equipment on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." Or Section 033053 "Miscellaneous Cast-in-Place Concrete."

E. Install seismic restraints according to manufacturers' written instructions.

F. Suspended Units: Suspend and brace units from structural-steel support frame using threaded steel rods and spring hangers. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

G. Install units with clearances for service and maintenance.

H. Comply with requirements for ductwork specified in Section 233113 "Metal Ducts."

3.2 PIPING CONNECTIONS

A. Comply with requirements for piping specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to unit, allow space for service and maintenance.

C. Connect piping to units mounted on vibration isolators with flexible connectors.

D. Condensate Drain Piping: Pipe drains from drain pans to nearest floor drain; use ASTM B88, Type L (ASTM B88M, Type B), drawn-temper copper water tubing with soldered joints, same size as condensate drain connection.

E. Condensate Drain Piping: Pipe drains from drain pans to nearest floor drain; use ASTM D1785, Schedule 40 PVC pipe and solvent-welded fittings, same size as condensate drain connection.

F. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

3.3 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Adjust seals and purge.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
4. Set initial temperature and humidity set points.
5. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

D. Air-to-air energy recovery equipment will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train or train Owner's maintenance personnel to adjust, operate, and maintain air-to-air energy recovery units.

END OF SECTION 237213

SECTION 237216 - HEAT PIPE AIR-TO-AIR ENERGY RECOVERY UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes heat-pipe heat exchangers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: For air-to-air energy recovery equipment.

1. Include plans, elevations, sections, and mounting or attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

D. Delegated-Design Submittal: For air-to-air energy recovery equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of air-to-air energy recovery equipment.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, elevations, and other details, drawn to scale and coordinated with each other, using input from installers of the items involved.

B. Seismic Qualification Data: Certificates, for air-to-air energy recovery equipment, accessories, and components, from manufacturer.

C. Field quality-control reports.

D. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of air-to-air energy recovery equipment that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Heat Pipe Energy Recovery Equipment: Two years.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NPFA Compliance: Comply with NFPA 90A for design, fabrication, and installation of unit components.

C. ASHRAE Compliance:

1. Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
2. Capacity ratings for air-to-air energy recovery equipment shall comply with ASHRAE 84, "Method of Testing Air-to-Air Heat/Energy Exchangers."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to detail fabrication and assembly of air-to-air energy recovery equipment.

F. Seismic Performance: Air-to-air energy recovery equipment shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 - 1.0.

2.2 CAPACITIES AND CHARACTERISTICS

A. Exhaust Air:

1. Airflow: As directed, cfm (L/s).
2. Face Velocity: As directed, fpm (m/s).
3. Summer:

    a. Entering-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    b. Entering-Air Temperature, Wet Bulb: As directed, deg F (deg C).
    c. Leaving-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    d. Leaving-Air Temperature, Wet Bulb: As directed, deg F (deg C).

4. Winter:

    a. Entering-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    b. Entering-Air Temperature, Wet Bulb: As directed, deg F (deg C).
    c. Leaving-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    d. Leaving-Air Temperature, Wet Bulb: As directed, deg F (deg C).

5. Air Pressure Drop: As directed, inches wg (Pa).

B. Supply Air:

1. Airflow: As directed, cfm (L/s).
2. Face Velocity: As directed, fpm (m/s).
3. Summer:

    a. Entering-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    b. Entering-Air Temperature, Wet Bulb: As directed, deg F (deg C).
    c. Leaving-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    d. Leaving-Air Temperature, Wet Bulb: As directed, deg F (deg C).

4. Winter:

    a. Entering-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    b. Entering-Air Temperature, Wet Bulb: As directed, deg F (deg C).
    c. Leaving-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    d. Leaving-Air Temperature, Wet Bulb: As directed, deg F (deg C).

5. Air Pressure Drop: As directed, inches wg (Pa).

C. Tilt Motor:

1. Horsepower: As directed, hp.
2. Electrical Characteristics:

    a. Volts: As directed, V.
    b. Phase: As directed.
    c. Hertz: 60 Hz.

D. Effectiveness: As directed.

2.3 HEAT-PIPE HEAT EXCHANGERS

A. Casing: Galvanized or Stainless steel flanged casing, with airtight single or double partition between airstreams.

B. Refrigerant: ASHRAE 34, Safety Group 1.

C. Tubes:

1. Tube Diameter: As directed, diameter.
2. Tube Material: Aluminum or Copper.
3. Number of Tube Rows: As required to meet scheduled capacity conditions.

D. Fins: As directed.

1. Fin Spacing: As required to meet scheduled capacity conditions.
2. Fin and Tube Joint: Mechanical bond or Silver brazed.

E. Coating: None, Flexible epoxy polymer e-coating or Baked phenolic; apply to supply and exhaust.

F. Control: Integral plenum containing heat-pipe coil and gasketed, face-and-bypass, opposed-blade dampers with rods extended outside casing for damper operator and linkage.

G. Control: Pivot center of bottom of heat-pipe coil on shaft and bearings to tilt coil. Include tilt controls with electronic controller, electric actuator and linkage, thermostats, sensors, and polyester fabric with PVC-coated flexible connector for automatic supply temperature regulation, summer/winter changeover, and frost protection.

2.4 SOURCE QUALITY CONTROL

A. AHRI Certification: Certified according to AHRI 410.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install heat-pipe heat exchangers so supply and exhaust airstreams flow in opposite directions. Install flexible connectors on ducts to enable tilt control; make connections airtight and with slack to compensate for full tilt.

1. Install heat exchanger with clearance space for heat-pipe coil removal.
2. Install duct access doors in both supply and exhaust ducts, both upstream and downstream, for access to both sides of heat-pipe coil. Access doors and panels are specified in Section 233300 "Air Duct Accessories."
3. Install tilt-control components, including electronic controller, electric actuator and linkage, thermostats, and sensors.

B. Install floor-mounted units on 4-inch- (100-mm) high, concrete base designed to withstand, without damage to equipment, seismic force required by code.

C. Equipment Mounting:

1. Install air-to-air energy recovery equipment on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." Or Section 033053 "Miscellaneous Cast-in-Place Concrete."

D. Install seismic restraints according to manufacturers' written instructions.

E. Install units with clearances for service and maintenance.

3.2 PIPING CONNECTIONS

A. Comply with requirements for piping specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to unit, allow space for service and maintenance.

C. Connect piping to units mounted on vibration isolators with flexible connectors.

D. Condensate Drain Piping: Pipe drains from drain pans to nearest floor drain; use ASTM B88, Type L (ASTM B88M, Type B), drawn-temper copper water tubing with soldered joints, same size as condensate drain connection.

E. Condensate Drain Piping: Pipe drains from drain pans to nearest floor drain; use ASTM D1785, Schedule 40 PVC pipe and solvent-welded fittings, same size as condensate drain connection.

F. Condensate Drain Piping Installation: Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

3.3 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260529 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished with units, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."

2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper tilt control and unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

D. Air-to-air energy recovery equipment will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform or Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that shipping, blocking, and bracing are removed.
3. Verify that unit is secure on mountings and supporting devices and that connections to electrical systems are complete. Verify that proper thermal-overload protection is installed.
4. Verify tilt mechanism operation.
5. Verify that moving parts are lubricated with factory-recommended lubricants.

B. Starting procedures for air-handling units include the following:

1. Energize actuator motor and verify proper operation of motor and tilt system.
2. Measure and record motor electrical values for voltage and amperage.
3. Operate bypass dampers from full closed to fully open position.

3.7 ADJUSTING

A. Adjust tilt mechanism for proper operation.

B. Adjust bypass dampers for proper operation.

C. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

3.8 CLEANING

A. After completing system installation and testing, adjusting, and balancing air-to-air heat recovery unit, and after completing startup service, clean unit to remove foreign material and construction dirt and dust.

3.9 DEMONSTRATION

A. Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain heat pipe air-to-air energy recovery units.

END OF SECTION 237216

SECTION 237219 - FIXED PLATE AIR-TO-AIR ENERGY RECOVERY UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes fixed-plate, sensible and total, heat exchangers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: For air-to-air energy recovery equipment.

1. Include plans, elevations, sections, and mounting or attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

D. Delegated-Design Submittal: For air-to-air energy recovery equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of air-to-air energy recovery equipment.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, elevations, and other details, drawn to scale and coordinated with each other, using input from installers of the items involved.

B. Seismic Qualification Data: Certificates, for air-to-air energy recovery equipment, accessories, and components, from manufacturer.

C. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of air-to-air energy recovery equipment that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Fixed-Plate Total Heat Exchangers: 10 years.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of unit components.

C. ASHRAE Compliance:

1. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
2. Capacity ratings for air-to-air energy recovery equipment shall comply with ASHRAE 84, "Method of Testing Air-to-Air Heat/Energy Exchangers."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. Comply with ASTM E84 or UL 723.

F. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to detail fabrication and assembly of air-to-air energy recovery equipment.

G. Seismic Performance: Air-to-air energy recovery equipment shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 - 1.0.

2.2 CAPACITIES AND CHARACTERISTICS

A. Type: Fixed-plate sensible or total heat exchanger.

B. Exhaust Air:

1. Airflow: As directed, cfm (L/s).

2. Face Velocity: As directed, fpm (m/s).
3. Summer:

    a. Entering-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    b. Entering-Air Temperature, Wet Bulb: As directed, deg F (deg C).
    c. Leaving-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    d. Leaving-Air Temperature, Wet Bulb: As directed, deg F (deg C).

4. Winter:

    a. Entering-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    b. Entering-Air Temperature, Wet Bulb: As directed, deg F (deg C).
    c. Leaving-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    d. Leaving-Air Temperature, Wet Bulb: As directed, deg F (deg C).

5. Air Pressure Drop: As directed, inches wg (Pa).

C. Supply Air:

1. Airflow: As directed, cfm (L/s).
2. Face Velocity: As directed, fpm (m/s).
3. Summer:

    a. Entering-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    b. Entering-Air Temperature, Wet Bulb: As directed, deg F (deg C).
    c. Leaving-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    d. Leaving-Air Temperature, Wet Bulb: As directed, deg F (deg C).

4. Winter:

    a. Entering-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    b. Entering-Air Temperature, Wet Bulb: As directed, deg F (deg C).
    c. Leaving-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    d. Leaving-Air Temperature, Wet Bulb: As directed, deg F (deg C).

5. Air Pressure Drop: As directed, inches wg (Pa).

D. Effectiveness: As directed.

2.3 FIXED-PLATE SENSIBLE HEAT EXCHANGERS

A. Casing: Aluminum or Galvanized steel with duct collars.

B. Plates: Evenly spaced, sealed, and arranged for counter or cross airflow.

1. Plate Material: Embossed aluminum, Stainless steel or High-density plastic.
2. Plate Coating: None or Epoxy.

C. Bypass Plenum: Within casing, with gasketed face-and-bypass dampers having operating rods extended outside casing.

D. Maximum Differential Pressure: Suitable for maximum 6-inch wg (1500 Pa).

E. Maximum Temperature: Suitable for maximum 194 deg F (90 deg C).

F. Water Wash: Automatic system, with spray manifold to individual spray tubes or traversing type with stainless-steel-screw operating mechanism and electric motor drive; activated by time clock, with detergent injection.

2.4 FIXED-PLATE TOTAL HEAT EXCHANGERS

A. Casing: Aluminum or Galvanized steel.

B. Drain Pan: Same material as casing, with drain connections on exhaust and supply side or Molded ABS covering bottom of case, with drain connections on exhaust and supply side.

1. Comply with requirements in ASHRAE 62.1.

C. Plates: Evenly spaced, sealed, and arranged for counter airflow.

1. Plate Material and Coating: Chemically treated paper, or polymer on aluminum, with selective hydroscopicity, moisture permeability, and gas barrier properties.

D. Bypass Plenum: Within casing, with gasketed face-and-bypass dampers having operating rods extended outside casing.

E. Maximum Differential Pressure: Suitable for maximum 6-inch wg (1500 Pa).

F. Maximum Temperature: Suitable for maximum 194 deg F (90 deg C).

2.5 SOURCE QUALITY CONTROL

A. AHRI 1060 Certification: Certified according to AHRI 1060.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install fixed-plate heat exchangers so supply and exhaust airstreams flow in opposite directions.

1. Install duct access doors in both supply and exhaust ducts, both upstream and downstream, for access to heat exchanger. Access doors and panels are specified in Section 233300 "Air Duct Accessories."

B. Install floor-mounted units on 4-inch (100-mm) high, concrete base designed to withstand, without damage to equipment, seismic force required by code.

C. Equipment Mounting:

1. Install air-to-air energy recovery equipment on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." Or Section 033053 "Miscellaneous Cast-in-Place Concrete."

D. Install seismic restraints according to manufacturers' written instructions.

E. Install units with clearances for service and maintenance.

F. Comply with requirements for ductwork specified in Section 233113 "Metal Ducts."

G. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

3.2 PIPING CONNECTIONS

A. Comply with requirements for piping specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to unit, allow space for service and maintenance.

C. Connect piping to units mounted on vibration isolators with flexible connectors.

D. Condensate Drain Piping: Pipe drains from drain pans to nearest floor drain; use ASTM B88, Type L (ASTM B88M, Type B), drawn-temper copper water tubing with soldered joints, same size as condensate drain connection.

E. Condensate Drain Piping: Pipe drains from drain pans to nearest floor drain; use ASTM D1785, Schedule 40 PVC pipe and solvent-welded fittings, same size as condensate drain connection.

F. Condensate Drain Piping Installation: Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

3.3 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260529 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 250526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."

2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper water wash control and unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

D. Air-to-air energy recovery equipment will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.6 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform or Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that shipping, blocking, and bracing are removed.
3. Verify that unit is secure on mountings and supporting devices and that connections to electrical systems are complete. Verify that proper thermal-overload protection is installed.
4. Verify water wash mechanism operation.

B. Starting procedures for air-handling units include the following:

1. Energize water wash motor and verify proper operation of motor and water wash system.
2. Measure and record motor electrical values for voltage and amperage.

3.7 CLEANING

A. After completing system installation and testing, adjusting, and balancing air-to-air heat recovery unit, and after completing startup service, clean unit to remove foreign material and construction dirt and dust.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train or train Owner's maintenance personnel to adjust, operate, and maintain fixed-plate air-to-air energy recovery units.

END OF SECTION 237219

SECTION 237223.13 - PACKAGED INDOOR HEAT WHEEL ENERGY RECOVERY UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Heat wheels in packaged energy-recovery units.

B. Related Requirements:

1. Section 237313.16 "Indoor, Semi-Custom Air-Handling Units" for indoor, semi-custom air-handling units if they also include coils, other than electric coils for frost control, in addition to heat wheels.
2. Section 237313.19 "Indoor, Custom Air-Handling Units" for indoor, custom air-handling units if they also include coils, other than electric coils for frost control, in addition to heat wheels.
3. Section 237343.16 "Outdoor, Semi-Custom Air-Handling Units" for outdoor, semi-custom air-handling units if they also include coils, other than electric coils for frost control, in addition to heat wheels.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: For air-to-air energy recovery equipment.

1. Include plans, elevations, sections, details, and mounting or attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

D. Delegated-Design Submittal: For air-to-air energy-recovery equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of air-to-air energy-recovery equipment.
2. Vibration-Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
3. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration-isolation bases.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, elevations, and other details, drawn to scale and coordinated with each other, using input from installers of the items involved.

B. Seismic Qualification Data: Certificates, for air-to-air energy-recovery equipment, accessories, and components, from manufacturer.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of packaged, indoor, heat wheel energy-recovery units that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Packaged Energy-Recovery Units: Two years.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

B. ASHRAE Compliance:

1. Applicable requirements in ASHRAE 62.1.
2. Capacity ratings for air-to-air energy-recovery equipment shall comply with ASHRAE 84.

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.

D. UL Compliance:

1. Packaged heat-recovery ventilators shall comply with requirements in UL 1812 or UL 1815.
2. Electric coils shall comply with requirements in UL 1995.

E. Comply with ASTM E84 or UL 723.

F. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration-isolation controls and seismic restraints, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

G. Seismic Performance: Packaged, indoor, heat wheel energy-recovery units shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 - 1.0.

2.2 CAPACITIES AND CHARACTERISTICS

A. Exhaust Air:

1. Airflow: As directed, cfm (L/s).
2. Face Velocity: As directed, fpm (m/s).
3. Summer:

    a. Entering-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    b. Entering-Air Temperature, Wet Bulb: As directed, deg F (deg C).
    c. Leaving-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    d. Leaving-Air Temperature, Wet Bulb: As directed, deg F (deg C).

4. Winter:

    a. Entering-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    b. Entering-Air Temperature, Wet Bulb: As directed, deg F (deg C).
    c. Leaving-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    d. Leaving-Air Temperature, Wet Bulb: As directed, deg F (deg C).

5. Air Pressure Drop: As directed, inches wg (Pa).
6. Fan Motor Size: As directed, horsepower (watts).
7. Fan Motor Electrical Characteristics:

    a. Volts: 120, 208 or 230 V.
    b. Phase: Single or Three.
    c. Hertz: 60.

B. Supply Air:

1. Airflow: As directed, cfm (L/s).
2. Face Velocity: As directed, fpm (m/s).
3. Summer:

    a. Entering-Air Temperature, Dry Bulb: As directed, deg F (deg C).

b. Entering-Air Temperature, Wet Bulb: As directed, deg F (deg C).
c. Leaving-Air Temperature, Dry Bulb: As directed, deg F (deg C).
d. Leaving-Air Temperature, Wet Bulb: As directed, deg F (deg C).

4. Winter:

a. Entering-Air Temperature, Dry Bulb: As directed, deg F (deg C).
b. Entering-Air Temperature, Wet Bulb: As directed, deg F (deg C).
c. Leaving-Air Temperature, Dry Bulb: As directed, deg F (deg C).
d. Leaving-Air Temperature, Wet Bulb: As directed, deg F (deg C).

5. Air Pressure Drop: As directed, inches wg (Pa).
6. Fan Motor Size: As directed, horsepower (watts).
7. Fan Motor Electrical Characteristics:

a. Volts: 120, 208 or 230 V.
b. Phase: Single or Three.
c. Hertz: 60.

C. Wheel Drive:

1. Motor Size: As directed, horsepower (watts).
2. Motor Electrical Characteristics:

a. Volts: 120, 208 or 230.
b. Phase: Single or Three.
c. Hertz: 60.

D. Effectiveness: As directed, percent.

E. Electric Frost-Control Coils:

1. Heat-Transfer Rate: As directed, Btu/h (kW).
2. Entering-Air Temperature: As directed, deg F (deg C).
3. Leaving-Air Temperature: As directed, deg F (deg C).
4. Power Input: As directed, Kw.
5. Volts: As directed, V.
6. Phase: Single or Three.
7. Hertz: 60.
8. Full-Load Amperes: As directed, A.
9. Maximum Overcurrent Protection: As directed, A.
10. Capacity Control Number of Steps: As directed.

F. Filters:

1. Type: Flat, nonpleated or pleated.
2. Face Dimensions, each: As directed, inches by inches (mm by mm).
3. Depth: As directed, inches (mm).
4. Number of Filters, Wide by High: As directed, inches by inches (mm by mm).
5. Maximum or Rated Face Velocity: As directed, fpm (m/s).
6. Initial Resistance: As directed, inches wg (Pa).

7. Recommended Final Resistance: As directed, inches wg (Pa).
8. Minimum Efficiency Reporting Value and Average Arrestance:

    a. MERV Rating: MERV 1, MERV 2, MERV 3 and MERV 4]and corresponding average arrestance according to ASHRAE 52.2.

9. Minimum Efficiency Reporting Value:

    a. MERV Rating: MERV 6 or MERV 13 according to ASHRAE 52.2.

2.3 PACKAGED, INDOOR, HEAT WHEEL ENERGY-RECOVERY UNITS

A. Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. Housing: Manufacturer's standard construction with corrosion-protection coating and exterior finish, gasketed, hinged access doors or removable panels with neoprene gaskets for inspection and access to internal parts, minimum (1- (25) – (2- (50-) inch- (mm-) thick, thermal insulation, knockouts for electrical connections, exterior drain connection, and lifting lugs.

C. Heat Wheel:

1. Casing:

    a. Manufacturer's standard construction with standard factory finish.
    b. Slide-in, slide-out cassette style for easy access.
    c. Integral purge section, limiting carryover of exhaust air to between percent at (as directed) inch (Pa) and percent at (as directed) inch (Pa) differential pressure.
    d. Casing seals on periphery of rotor and on duct divider and purge section.
    e. Support vertical rotors on grease-lubricated ball bearings having extended grease fittings or permanently lubricated bearings with an L-50 of 200,000 hours. Support horizontal rotors on tapered roller bearing.

2. Rotor: Aluminum or polymer segmented wheel, strengthened with radial spokes.
3. Rotor: Aluminum or polymer segmented wheel, strengthened with radial spokes, with nontoxic, noncorrosive, silica-gel coating.
4. Rotor: Aluminum, metallic, or polymer segmented wheel, strengthened with radial spokes impregnated with nonmigrating, water-selective, four-angstrom, molecular-sieve desiccant coating.
5. Drive: Fractional horsepower motor and gear reducer, with speed changed by variable-frequency motor controller and self-adjusting multilink belt around outside of rotor.

    a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
    b. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

D. Supply and Exhaust Fans: Forward-curved, centrifugal fan with spring isolators of restrained, spring isolators of 1- (25-) inch (mm) static deflection, as directed.

1. Motor and Drive: Direct driven or Belt driven with adjustable sheaves; motor mounted on adjustable base, with speed changed by variable-frequency motor controller.
2. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

E. Filters:

1. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."

F. Filters:

1. Description: Flat, nonpleated or Pleated factory-fabricated, self-supported, disposable air filters with holding frames.
2. UL Compliance: Comply with UL 900.
3. Media: Interlaced glass fibers sprayed with nonflammable adhesive and antimicrobial agent.
4. Filter Media Frame: Beverage board with perforated metal retainer or metal grid on outlet side.
5. Filter-Mounting Frames: Arranged with access doors or panels on both sides of unit. Filters shall be removable from one side or lift out from access plenum.

G. Electric Coils:

1. Casing Assembly: Slip-in or Flanged type with galvanized-steel frame.
2. Access: Fabricate coil section to allow removal and replacement of coil and to allow in-place access for service.
3. Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
4. Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout safety device; serviceable through terminal box without removing heater from coil section.
5. Secondary Protection: Load-carrying, manually resetting or manually replaceable thermal cutouts; factory wired in series with each heater stage.
6. Control Panel: Unit or Remote mounted with disconnecting means and overcurrent protection.

    a. Magnetic contactor.
    b. Solid-state, stepless SCR controller or Step controller.
    c. Time-delay relay.
    d. Pilot lights

        1) One per step for step-controlled coils.

    e. Airflow proving switch.

H. Wiring: Fabricate units with space within housing for electrical conduits. Wire motors and controls, so only external connections are required during installation.

1. Indoor Enclosure: NEMA 250, Type 12 enclosure contains relays, starters, and terminal strip.
2. Include fused or nonfused disconnect switches.

2.4 CONTROLS

A. Control Panel: Solid-state, programmable, microprocessor-based control unit for wall mounting. Integrate to BACnet, LonWorks, or Modbus, as specified in Section 230923 "Direct Digital Control (DDC) System for HVAC".

B. Starting relay, factory mounted and wired, and manual motor starter for field wiring.

C. Frost Control: Electric preheat or Variable rotor speed.

D. Motion (Occupancy) Sensor: Passive infrared sensor for wall or ceiling mounting, with adjustable time-off delay of up to 30 minutes to energize unit.

E. Carbon Dioxide Sensor: Adjustable control from 600 to 2000 ppm for wall or duct mounting, with digital display and computer/building management system interface to energize unit.

F. Economizer Control: Stop wheel rotation or modulate wheel rotation when conditions are favorable for economizer operation.

G. Economizer Control: Heat wheel airflow bypass. See Section 230923 "Direct Digital Control (DDC) System for HVAC" for control sequence.

H. Dry-bulb temperature or Enthalpy sensor.

I. Rotation sensor and alarm.

J. Dirty filter switch.

K. Low-Voltage Transformer: Integral transformer to provide control voltage to unit from primary incoming electrical service.

L. Electric Coil Controls:

1. Factory-mounted sensor in outside-air intake with sensor adjustment located in control panel to control electric coil and maintain minimum entering temperature, to avoid frost formation.

M. Variable-Frequency Motor Controller: Comply with Section 262923 "Variable-Frequency Motor Controllers."

N. Variable-Frequency Motor Controller: Serving wheel rotation motor.

1. Manufactured Units: Pulse-width modulated; constant torque and variable torque, as directed, for Design A and Design B or inverter-duty motors, as directed.
2. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range or 66 Hz, with torque constant as speed changes; maximum voltage equals input voltage.

3. Unit Operating Requirements:

   a. Internal Adjustability:

      1) Minimum Speed: 5 to 25 percent of maximum rpm.
      2) Maximum Speed: 80 to 100 percent of maximum rpm.
      3) Acceleration: 0.1 to 999.9 seconds, as directed.
      4) Deceleration: 0.1 to 999.9 seconds, as directed.
      5) Current Limit: 30 to minimum of 150 percent of maximum rating.

   b. Self-Protection and Reliability Features:

      1) Surge suppression.
      2) Loss of input signal protection.
      3) Under- and overvoltage trips.
      4) Variable-frequency motor controller and motor-overload/overtemperature protection.
      5) Critical frequency rejection.
      6) Loss-of-phase protection.
      7) Reverse-phase protection.
      8) Motor-overtemperature fault.

   c. Bidirectional autospeed search.
   d. Torque boost.
   e. Motor temperature compensation at slow speeds.

      1) Panel-mounted operator station.
      2) Historical logging information and displays.
      3) Digital indicating devices.

   f. Control Signal Interface: Electric.
   g. Proportional integral derivative (PID) control interface.
   h. DDC System for HVAC Protocols for Network Communications: ASHRAE 135.

4. Line Conditioning:

   a. Input line conditioning.
   b. Output filtering.
   c. EMI/RFI filtering.

O. Variable-Speed Control: Factory mounted and wired, permitting input of field-connected, 4-20 mA or 1-10-V control signal.

P. Variable-Speed Control: Factory mounted and wired, with exhaust-air sensor to vary rotor speed and maintain exhaust temperature above freezing.

Q. Variable-Speed Control: Factory mounted and wired, with exhaust- and outdoor-air sensors, automatic changeover thermostat, and set-point adjuster, to vary rotor speed and maintain exhaust temperature above freezing and air differential temperature above set point. Rotor speed shall increase to maximum when exhaust-air temperature is less than outdoor-air temperature.

2.5 SOURCE QUALITY CONTROL

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended application.

B. AHRI Compliance: Capacity ratings for air-to-air energy-recovery equipment certified as complying with AHRI 1060 (AHRI 1061).

C. Fan Performance Rating: Comply with AMCA 211 and label fans with AMCA-certified rating seal. Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency according to AMCA 210/ASHRAE 51.

D. Fan Sound Rating: Comply with AMCA 301 or AHRI 260 (IP). Air-handling unit fan sound ratings shall comply with AMCA 301 or AHRI 260 (IP).

E. UL Compliance:

1. Packaged heat recovery ventilators shall comply with requirements in UL 1812 or UL 1815.
2. Electric Coils: Comply with UL 1995.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Examine casing insulation materials and filter media before packaged, indoor, heat wheel energy-recovery unit installation. Replace with new insulation materials any filter media that are wet, moisture damaged, or mold damaged.

B. Install packaged, indoor, heat wheel energy-recovery units, so supply and exhaust airstreams flow in opposite directions, and rotation is away from exhaust side to purge section to supply side.

1. Install access doors in both supply and exhaust ducts, both upstream and downstream, for access to wheel surfaces, drive motor, and seals.
2. Install removable panels or access doors between supply and exhaust ducts on building side for bypass during startup.
3. Access doors and panels are specified in Section 233300 "Air Duct Accessories."

C. Equipment Mounting:

1. Install packaged, indoor, heat wheel energy-recovery units on 4-inch(100mm) cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." Or Section 033053 "Miscellaneous Cast-in-Place Concrete."
2. Comply with requirements for vibration-isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

3. Comply with requirements for vibration-isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

D. Suspended Units: Suspend and brace units from structural-steel support frame, using threaded steel rods and spring hangers. Comply with requirements for vibration-isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC." Or Section 230548.13 "Vibration Controls for HVAC."

E. Install units with clearances for service and maintenance.

F. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.

3.2 DUCTWORK CONNECTIONS

A. Comply with requirements for ductwork according to Section 233113 "Metal Ducts."

B. Connect duct to units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."

C. Isolation Dampers: Install isolation dampers according to Section 230923.12 "Control Dampers."

3.3 PIPING CONNECTIONS

A. Comply with requirements for piping specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to unit, allow service and maintenance.

C. Connect piping to units mounted on vibration isolators with flexible connectors.

D. Condensate Drain Piping: See Section 232113 "Hydronic Piping" for pipe type. Pipe drains from drain pans to nearest floor drain, same size as condensate drain connection.

1. Construct deep trap at connection to drain pan, and install cleanouts at changes in direction.

3.4 ELECTRICAL CONNECTIONS

A. Install electrical devices furnished with units but not factory mounted.

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

D. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

E. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.5 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Tests and Inspections:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Packaged, indoor, heat wheel energy-recovery equipment will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train or train Owner's maintenance personnel to adjust, operate, and maintain air-to-air energy-recovery units.

END OF SECTION 237223.13

SECTION 237223.19 – PACKAGED INDOOR FIXED PLATE ENERGY RECOVERY UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fixed-plate, sensible heat exchangers in packaged, indoor, energy-recovery units.
2. Fixed-plate, total heat exchangers in packaged, indoor, energy-recovery units.

B. Related Requirements:

1. Section 237313.16 "Indoor, Semi-Custom Air-Handling Units" for indoor, semi-custom air-handling units if they also include coils, other than electric coils for frost control, in addition to fixed plate heat exchangers.
2. Section 237313.19 "Indoor, Custom Air-Handling Units" for indoor, custom air-handling units if they also include coils, other than electric coils for frost control, in addition to fixed plate heat exchangers.
3. Section 237343.16 "Outdoor, Semi-Custom Air-Handling Units" for outdoor, semi-custom air-handling units if they also include coils, other than electric coils for frost control, in addition to fixed plate heat exchangers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: For packaged, indoor, fixed-plate, energy-recovery units.

1. Include plans, elevations, sections, details, and mounting or attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, elevations, and other details, drawn to scale and coordinated with each other, using input from installers of the items involved.

B. Seismic Qualification Data: Certificates, for packaged, indoor, fixed-plate, energy-recovery units, accessories, and components, from manufacturer.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of packaged, indoor, fixed-plate, energy-recovery units that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Packaged Energy-Recovery Units: Two years.
2. Warranty Period for Fixed-Plate Total Heat Exchangers: 10 years.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

B. ASHRAE Compliance:

1. Applicable requirements in ASHRAE 62.1.
2. Capacity ratings for fixed-plate energy-recovery units shall comply with ASHRAE 84.

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.

D. UL Compliance:

1. Packaged heat-recovery ventilators shall comply with requirements in UL 1812 or UL 1815.
2. Electric coils shall comply with requirements in UL 1995.

E. Comply with ASTM E84 or UL 723.

F. Seismic Performance: Packaged, indoor, fixed-plate, energy-recovery units shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 - 1.0.

2.2 CAPACITIES AND CHARACTERISTICS

A. Type: Fixed-plate sensible or total energy-recovery unit.

B. Exhaust Air:

1. Airflow: As directed, cfm (L/s).
2. Face Velocity: As directed, fpm (m/s).
3. Summer:

    a. Entering-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    b. Entering-Air Temperature, Wet Bulb: As directed, deg F (deg C).
    c. Leaving-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    d. Leaving-Air Temperature, Wet Bulb: As directed, deg F (deg C).

4. Winter:

    a. Entering-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    b. Entering-Air Temperature, Wet Bulb: As directed, deg F (deg C).
    c. Leaving-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    d. Leaving-Air Temperature, Wet Bulb: As directed, deg F (deg C).

5. Air Pressure Drop: As directed, inches wg (Pa).
6. Fan Motor Size: As directed, horsepower (watts).
7. Fan Motor Electrical Characteristics:

    a. Volts: 120, 208 or 230 V.
    b. Phase: Single or Three.
    c. Hertz: 60.

C. Supply Air:

1. Airflow: As directed, cfm (L/s).
2. Face Velocity: As directed, fpm (m/s).
3. Summer:

    a. Entering-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    b. Entering-Air Temperature, Wet Bulb: As directed, deg F (deg C).
    c. Leaving-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    d. Leaving-Air Temperature, Wet Bulb: As directed, deg F (deg C).

4. Winter:

    a. Entering-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    b. Entering-Air Temperature, Wet Bulb: As directed, deg F (deg C).
    c. Leaving-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    d. Leaving-Air Temperature, Wet Bulb: As directed, deg F (deg C).

5. Air Pressure Drop: As directed, inches wg (Pa).
6. Fan Motor Size: As directed.
7. Fan Motor Electrical Characteristics:

a. Volts: 120, 208 or 230 V.
b. Phase: Single or Three.
c. Hertz: 60.

D. Effectiveness: As directed, percent.

E. Electric Frost-Control Coils:

1. Heat-Transfer Rate: As directed, Btu/h (kW).
2. Entering-Air Temperature: As directed, deg F (deg C).
3. Leaving-Air Temperature: As directed, deg F (deg C).
4. Power Input: Kw.
5. Volts: 208, 230 or 480 V.
6. Phase: Single or Three.
7. Hertz: 60.
8. Full-Load Amperes: As directed, A.
9. Maximum Overcurrent Protection: As directed, A.
10. Capacity Control Number of Steps: As directed.

F. Filters:

1. Type: Flat, nonpleated or Pleated.
2. Face Dimensions, Each: As directed, inches by inches (mm by mm).
3. Depth: As directed, inches (mm).
4. Number of Filters, Wide by High: As directed, inches by inches (mm by mm).
5. Maximum or Rated Face Velocity: As directed, fpm (m/s).
6. Initial Resistance: As directed, inches wg (Pa).
7. Recommended Final Resistance: As directed, inches wg (Pa).
8. Minimum Efficiency Reporting Value and Average Arrestance:

a. MERV Rating: MERV 1, MERV 2, MERV 3 or MERV 4, as directed, and corresponding average arrestance according to ASHRAE 52.2.

9. Minimum Efficiency Reporting Value:

a. MERV Rating: MERV 6 or MERV 13 according to ASHRAE 52.2.

2.3 PACKAGED, INDOOR, FIXED-PLATE, SENSIBLE ENERGY-RECOVERY UNITS

A. Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. Housing: Manufacturer's standard construction with corrosion-protection coating and exterior finish, gasketed, hinged access doors or removable panels with neoprene gaskets for inspection and access to internal parts, minimum 1-inch (25mm) - 2-inch (50mm) thick, thermal insulation, knockouts for electrical and piping connections, exterior drain connection, and lifting lugs.

C. Fixed-Plate Sensible Heat Exchanger:

1. Casing: Aluminum
2. Drain Pan: Same material as casing, with drain connections on exhaust and supply side.

a. Comply with requirements in ASHRAE 62.1.

3. Plates: Evenly spaced, sealed, and arranged for counter or cross flow.

a. Plate Material: Embossed aluminum.

4. Bypass Plenum: Within casing, with gasketed face-and-bypass dampers having operating rods extended outside casing.

D. Supply and Exhaust Fans: Forward-curved centrifugal fan with spring isolators or restrained spring isolators of 1-inch (25-mm) static deflection.

1. Motors and Drives: Direct driven, Belt driven with adjustable sheaves or Belt driven with fixed sheaves.

a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
b. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

E. Filters:

1. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."

F. Filters:

1. Description: Flat, nonpleated or Pleated factory-fabricated, self-supported, disposable air filters with holding frames.
2. UL Compliance: Comply with UL 900.
3. Media: Interlaced glass fibers sprayed with nonflammable adhesive and antimicrobial agent.
4. Filter Media Frame: Beverage board with perforated metal retainer or metal grid on outlet side.
5. Filter-Mounting Frames: Arranged with access doors or panels on both sides of unit. Filters shall be removable from one side or lift out from access plenum.

G. Electric Coils:

1. Casing Assembly: Slip-in or Flanged type with galvanized-steel frame.
2. Access: Fabricate coil section to allow removal and replacement of coil and to allow in-place access for service.
3. Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
4. Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout safety device; serviceable through terminal box without removing heater from coil section.
5. Secondary Protection: Load-carrying, manually resetting or manually replaceable thermal cutouts; factory wired in series with each heater stage.
6. Control Panel: Unit or Remote mounted with disconnecting means and overcurrent protection.

a. Magnetic contactor.
b. Solid-state, stepless SCR controller or Step controller.
c. Time-delay relay.
d. Pilot Lights:

1) One per step for step-controlled coils.

e. Airflow proving switch.

H. Wiring: Fabricate units with space within housing for electrical conduits. Wire motors and controls so only external connections are required during installation.

1. Indoor Enclosure: NEMA 250, Type 12 enclosure contains relays, starters, and terminal strip.
2. Include fused or nonfused disconnect switches.

2.4 PACKAGED, INDOOR, FIXED-PLATE TOTAL ENERGY RECOVERY UNITS

A. Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. Housing: Manufacturer's standard construction with corrosion-protection coating and exterior finish, gasketed, hinged access doors or removable panels with neoprene gaskets for inspection and access to internal parts, minimum 1-inch (25-mm) or 2-inch (50-mm) thick thermal insulation as directed, knockouts for electrical connections, exterior drain connection, and lifting lugs.

C. Fixed-Plate Total Heat Exchanger:

1. Casing: Galvanized steel.
2. Plates: Evenly spaced and sealed and arranged for counter flow or crossflow.

a. Plate Material: Chemically treated paper or polymer membrane with selective hydroscopicity and moisture permeability, and gas barrier properties.

3. Bypass Plenum: Within casing, with gasketed face-and-bypass dampers having operating rods extended outside casing.

D. Supply and Exhaust Fans: Forward-curved centrifugal fan with spring isolators or restrained spring isolators of 1-inch (25mm) static deflection.

1. Motor and Drive: Direct driven, Belt driven with adjustable sheaves or Belt driven with fixed sheaves.
2. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

E. Filters:

1. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."

F. Filters:

1. Description: Flat, nonpleated or Pleated factory-fabricated, self-supported, disposable air filters with holding frames.
2. UL Compliance: Comply with UL 900.
3. Media: Interlaced glass fibers sprayed with nonflammable adhesive and antimicrobial agent.
4. Filter Media Frame: Beverage board with perforated metal retainer, or metal grid, on outlet side.
5. Filter Mounting Frames: Arranged with access doors or panels on both sides of unit. Filters shall be removable from one side or lift out from access plenum.

G. Electric Coils:

1. Casing Assembly: Slip-in or Flang type with galvanized-steel frame.
2. Access: Fabricate coil section to allow removal and replacement of coil and to allow in-place access for service.
3. Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
4. Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout safety device; serviceable through terminal box without removing heater from coil section.
5. Secondary Protection: Load-carrying, manually resetting or manually replaceable thermal cutouts; factory wired in series with each heater stage.
6. Control Panel: Unit or Remote mounted with disconnecting means and overcurrent protection.

    a. Magnetic contactor.
    b. Solid-state, stepless SCR controller or Step controller.
    c. Time-delay relay.
    d. Pilot Lights:

        1) One per step for step-controlled coils.

    e. Airflow proving switch.

H. Wiring: Fabricate units with space within housing for electrical conduits. Wire motors and controls, so only external connections are required during installation.

1. Indoor Enclosure: NEMA 250, Type 12 enclosure contains relays, starters, and terminal strip.
2. Include fused or nonfused disconnect switches.

2.5 CONTROLS

A. Control Panel: Solid-state, programmable, microprocessor-based control unit for wall mounting, Integrate to BACnet, LonWorks, or Modbus, as specified in Section 230923 "Direct Digital Control (DDC) System for HVAC".

B. Starting relay, factory mounted and wired, and manual motor starter for field wiring.

C. Frost Control: Electric preheat.

D. Motion (Occupancy) Sensor: Passive infrared sensor for wall or ceiling mounting with adjustable time-off delay of up to 30 minutes to energize unit.

E. Carbon Dioxide Sensor: Adjustable control from 600 to 2000 ppm for wall or duct mounting, with digital display and computer/building management system interface to energize unit.

F. Economizer Control: Fixed-plate airflow bypass. See Section 230923 "Direct Digital Control (DDC) System for HVAC" for control sequence.

G. Dry-bulb temperature or Enthalpy sensor.

H. Dirty filter switch.

I. Low-Voltage Transformer: Integral transformer to provide control voltage to unit from primary incoming electrical service.

J. Electric-Coils Controls:

1. Factory-mounted sensor in outside-air intake with sensor adjustment located in control panel to control electric coil and maintain minimum entering temperature, to avoid frost formation.

2.6 SOURCE QUALITY CONTROL

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

B. AHRI Compliance: Capacity ratings for air-to-air energy-recovery equipment certified as complying with AHRI 1060 (AHRI 1061).

C. Fan Performance Rating: Comply with AMCA 211 and label fans with AMCA-certified rating seal. Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency according to AMCA 210/ASHRAE 51.

D. Fan Sound Ratings: Comply with AMCA 301 or AHRI 260 (IP). Air-handling unit fan sound ratings shall comply with AMCA 301 or AHRI 260 (IP).

E. UL Compliance:

1. Packaged fixed plate energy recovery units shall comply with requirements in UL 1812; or UL 1815.
2. Electric Coils: Comply with UL 1995.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Examine casing insulation materials and filter media before packaged, indoor, fixed-plate, energy-recovery unit installation. Replace with new insulation materials and filter media that are wet, moisture damaged, or mold damaged.

B. Install packaged, indoor, fixed-plate, energy-recovery units, so supply and exhaust airstreams flow in opposite directions.

1. Install access doors in both supply and exhaust ducts, both upstream and downstream, for access to interior components.
2. Install removable panels or access doors between supply and exhaust ducts on building side for bypass during startup.
3. Access doors and panels are specified in Section 233300 "Air Duct Accessories."

C. Equipment Mounting:

1. Install packaged, indoor, fixed-plate, energy-recovery units on 4-inch (100-mm) cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." Or Section 033053 "Miscellaneous Cast-in-Place Concrete."
2. Comply with requirements for vibration-isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration-isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

D. Suspended Units: Suspend and brace units from structural-steel support frame, using threaded steel rods and spring hangers. Comply with requirements for vibration-isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC." Or Section 230548.13 "Vibration Controls for HVAC."

E. Install units with clearances for service and maintenance.

F. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.

3.2 DUCTWORK CONNECTIONS

A. Comply with requirements for ductwork according to Section 233113 "Metal Ducts."

B. Connect duct to units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."

C. Isolation Dampers: Install isolation dampers according to Section 230923.12 "Control Dampers."

3.3 PIPING CONNECTIONS

A. Comply with requirements for piping specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to unit, allow for service and maintenance.

C. Connect piping to units mounted on vibration isolators with flexible connectors.

D. Condensate Drain Piping: See Section 232113 "Hydronic Piping" for pipe type. Pipe drains from drain pans to nearest floor drain, same size as condensate drain connection.

1. Construct deep trap at connection to drain pan, and install cleanouts at changes in direction.

3.4 ELECTRICAL CONNECTIONS

A. Install electrical devices furnished with units but not factory mounted.

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

D. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

E. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.5 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Tests and Inspections:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Packaged, indoor, fixed-plate, energy-recovery units will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train or train Owner's maintenance personnel to adjust, operate, and maintain air-to-air energy-recovery units.

END OF SECTION 237223.19

SECTION 237223.23 - PACKAGED, OUTDOOR, HEAT WHEEL ENERGY RECOVERY UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Heat wheels in packaged, outdoor, sensible heat or total energy recovery units.

B. Related Requirements:

1. Section 237343.16 "Outdoor, Semi-Custom Air-Handling Units" for outdoor, semi-custom air-handling units if they also include coils, other than electric coils for frost control, in addition to heat wheels.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

C. Shop Drawings: For packaged, outdoor, heat-wheel, energy-recovery units.

1. Include plans, elevations, sections, details, and mounting or attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, lifting requirements, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

D. Delegated-Design Submittal: For packaged, outdoor, heat-wheel, energy-recovery units indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of heat-wheel, energy-recovery equipment.
2. Vibration-Isolation Roof Curb Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include rails and frames for equipment mounting.
3. Design Calculations: Calculate requirements for selecting vibration isolators, seismic restraints and for designing vibration-isolation roof curbs.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, roof plans, elevations, and other details, drawn to scale and coordinated with each other, using input from installers of items involved.

B. Seismic Qualification Data: Certificates, for packaged, outdoor, heat-wheel, energy-recovery units, accessories, and components, from manufacturer.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 COORDINATION

A. Coordinate sizes and locations of building openings and duct connections with actual equipment provided.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of packaged, outdoor, heat-wheel, energy-recovery units that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Packaged Energy-Recovery Units: One – Three years from date of Substantial Completion.
2. Warranty Period for Energy-Recovery Wheel: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

B. ASHRAE Compliance:

1. Applicable requirements in ASHRAE 62.1.
2. Capacity ratings for heat-wheel, energy-recovery equipment: Comply with ASHRAE 84.

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.

D. UL Compliance:

1. Packaged Heat-Recovery Ventilators: Comply with requirements in UL 1815 or UL 1812.
2. Electric Coils: Comply with requirements in UL 1995.

E. Comply with ASTM E84 or UL 723.

F. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration-isolation controls and seismic restraints, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

G. Seismic Performance: Packaged, outdoor, heat wheel energy-recovery units shall withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 - 1.0.

2.2 CAPACITIES AND CHARACTERISTICS

A. Type: Heat-wheel sensible heat or total energy-recovery unit.

B. Exhaust Air:

1. Airflow: As directed, cfm (L/s).
2. Face Velocity: As directed, fpm (m/s).
3. Summer:

    a. Entering-Air Temperature, Dry Bulb: As directed, Insert deg F (deg C).
    b. Entering-Air Temperature, Wet Bulb: As directed, Insert deg F (deg C).
    c. Leaving-Air Temperature, Dry Bulb: As directed, Insert deg F (deg C).
    d. Leaving-Air Temperature, Wet Bulb: As directed, Insert deg F (deg C).

4. Winter:

    a. Entering-Air Temperature, Dry Bulb: As directed, Insert deg F (deg C).
    b. Entering-Air Temperature, Wet Bulb: As directed, Insert deg F (deg C).
    c. Leaving-Air Temperature, Dry Bulb: As directed, Insert deg F (deg C).
    d. Leaving-Air Temperature, Wet Bulb: As directed, Insert deg F (deg C).

5. Air Pressure Drop: As directed, inches wg (Pa).
6. Fan Motor Electrical Characteristics:

    a. Volts: 208, 230 or 460 V.
    b. Phase: Single or Three.
    c. Hertz: 60.

C. Supply Air:

1. Airflow: As directed, cfm (L/s).
2. Face Velocity: As directed, fpm (m/s).
3. Summer:

    a. Entering-Air Temperature, Dry Bulb: As directed, Insert deg F (deg C).

b. Entering-Air Temperature, Wet Bulb: As directed, Insert deg F (deg C).
c. Leaving-Air Temperature, Dry Bulb: As directed, Insert deg F (deg C).
d. Leaving-Air Temperature, Wet Bulb: As directed, Insert deg F (deg C).

4. Winter:

a. Entering-Air Temperature, Dry Bulb: As directed, Insert deg F (deg C).
b. Entering-Air Temperature, Wet Bulb: As directed, Insert deg F (deg C).
c. Leaving-Air Temperature, Dry Bulb: As directed, Insert deg F (deg C).
d. Leaving-Air Temperature, Wet Bulb: As directed, Insert deg F (deg C).

5. Air Pressure Drop: As directed, inches wg (Pa).
6. Fan Motor Size: As directed, horsepower (watts).
7. Fan Motor Electrical Characteristics:

a. Volts: 208, 230 or 460 V.
b. Phase: Single or Three.
c. Hertz: 60.

D. Wheel Drive:

1. Motor Size: As directed, horsepower (watts).
2. Motor Electrical Characteristics:

a. Volts: 208, 230 or 460 V.
b. Phase: Single or Three.
c. Hertz: 60.

E. Effectiveness: As directed, percent.

F. Electric Frost-Control Coils:

1. Heat-Transfer Rate: As directed, Btu/h (kW).
2. Entering-Air Temperature: As directed, deg F (deg C).
3. Leaving-Air Temperature: As directed, deg F (deg C).
4. Power Input: As directed, Kw.
5. Volts: 208, 230 or 480 V.
6. Phase: Single or Three.
7. Hertz: 60.
8. Full-Load Amperes: As directed, A.
9. Maximum Overcurrent Protection: As directed, A.
10. Provide Silicon-Controlled Rectifier (SCR) to modulate electric coil.

G. Filters:

1. Type: Cleanable wire mesh and Pleated.
2. Face Dimensions, each: As directed, inches by inches (mm by mm).
3. Depth: As directed, inches (mm).
4. Filter Quantity: As directed, Dimensions (Wide by High) inches by inches (mm by mm).
5. Maximum or Rated Face Velocity: As directed, fpm (m/s).

6. Initial Resistance: As directed, inches wg (Pa).
7. Recommended Final Resistance: As directed, inches wg (Pa).
8. Minimum Efficiency Reporting Value and Average Arrestance:

    a. MERV Rating: MERV 4 and corresponding average arrestance according to ASHRAE 52.2.

9. Minimum Efficiency Reporting Value:

    a. MERV Rating: MERV 6, MERV 8, MERV 11 or MERV 13 in accordance with ASHRAE 52.2.

2.3 PACKAGED, OUTDOOR, HEAT-WHEEL, ENERGY-RECOVERY UNITS

A. Source Limitations: Obtain packaged, outdoor, heat-wheel, energy-recovery units from single manufacturer.

B. Surfaces in Contact with Airstream: Comply with requirements in ASHRAE 62.1.

C. Housing: Manufacturer's standard construction with corrosion-protection coating and exterior finish, gasketed, hinged access doors or removable panels with neoprene gaskets for inspection and access to internal parts, minimum 1 inch (25 mm) or 2 inches (50 mm) thick, thermal insulation, knockouts for electrical connections, exterior drain connection, and lifting lugs.

D. Heat Wheel:

1. Casing:

    a. Manufacturer's standard construction with standard factory finish.
    b. Slide-in, slide-out cassette style.
    c. Provide unit with integral purge section, limiting carryover of exhaust air to between percent inch wg (Pa) as directed, and percent at inch wg (Pa) as directed, differential pressure.
    d. Provide casing seals on periphery of rotor and on duct divider and purge section.
    e. Support vertical rotors on grease-lubricated ball bearings having extended grease fittings or permanently lubricated bearings with minimum L-50 of 200,000 hours. Support horizontal rotors on tapered roller bearing.

2. Rotor: Aluminum or polymer segmented wheel, strengthened with radial spokes.
3. Rotor: Aluminum or polymer segmented wheel, strengthened with radial spokes, with nontoxic, noncorrosive, silica-gel coating.
4. Rotor: Aluminum, metallic, or polymer segmented wheel, strengthened with radial spokes impregnated with nonmigrating, water-selective, four-angstrom, molecular-sieve desiccant coating.
5. Drive: Electric motor, with speed changed by variable-frequency motor controller and self-adjusting multilink belt around outside of rotor.

    a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

b. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

E. Supply and Exhaust Fans: Centrifugal, forward-curved or backward-inclined fan with spring isolators, restrained, spring isolators of 1-inch (25-mm) static deflection.

1. Motor and Drive: Direct driven or Belt driven, with adjustable sheaves; motor mounted on adjustable base, with speed changed by variable-frequency motor controller.

a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
b. Motor Sizes: Minimum size as indicated. If size is not indicated, provide motor large enough so driven load will not require motor to operate in service factor range above 1.0.

F. Filters:

1. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."

G. Filters:

1. Description: Cleanable wire mesh at outside air intake and pleated, factory-fabricated, self-supported, disposable air filters with holding frames.
2. UL Compliance: Comply with UL 900.
3. Media: Interlaced glass fibers sprayed with nonflammable adhesive and antimicrobial coating.
4. Filter Media Frame: Beverage board with perforated metal retainer or metal grid on outlet side.
5. Filter-Mounting Frames: Arranged with access doors or panels on one or both sides of unit. Design unit with filters removable from one side, or lift out from access plenum.

H. Electric Coils:

1. Casing Assembly: Slip-in or Flanged type with galvanized-steel frame.
2. Access: Fabricate coil section to allow removal and replacement of coil, and to allow in-place access for service.
3. Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium, supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
4. Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout safety device; serviceable through terminal box without removing heater from coil section.
5. Secondary Protection: Load-carrying, manually resetting or manually replaceable thermal cutouts; factory wired in series with heater.
6. Control Panel: Unit or Remote mounted, with disconnecting means and overcurrent protection.

a. Magnetic contactor.
b. Solid-state, stepless SCR controller.
c. Time-delay relay.

d. Airflow proving switch.

I. Wiring: Fabricate units with space within housing for electrical conduits. Wire motors and controls, so only external connections are required during installation.

1. Outdoor Enclosure: NEMA 250, Type 3R enclosure contains relays, starters, and terminal strip.
2. Include fused or nonfused disconnect switches.

2.4 CONTROLS

A. Control Panel: Solid-state, programmable, microprocessor-based control unit for wall mounting, Integrate to BACnet, LonWorks, or Modbus, as specified in Section 230923 "Direct Digital Control (DDC) System for HVAC".

B. Starting relay, factory mounted and wired, and manual motor starter for field wiring.

C. Frost Control: None, Timed exhaust-only operation, Electric preheat or Variable rotor speed or Low-temperature thermostat deenergizes supply air fan.

D. Motion (Occupancy) Sensor: Passive infrared sensor for wall or ceiling mounting, with adjustable time-off delay of up to 30 minutes to energize unit.

E. Carbon Dioxide Sensor: Adjustable control from 600 to 2000 ppm for wall or duct mounting, with digital display and direct digital control (DDC) system interface to energize unit.

F. Economizer Control, Stop Wheel: Stop wheel rotation or modulate wheel rotation speed when conditions are favorable for economizer operation.

G. Economizer Control, Airflow Bypass: Heat-wheel airflow bypass. See Section 230923 "Direct Digital Control (DDC) System for HVAC" for control sequence.

H. Dry-bulb temperature or Enthalpy sensor.

I. Rotation sensor and alarm.

J. Dirty filter switch.

K. Low-Voltage Transformer: Integral transformer to provide control voltage to unit from primary incoming electrical service.

L. Electric Coil Controls:

1. Factory-mounted sensor in outside-air intake with sensor adjustment located in control panel to control electric coil and maintain minimum entering temperature, to avoid frost formation.

M. Variable-Frequency Motor Controller: Comply with Section 262923 "Variable-Frequency Motor Controllers."

N. Variable-Frequency Motor Controller: Serving wheel rotation motor.

1. Manufactured Units: Pulse-width modulated; constant torque and variable torque for Design A and Design B or inverter-duty motors.
2. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range or 66 Hz, with torque constant as speed changes; maximum voltage equals input voltage.
3. Unit Operating Requirements:

    a. Internal Adjustability:

        1) Minimum Speed: 5 to 25 percent of maximum rpm.
        2) Maximum Speed: 80 to 100 percent of maximum rpm.
        3) Acceleration: 0.1 to 999.9 seconds, as directed.
        4) Deceleration: 0.1 to 999.9 seconds, as directed.
        5) Current Limit: 30 to minimum of 150 percent of maximum rating.

    b. Self-Protection and Reliability Features:

        1) Surge suppression.
        2) Loss of input signal protection.
        3) Under- and overvoltage trips.
        4) Variable-frequency motor controller and motor-overload/overtemperature protection.
        5) Critical frequency rejection.
        6) Loss-of-phase protection.
        7) Reverse-phase protection.
        8) Motor-overtemperature fault.

    c. Bidirectional autospeed search.
    d. Torque boost.
    e. Motor temperature compensation at slow speeds.

        1) Panel-mounted operator station.
        2) Historical logging information and displays.
        3) Digital indicating devices.

    f. Control Signal Interface: Electric.
    g. Proportional integral derivative (PID) control interface.
    h. DDC System for HVAC Protocols for Network Communications: ASHRAE 135.

4. Line Conditioning:

    a. Input line conditioning.
    b. Output filtering.
    c. EMI/RFI filtering.

O. Variable-Speed Control: Factory mounted and wired, permitting input of field-connected, 4- to 20-mA or 1- to 10-V control signal.

P. Variable-Speed Control: Factory mounted and wired, with exhaust-air sensor to vary rotor speed and maintain exhaust temperature above freezing.

Q. Variable-Speed Control: Factory mounted and wired, with exhaust- and outdoor-air sensors, automatic changeover thermostat, and set-point adjuster, to vary rotor speed and maintain exhaust temperature above freezing and air differential temperature above set point. Increase rotor speed to maximum when exhaust-air temperature is less than outdoor-air temperature.

2.5 SOURCE QUALITY CONTROL

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended application.

B. AHRI Compliance: Capacity ratings for air-to-air energy-recovery equipment certified as complying with AHRI 1060 (IP) (AHRI 1061 SI).

C. Fan Performance Rating: Comply with AMCA 211, and label fans with AMCA-certified rating seal. Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency in accordance with AMCA 210 and ASHRAE 51.

D. Fan Sound Rating: Comply with AMCA 301 or AHRI 260 (IP) (AHRI 261 SI).

E. UL Compliance:

1. Packaged Heat-Recovery Ventilators: Comply with requirements in UL 1812.
2. Electric Coils: Comply with UL 1995.

PART 3 - EXECUTION

3.1 INSTALLATION OF PACKAGED, OUTDOOR, HEAT-WHEEL, ENERGY-RECOVERY UNITS

A. Examine casing insulation materials and filter media before packaged, outdoor, heat wheel energy-recovery unit installation. Replace insulation materials and filter media that are wet, moisture damaged, or mold contaminated.

B. Install packaged, outdoor, heat-wheel, energy-recovery units, so supply and exhaust airstreams flow in opposite directions, and rotation is away from exhaust side to purge section to supply side.

1. Install access doors in both supply and exhaust ducts, both upstream and downstream, for access to wheel surfaces, drive motor, and seals.
2. Install removable panels or access doors between supply and exhaust ducts on building side for bypass during startup.
3. Access doors and panels are specified in Section 233300 "Air Duct Accessories."

C. Equipment Mounting:

1. Install deck-mounted packaged, outdoor, heat-wheel, energy-recovery units on 4-inch (100-mm) cast-in-place concrete equipment bases. Comply with requirements for

equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." Or Section 033053 "Miscellaneous Cast-in-Place Concrete."

2. Install roof-mounted packaged, outdoor, heat-wheel, energy-recovery units on manufacturer's-recommended-height equipment roof curbs. Comply with requirements for equipment curbs specified in Section 077200 "Roof Accessories."
3. Comply with requirements for vibration-isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
4. Comply with requirements for vibration-isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

D. Suspended Units: Suspend and brace units from outdoor structural-steel support frame, using threaded steel rods and spring hangers. Comply with requirements for vibration-isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC." Or Section 230548.13 "Vibration Controls for HVAC."

E. Install units with clearances for service and maintenance.

F. Do not operate equipment fans until temporary or permanent filters are in place. Replace temporary filters used during construction and testing with new, clean filters prior to final inspection.

3.2 DUCTWORK CONNECTIONS

A. Comply with requirements for ductwork in accordance with Section 233113 "Metal Ducts."

B. Connect duct to units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."

C. Isolation Dampers: Install isolation dampers in accordance with Section 230923.12 "Control Dampers."

3.3 PIPING CONNECTIONS

A. Comply with requirements for piping specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to unit, allow service and maintenance.

C. Connect piping to units mounted on vibration isolators with flexible connectors.

D. Condensate Drain Piping: See Section 232113 "Hydronic Piping" for pipe type. Install condensate drain piping from drain pans to nearest floor drain, same size as condensate drain connection.

1. Construct deep trap at connection to drain pan, and install cleanouts at changes in direction.

3.4 ELECTRICAL CONNECTIONS

A. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.5 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage qualified testing agency to perform tests and inspections.

C. Perform tests and inspections with assistance of factory-authorized service representative.

D. Tests and Inspections:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Packaged, outdoor, heat-wheel, energy-recovery equipment will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.7 DEMONSTRATION

A. Engage factory-authorized service representative to train or train Owner's maintenance personnel to adjust, operate, and maintain air-to-air energy-recovery units.

END OF SECTION 237223.23

SECTION 237223.29 - PACKAGED, OUTDOOR, FIXED PLATE ENERGY RECOVERY UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fixed-plate, sensible heat exchangers in packaged, outdoor, energy-recovery units.

B. Related Requirements:

1. Section 237343.16 "Outdoor, Semi-Custom Air-Handling Units" for outdoor, semi-custom air-handling units if they also include coils, other than electric coils for frost control, in addition to fixed-plate heat exchangers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

C. Shop Drawings: For packaged, outdoor, fixed-plate, energy-recovery units.

1. Include plans, elevations, sections, details, and mounting or attachment details as directed.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, lifting requirements, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

D. Delegated-Design Submittal: For air-to-air energy-recovery equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of air-to-air energy-recovery equipment.
2. Vibration-Isolation Roof Curb Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include rails and frames for equipment mounting.
3. Design Calculations: Calculate requirements for selecting vibration isolators, seismic restraints, and for designing vibration-isolation bases.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, roof plans elevations, and other details, drawn to scale. and coordinated with each other, using input from installers of items involved.

B. Seismic Qualification Data: Certificates, for packaged, outdoor, fixed-plate, energy-recovery units, accessories, and components, from manufacturer.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 COORDINATION

A. Coordinate sizes and locations of building openings and duct connections with actual equipment provided.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of packaged, outdoor, fixed-plate, energy-recovery units that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Packaged Energy-Recovery Units: One years from date of Substantial Completion.
2. Warranty Period for Fixed-Plate Heat Exchangers: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

B. ASHRAE Compliance:

1. Applicable requirements in ASHRAE 62.1.
2. Capacity ratings for fixed-plate energy-recovery units shall comply with ASHRAE 84.

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.

D. UL Compliance:

1. Packaged heat-recovery ventilators shall comply with requirements in UL 1815 or UL 1812.
2. Electric coils shall comply with requirements in UL 1995.

E. Comply with ASTM E84 or UL 723.

F. Delegated Design: Engage registered professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration-isolation controls and seismic restraints, including comprehensive engineering analysis using performance requirements and design criteria indicated.

G. Seismic Performance: Packaged, outdoor, fixed-plate, energy-recovery units shall withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: As directed, 1.5 or 1.0.

2.2 CAPACITIES AND CHARACTERISTICS

A. Type: Fixed-plate sensible heat, energy-recovery unit.

B. Exhaust Air:

1. Airflow: As directed, cfm (L/s).
2. Face Velocity: As directed, fpm (m/s).
3. Summer:

    a. Entering-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    b. Entering-Air Temperature, Wet Bulb: As directed, deg F (deg C).
    c. Leaving-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    d. Leaving-Air Temperature, Wet Bulb: As directed, deg F (deg C).

4. Winter:

    a. Entering-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    b. Entering-Air Temperature, Wet Bulb: As directed, deg F (deg C).
    c. Leaving-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    d. Leaving-Air Temperature, Wet Bulb: As directed, deg F (deg C).

5. Air Pressure Drop: As directed, inches wg (Pa).
6. Fan Motor Size: As directed, horsepower (watts).
7. Fan Motor Electrical Characteristics:

    a. Volts: As directed, 208, 230 or 460 V.
    b. Phase: As directed, Single or Three.
    c. Hertz: 60.

C. Supply Air:

1. Airflow: As directed, cfm (L/s).
2. Face Velocity: As directed, fpm (m/s).
3. Summer:

    a. Entering-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    b. Entering-Air Temperature, Wet Bulb: As directed, deg F (deg C).
    c. Leaving-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    d. Leaving-Air Temperature, Wet Bulb: As directed, deg F (deg C).

4. Winter:

    a. Entering-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    b. Entering-Air Temperature, Wet Bulb: As directed, deg F (deg C).
    c. Leaving-Air Temperature, Dry Bulb: As directed, deg F (deg C).
    d. Leaving-Air Temperature, Wet Bulb: As directed, deg F (deg C).

5. Air Pressure Drop: As directed, inches wg (Pa).
6. Fan Motor Size: As directed, horsepower (watts).
7. Fan Motor Electrical Characteristics:

    a. Volts: As directed, 208 or 230 V.
    b. Phase: As directed, Single or Three.
    c. Hertz: 60.

D. Effectiveness: Percent as directed.

E. Electric Frost-Control Coils:

1. Heat-Transfer Rate: As directed, Btu/h (kW).
2. Entering-Air Temperature: As directed, deg F (deg C).
3. Leaving-Air Temperature: As directed, deg F (deg C).
4. Power Input: As directed, Kw.
5. Volts: As directed, 208, 230 or 480V.
6. Phase: As directed, Single or Three.
7. Hertz: 60.
8. Full-Load Amperes: As directed, A.
9. Maximum Overcurrent Protection: As directed, A.
10. Provide Silicon-Controlled Rectifier (SCR) to modulate electric coil.

F. Filters:

1. Type: Cleanable wire mesh and Pleated.
2. Face Dimensions, Each: As directed, inches by inches (mm by mm).
3. Depth: As directed, inches (mm).
4. Filter Quantity: Number As directed, Dimensions (Wide by High) inches by inches (mm by mm).
5. Maximum or Rated Face Velocity: As directed, fpm (m/s).
6. Initial Resistance: As directed, inches wg (Pa).
7. Recommended Final Resistance: As directed, inches wg (Pa).
8. Minimum Efficiency Reporting Value and Average Arrestance:

    a. MERV Rating: MERV 4 and corresponding average arrestance in accordance with ASHRAE 52.2.

9. Minimum Efficiency Reporting Value:

    a. MERV Rating: As directed, MERV 6, MERV 8, MERV 11 or MERV 13 in accordance with ASHRAE 52.2.

2.3 PACKAGED, OUTDOOR, FIXED-PLATE, SENSIBLE HEAT, ENERGY-RECOVERY UNITS

A. Source Limitations: Obtain packaged, outdoor, fixed-plate, energy-recovery units from single manufacturer.

B. Surfaces in Contact with Airstream: Comply with requirements in ASHRAE 62.1.

C. Housing: As directed, Manufacturer's standard construction with corrosion-protection coating and exterior finish, gasketed, hinged access doors or removable panels with neoprene gaskets for inspection and access to internal parts, minimum 1-inch (25-mm) or 2-inch (50-mm) thick, thermal

insulation, knockouts for electrical and piping connections, exterior drain connection, and lifting lugs.

D. Fixed-Plate, Sensible Heat Exchanger:

1. Casing: Aluminum.
2. Drain Pan: Same material as casing, with drain connections on exhaust and supply side.

    a. Comply with requirements in ASHRAE 62.1.

3. Plates: As directed Evenly spaced, sealed, and arranged for counter- or cross-flow.

    a. Plate Material: Embossed aluminum.

4. Bypass Plenum: Within casing, with gasketed face-and-bypass dampers having operating rods extended outside casing.

E. Supply and Exhaust Fans: As directed, Forward-curved centrifugal fan with spring isolators or restrained spring isolators of 1-inch (25-mm) static deflection.

1. Motors and Drives: As directed, Direct driven, Belt driven, with adjustable sheaves or Belt driven, with fixed sheaves as directed.

    a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
    b. Motor Sizes: Minimum size as indicated. If size is not indicated, provide motor large enough so driven load will not require motor to operate in service factor range above 1.0.

F. Filters:

1. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."

G. Filters:

1. Description: Cleanable wire mesh at outside air intake and pleated factory-fabricated, self-supported, disposable air filters with holding frames.
2. UL Compliance: Comply with UL 900.
3. Media: Interlaced glass fibers sprayed with nonflammable adhesive and antimicrobial agent.
4. Filter Media Frame: Beverage board with perforated metal retainer or metal grid on outlet side.
5. Filter-Mounting Frames: Arranged with access doors or panels on both sides of unit. Filters shall be removable from one side or lift out from access plenum.

H. Electric Coils:

1. Casing Assembly: As directed, Slip-in or Flanged type with galvanized-steel frame.
2. Access: Fabricate coil section to allow removal and replacement of coil and to allow in-place access for service.
3. Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.

4. Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout safety device; serviceable through terminal box without removing heater from coil section.
5. Secondary Protection: Load-carrying, manually resetting or manually replaceable thermal cutouts; factory wired in series with each heater stage.
6. Control Panel: As directed, Unit or Remote mounted with disconnecting means and overcurrent protection.

    a. Magnetic contactor.
    b. Solid-state, stepless SCR controller.
    c. Time-delay relay.
    d. Airflow proving switch.

I. Wiring: Fabricate units with space within housing for electrical conduits. Wire motors and controls so only external connections are required during installation.

1. Outdoor Enclosure: NEMA 250, Type 3R enclosure contains relays, starters, and terminal strip.
2. As directed, include fused or nonfused disconnect switches.

2.4 CONTROLS

A. Control Panel: Solid-state, programmable, microprocessor-based control unit for wall mounting. Integrate to BACnet, LonWorks, or Modbus, as specified in Section 230923 "Direct Digital Control (DDC) System for HVAC".

B. Starting relay, factory mounted and wired, and manual motor starter for field wiring.

C. Frost Control: As directed, None, Timed exhaust-only operation, Electric preheat or Low-temperature thermostat deenergizes supply air fan.

D. Motion (Occupancy) Sensor: As directed, Passive infrared sensor for wall or ceiling mounting, with adjustable time-off delay of up to 30 minutes to energize unit.

E. Carbon Dioxide Sensor: As directed, Adjustable control from 600 to 2000 ppm for wall or duct mounting, with digital display and direct digital control (DDC) system interface to energize unit.

F. Economizer Control: Fixed-plate airflow bypass. See Section 230923 "Direct Digital Control (DDC) System for HVAC" for control sequence.

G. Dry-bulb temperature sensor.

H. Dirty filter switch.

I. Low-Voltage Transformer: Integral transformer to provide control voltage to unit from primary incoming electrical service.

J. Electric Coil Controls:

1. Factory-mounted sensor in outside-air intake with sensor adjustment located in control panel to control electric coil and maintain minimum entering temperature, to avoid frost formation.

2.5 SOURCE QUALITY CONTROL

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by NRTL, and marked for intended location and application.

B. AHRI Compliance: Capacity ratings for air-to-air energy-recovery equipment certified as complying with AHRI 1060 (IP) (AHRI 1061 SI).

C. Fan Performance Rating: Comply with AMCA 211, and label fans with AMCA-certified rating seal. Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency in accordance with AMCA 210 and ASHRAE 51.

D. Fan Sound Ratings: Comply with AMCA 301 or AHRI 260 (IP) (AHRI 261 SI).

E. UL Compliance:

1. Packaged, Fixed-Plate, Energy-Recovery Units: Comply with requirements in UL 1812.
2. Electric Coils: Comply with UL 1995.

PART 3 - EXECUTION

3.1 INSTALLATION OF PACKAGED, OUTDOOR, FIXED-PLATE, ENERGY-RECOVERY UNITS

A. Examine casing insulation materials and filter media before packaged, outdoor, fixed-plate, energy-recovery unit installation. Replace insulation materials and filter media that are wet, moisture damaged, or mold damaged.

B. Install packaged, outdoor, fixed-plate, energy-recovery units, so supply and exhaust airstreams flow in opposite directions.

1. Install access doors in both supply and exhaust ducts, both upstream and downstream, for access to interior components.
2. Install removable panels or access doors between supply and exhaust ducts on building side for bypass during startup.
3. Access doors and panels are specified in Section 233300 "Air Duct Accessories."

C. Equipment Mounting:

1. Install packaged, outdoor, fixed-plate, energy-recovery units on 4-inch (100-mm) cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.
2. Install roof-mounted packaged, outdoor, fixed-plate, energy-recovery units on manufacturer's-recommended-height equipment roof curbs. Comply with requirements for equipment curbs specified in Section 077200 "Roof Accessories."
3. Comply with requirements for vibration-isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
4. Comply with requirements for vibration-isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

D. Suspended Units: Suspend and brace units from outdoor structural-steel support frame, using threaded steel rods and spring hangers. Comply with requirements for vibration-isolation devices

specified in Section 230548 "Vibration and Seismic Controls for HVAC" or Section 230548.13 "Vibration Controls for HVAC" as directed.

E. Install units with clearances for service and maintenance.

F. Do not operate equipment fans until temporary or permanent filters are in place. Replace temporary filters used during construction and testing with new, clean filters prior to final inspection.

3.2 DUCTWORK CONNECTIONS

A. Comply with requirements for ductwork in accordance with Section 233113 "Metal Ducts."

B. Connect duct to units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."

C. Isolation Dampers: Install isolation dampers in accordance with Section 230923.12 "Control Dampers."

3.3 PIPING CONNECTIONS

A. Comply with requirements for piping specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to unit, allow for service and maintenance.

C. Connect piping to units mounted on vibration isolators with flexible connectors.

D. Condensate Drain Piping: See Section 232113 "Hydronic Piping" for pipe type. Install condensate drain piping from drain pans to nearest floor drain, same size as condensate drain connection.

1. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

3.4 ELECTRICAL CONNECTIONS

A. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.5 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage qualified testing agency to perform tests and inspections.

C. Perform tests and inspections with assistance of factory-authorized service representative.

D. Tests and Inspections:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Packaged, outdoor, fixed-plate, energy-recovery units will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.7 DEMONSTRATION

A. As directed, Engage factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain air-to-air energy-recovery units.

END OF SECTION 237223.29

SECTION 237313.13 - INDOOR, BASIC AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Factory-assembled, indoor air-handling units with limited features.

1.2 ACTION SUBMITTALS

A. Product Data: For each air-handling unit.

1. Unit dimensions and weight.
2. Cabinet material, metal thickness, finishes, insulation, and accessories.
3. Fans:

    a. Certified fan-performance curves with system operating conditions indicated.
    b. Certified fan-sound power ratings.
    c. Fan construction and accessories.
    d. Motor ratings, electrical characteristics, and motor accessories.

4. Certified coil-performance ratings with system operating conditions indicated.
5. Dampers, including housings, linkages, and operators.
6. Filters with performance characteristics.

B. Sustainable Design Submittals:

C. Delegated-Design Submittal: For vibration isolation and seismic restraints indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Include design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, drawn to scale and coordinated with each other, using input from installers of the items involved.

B. Seismic Qualification Data: Certificates for indoor, basic air-handling units, accessories, and components, from manufacturer.

C. Source quality-control reports.

D. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

B. Coordinate sizes and locations of structural-steel support members, if any, with actual equipment provided.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation and seismic restraints, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

F. Structural Performance: Casing panels shall be self-supporting and capable of withstanding positive/negative 4-inch wg (996 Pa) of internal static pressure, without exceeding a midpoint deflection of 0.005 inches/inch (0.005 mm/mm) of panel span.

G. Seismic Performance: Air-handling units shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: As directed, 1.5 or 1.0.

2.2 CAPACITIES AND CHARACTERISTICS

A. Supply Fan:

1. Type: As directed, DWDI, forward-curved centrifugal fan or SWSI, airfoil unhoused centrifugal plenum fan.
2. As directed, Class I or Class II: AMCA 99-2408.
3. Drive: As directed, V-belt or Direct.
4. Number of Fan Wheels: One.
5. Fan Diameter: As directed, inches (mm).
6. Airflow: As directed, cfm (L/s).
7. Total Static Pressure: As directed, inches wg (kPa).
8. External Static Pressure: As directed, inches wg (kPa).
9. Speed: As directed.
10. Maximum Outlet Velocity: As directed, fpm (m/s).
11. Motor:

    a. Size: As directed.
    b. Speed: As directed.
    c. Volts: As directed, 208, 230 or 460 V.
    d. Phase: Three.
    e. Hertz: 60 Hz.
    f. Full-Load Amperes: As directed.
    g. Minimum Circuit Ampacity: As directed.
    h. Maximum Overcurrent Protection: As directed.

12. Fan Discharge Sound Power, dB:

    a. 1st Octave: As directed.
    b. 2nd Octave: As directed.
    c. 3rd Octave: As directed.
    d. 4th Octave: As directed.
    e. 5th Octave: As directed.
    f. 6th Octave: As directed.
    g. 7th Octave: As directed.
    h. 8th Octave: As directed.

B. Return Fan:

1. Type: As directed, DWDI, forward-curved centrifugal fan or SWSI, airfoil unhoused centrifugal plenum fan.
2. As directed, Class I or Class II: AMCA 99-2408.
3. Drive: As directed, V-belt or Direct.
4. Number of Fan Wheels: One.
5. Fan Diameter: As directed, inches (mm).
6. Airflow: As directed, cfm (L/s).
7. Total Static Pressure: As directed, inches wg (kPa).
8. External Static Pressure: As directed, inches wg (kPa).
9. Speed: As directed.
10. Maximum Outlet Velocity: As directed, fpm (m/s).
11. Motor:

    a. Size: As directed.
    b. Speed: As directed.
    c. Volts: As directed, 208 or 230 V.

d. Phase: Three.
e. Hertz: 60 Hz.
f. Full-Load Amperes: As directed.
g. Minimum Circuit Ampacity: As directed.
h. Maximum Overcurrent Protection: As directed.

12. Fan Inlet Sound Power, dB:

a. 1st Octave: As directed.
b. 2nd Octave: As directed.
c. 3rd Octave: As directed.
d. 4th Octave: As directed.
e. 5th Octave: As directed.
f. 6th Octave: As directed.
g. 7th Octave: As directed.
h. 8th Octave: As directed.

C. Preheat Coil:

1. Heat-Transfer Rate: As directed, Btu/h (kW).
2. Entering-Air Temperature: As directed, deg F (deg C).
3. Leaving-Air Temperature: As directed, deg F (deg C).
4. Face Area: As directed, sq. ft. (sq. m).
5. Maximum Face Velocity: As directed, fpm (m/s).
6. Maximum Air-Side, Static-Pressure Drop: As directed, inches wg (kPa).
7. Fin Spacing: Maximum As directed, fins per inch (per mm).
8. Minimum Number of Rows: As directed.
9. Water:

a. Water Flow: As directed, gpm (L/s).
b. Maximum Water Pressure Drop: As directed, feet of head (kPa).
c. Entering-Water Temperature: As directed, deg F (deg C).
d. Leaving-Water Temperature: As directed, deg F (deg C).
e. Tube Velocity: As directed, fpm (m/s).

D. Heating Coil:

1. Heat-Transfer Rate: As directed, Btu/h (kW).
2. Entering-Air Temperature: As directed, deg F (deg C).
3. Leaving-Air Temperature: As directed, deg F (deg C).
4. Face Area: As directed, sq. ft. (sq. m).
5. Maximum Face Velocity: As directed, fpm (m/s).
6. Maximum Air-Side, Static-Pressure Drop: As directed, inches wg (kPa).
7. Number of Rows: As directed.
8. Fin Spacing: Maximum As directed, fins per inch (per mm).
9. Water:

a. Water Flow: As directed, gpm (L/s).
b. Maximum Water Pressure Drop: As directed, feet of head (kPa).
c. Entering-Water Temperature: As directed, deg F (deg C).
d. Leaving-Water Temperature: As directed, deg F (deg C).

e. Tube Velocity: As directed, fpm (L/s).

E. Electric Heating Coil:

1. Heat-Transfer Rate: As directed, number of Btu/h (kW).
2. Input: As directed.
3. Volts: As directed, 120, 208 or 230 V.
4. Phase: As directed, Single or Three.
5. Full-Load Amperes: As directed.
6. Number of Steps: As directed.

F. Cooling Coil:

1. Sensible Heat-Transfer Rate: As directed, Btu/h (kW).
2. Total Heat-Transfer Rate: As directed, Btu/h (kW).
3. Entering-Air, Dry-Bulb Temperature: As directed, deg F (deg C).
4. Entering-Air, Wet-Bulb Temperature: As directed, deg F (deg C).
5. Leaving-Air, Dry-Bulb Temperature: As directed, deg F (deg C).
6. Leaving-Air, Wet-Bulb Temperature: As directed, deg F (deg C).
7. Face Area: As directed, sq. ft. (sq. m).
8. Maximum Face Velocity: As directed, fpm (m/s).
9. Maximum Air-Side, Static-Pressure Drop: As directed, inches wg (kPa).
10. Number of Rows: As directed.
11. Fin Spacing: Maximum fins per inch (per mm) As directed.
12. Water:

    a. Water Flow: As directed, gpm (L/s).
    b. Maximum Water Pressure Drop: As directed, feet of head (kPa).
    c. Entering-Water Temperature: As directed, deg F (deg C).
    d. Leaving-Water Temperature: As directed, deg F (deg C).
    e. Tube Velocity: As directed, fpm (L/s).

13. Refrigerant:

    a. Refrigerant Type: As directed.

G. Filters:

1. Type: As directed.
2. Face Dimensions, each: As directed, inches by inches (mm by mm).
3. Depth: As directed, inches (mm).
4. Number of Filters in Filter Bank: As directed, wide by high.
5. Access Location: Side.
6. Maximum or Rated Face Velocity: As directed, fpm (m/s).
7. Initial Resistance: As directed, inches wg (kPa).
8. Recommended Final Resistance: As directed, inches wg (kPa).
9. Minimum Efficiency Reporting Value and Average Arrestance:

    a. MERV Rating and Corresponding Average Arrestance: As directed, MERV 1, MERV 2, MERV 3 or MERV 4, and corresponding average arrestance according to ASHRAE 52.2.

10. Minimum Efficiency Reporting Value:

    a. MERV Rating: As directed, MERV 6 or MERV 13, according to ASHRAE 52.2.

11. Depth: As directed, inches (mm).

2.3 INDOOR, BASIC AIR-HANDLING UNIT MANUFACTURERS

2.4 UNIT CASINGS

A. General Fabrication Requirements for Casings:

1. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
2. Joints: Sheet metal screws or pop rivets.
3. Sealing: Seal all joints with water-resistant sealant. Hermetically seal at each corner and around entire perimeter.
4. Base Rail:

    a. Material: Galvanized steel.
    b. Height: 4 inches (150 mm).

B. Single Wall:

1. Material: Galvanized steel with manufacturer's standard finish.
2. Floor Plate: Galvanized steel, treadplate, minimum 18-gauge (1.3 mm) thick.
3. Insulation and Adhesive:

    a. Materials: ASTM C1071, Type I or Type II glass-fiber blanket or board insulation, neoprene coated or foil-faced.
    b. Location and Application: Factory applied with adhesive and mechanical fasteners to the internal surface of section panels downstream from, and including, the cooling coil section.

        1) Liner Adhesive: Comply with ASTM C916, Type I.
        2) Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, or mechanical attachment, to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.

C. Double Wall:

1. Outside Casing Wall: Galvanized steel, minimum 18-gauge (1.3 mm) thick, with manufacturer's standard finish.
2. Inside Casing Wall: Galvanized steel, solid or perforated, minimum 18-gauge (1.3 mm) thick.
3. Floor Plate: Galvanized steel, treadplate, minimum 18-gauge (1.3 mm) thick.
4. Casing Insulation:

    a. Materials: Glass-fiber blanket or board insulation, Type I or Type II ASTM C1071 or injected polyurethane foam insulation.

b. Casing Panel R-Value: Minimum As directed.
c. Insulation Thickness: 1 inch (25 mm).
d. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roofs of air-handling unit.

D. Static-Pressure Classifications:

1. For Unit Sections Upstream of Fans: Minus As directed, 2-inch wg (500 Pa) or 3-inch wg (750 Pa).
2. For Unit Sections Downstream and Including Fans: 2-inch wg (500 Pa), 3-inch wg (750 Pa) or 4-inch wg (1000 Pa).

E. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

F. Panels and Doors:

1. Panels:

a. Fabrication: Formed and reinforced with same materials and insulation thickness as casing.
b. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against airflow.
c. Gasket: Neoprene, applied around entire perimeters of panel frames.
d. Size: Large enough to allow unobstructed access for inspection and maintenance of air-handling unit's internal components. As directed, At least 18 inches (450 mm) or 24 inches (600 mm) wide by full height of unit casing up to a maximum height of 60 inches (1500 mm) or 72 inches (1800 mm).

2. Doors:

a. Fabrication: Formed and reinforced with same materials and insulation thickness as casing.
b. Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against airflow. Provide safety latch retainers on doors so that doors do not open uncontrollably.
c. Gasket: Neoprene, applied around entire perimeters of frame.
d. Size: Large enough to allow for unobstructed access for inspection and maintenance of air-handling unit's internal components. At least 18 inches (450 mm) wide by full height of unit casing up to a maximum height of 60 inches (1500 mm).

3. Locations and Applications:

a. Fan Section: As directed, Doors or Panels.
b. Coil Section: Panels.
c. Access Section: As directed, Doors or Panels.
d. Access Sections Immediately Upstream and Downstream of Coil Sections: As directed, Doors or Panels.
e. Damper Section: As directed, Doors or Panels.

f. Filter Section: As directed, Doors or Panels large enough to allow periodic removal and installation of filters.
g. Mixing Section: As directed, Doors or Panels.

G. Condensate Drain Pans:

1. Construction:

a. As directed, Single-wall, galvanized-steel or noncorrosive polymer or stainless-steel sheet.

2. Drain Connection:

a. Located at lowest point of pan and sized to prevent overflow. As directed, terminate with threaded nipple on one end or both ends of pan.
b. Minimum Connection Size: As directed, NPS 1 (DN 25) or NPS 2 (DN 50).

3. Slope: Minimum 0.125 in./ft. (10 mm/mm) slope, to comply with ASHRAE 62.1, in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers, and to direct water toward drain connection.
4. Length: Extend drain pan downstream from leaving face for distance to comply with ASHRAE 62.1.
5. Width: Entire width of water producing device.
6. Depth: A minimum of 2 inches (50 mm) deep.

2.5 FAN, DRIVE, AND MOTOR SECTION

A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.

1. Shafts: With field-adjustable alignment.

a. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
b. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

B. Centrifugal Fan Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.

1. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.
2. Horizontal-Flanged, Split Housing: Bolted construction.
3. Housing for Supply Fan: Attach housing to fan-section casing with metal-edged flexible duct connector.
4. Flexible Connector: Factory fabricated with a fabric strip minimum 3-1/2 inches (89 mm) wide, attached to two strips of minimum 2-3/4-inch (70-mm) wide by 0.028-inch- (0.7-mm-) thick, galvanized-steel sheet.

a. Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.

1) Fabric Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).
2) Fabric Minimum Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.
3) Fabric Minimum Service Temperature Range: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).

C. Plenum Fan Housings: Steel frame and panel; fabricated without fan scroll and volute housing. Provide inlet screens for Type SWSI fans.

D. Forward-Curved, Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; as directed, steel or aluminum hub swaged to backplate and fastened to shaft with setscrews.

E. Airfoil, Centrifugal Fan Wheels (Plenum Fan Wheels): Smooth-curved inlet flange, backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; steel hub riveted to backplate and fastened to shaft with setscrews.

F. Fan Shaft Bearings:

1. Self-aligning, pillow-block type with an L-50 rated life of minimum 100,000 hours according to ABMA 9.

G. Belt Drives: Factory mounted, with adjustable alignment and belt tensioning, and with 1.5 or 1.25 service factor based on fan motor as directed.

1. Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
2. Motor Pulleys: Adjustable pitch for use with 5-hp motors and smaller; fixed pitch for use with motors larger than 5 hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.
3. Belts: Oil resistant, nonsparking, and nonstatic; in matched sets for multiple-belt drives.
4. Belt Guards: Comply with requirements specified by OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards"; 0.146-inch- (2.7-mm-) thick, 3/4-inch (20-mm) diamond-mesh wire screen, welded to steel angle frame; prime coated.

H. Discharge Dampers: Heavy-duty steel assembly with channel frame and sealed ball bearings, and as directed, opposed or parallel blades constructed of two plates formed around and welded to shaft, with blades linked out of airstream to single control lever.

I. Internal Vibration Isolation and Seismic Control: Fans shall be factory mounted with manufacturer's standard restrained vibration isolation mounting devices having a minimum static deflection of 1 inch (25 mm).

J. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Enclosure Type: Totally enclosed, fan cooled.
2. NEMA Premium Efficient motors as defined in NEMA MG 1.
3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
5. Mount unit-mounted disconnect switches on exterior or interior of unit.

K. Variable-Frequency Motor Controller: Comply with Section 262923 "Variable-Frequency Motor Controllers."

L. Variable-Frequency Motor Controller: As directed, serving each fan individually or all fans combined in fan array.

1. Manufactured Units: Pulse-width modulated; constant torque and variable torque for Design A and Design B motors or inverter-duty motors as directed.
2. Output Rating: As directed, Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range or 66 Hz, with torque constant as speed changes; maximum voltage equals input voltage.
3. Unit Operating Requirements:

    a. Internal Adjustability:

        1) Minimum Speed: 5 to 25 percent of maximum rpm.
        2) Maximum Speed: 80 to 100 percent of maximum rpm.
        3) Acceleration: 0.1 to 999.9 seconds.
        4) Deceleration: 0.1 to 999.9 seconds.
        5) Current Limit: 30 to minimum of 150 percent of maximum rating.

    b. Self-Protection and Reliability Features:

        1) Surge suppression.
        2) Loss of input signal protection.
        3) Under- and overvoltage trips.
        4) Variable-frequency motor controller and motor-overload/overtemperature protection.
        5) Critical frequency rejection.
        6) Loss-of-phase protection.
        7) Reverse-phase protection.
        8) Motor-overtemperature fault.

    c. Bidirectional autospeed search.
    d. Torque boost.
    e. Motor temperature compensation at slow speeds.

        1) Panel-mounted operator station.
        2) Historical logging information and displays.
        3) Digital indicating devices.

    f. Control Signal Interface: Electric.
    g. Proportional Integral Directive (PID) control interface.

h. DDC system for HVAC Protocols for Network Communications: ASHRAE 135.

4. Line Conditioning:

a. Input line conditioning.
b. Output filtering.
c. EMI/RFI filtering.

2.6 COIL SECTION

A. General Requirements for Coil Section:

1. Comply with AHRI 410.
2. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
3. Coils shall not act as structural component of unit.

B. Preheat Coils:

1. Electrical Coils: Comply with UL 1995.

a. Casing Assembly: As directed, Slip-in or Flanged type with galvanized-steel frame.
b. Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
c. Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from coil section.
d. Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
e. Control Panel: As directed, Unit or Remote mounted with disconnecting means and overcurrent protection.

1) As directed, Magnetic or Mercury contactor.
2) Solid-state, stepless pulse controller.
3) Toggle switches, one per step.
4) Step controller.
5) Time-delay relay.
6) Pilot lights, one per step.
7) Airflow proving switch.

2. Hot-Water Coils: As directed, Continuous circuit, Self-draining or Cleanable.

a. Piping Connections: As directed, Threaded, Flanged, same end or opposite ends of coil.

b. Tube Material: Copper.
c. Fin Type: Plate.
d. Fin Material: As directed, Aluminum or Copper.
e. Fin Thickness: As directed, inches (mm).
f. Fin and Tube Joint: As directed, Mechanical bond or Silver brazed.
g. Headers:

1) Cast iron with cleaning plugs and drain and air vent tappings extended to exterior of unit.
2) Seamless copper tube with brazed joints, prime coated.
3) Fabricated steel, with brazed joints, prime coated.
4) Provide insulated cover to conceal exposed outside casings of headers.

h. Frames: Channel frame, minimum 0.052-inch- (1.3-mm-) thick galvanized steel.
i. Coil Working-Pressure Ratings: 200 psig (1380 kPa), 325 deg F (163 deg C).

C. Heating Coils:

1. Electrical Coils: Comply with UL 1995.

a. Casing Assembly: As directed, Slip-in or Flanged type with galvanized-steel frame.
b. Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
c. Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from coil section.
d. Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
e. Control Panel: As directed, Unit or Remote mounted with disconnecting means and overcurrent protection.

1) As directed, Magnetic or Mercury contactor.
2) Solid-state, stepless pulse controller.
3) Toggle switches, one per step.
4) Step controller.
5) Time-delay relay.
6) Pilot lights, one per step.
7) Airflow proving switch.

2. Hot-Water Coils: As directed, Continuous circuit, Self-draining or Cleaning.

a. Piping Connections: As directed, Threaded, Flanged, same end or opposite ends of coil.
b. Tube Material: Copper.
c. Fin Type: Plate.
d. Fin Material: As directed, Aluminum or Copper.
e. Fin Thickness: As directed, inches (mm).
f. Fin and Tube Joint: As directed, Mechanical bond or Silver brazed.

g. Headers:

1) Cast iron with cleaning plugs and drain and air vent tappings extended to exterior of unit.
2) Seamless copper tube with brazed joints, prime coated.
3) Fabricated steel, with brazed joints, prime coated.
4) Provide insulated cover to conceal exposed outside casings of headers.

h. Frames: Channel frame, minimum 0.052-inch- (1.3-mm-) thick galvanized steel.
i. Coil Working-Pressure Ratings: 200 psig (1380 kPa), 325 deg F (163 deg C).

D. Cooling Coils:

1. Chilled-Water Coil: As directed, Continuous circuit, Self-draining or Cleanable.

a. Piping Connections: As directed, Threaded, Flanged, same end or opposite ends of coil.
b. Tube Material: Copper.
c. Tube Thickness: As directed, inches (mm).
d. Fin Type: Plate.
e. Fin Material: As directed, Aluminum or Copper.
f. Fin Thickness: As directed, inches (mm).
g. Fin and Tube Joint: Mechanical bond or Silver brazed.
h. Headers:

1) Cast iron with cleaning plugs and drain and air vent tappings extended to exterior of unit.
2) Seamless copper tube with brazed joints, prime coated.
3) Fabricated steel, with brazed joints, prime coated.
4) Provide insulated cover to conceal exposed outside casings of headers.

i. Frames: Channel frame, minimum 0.052-inch- (1.3-mm-) thick galvanized steel.
j. Working-Pressure Ratings: 200 psig (1380 kPa), 325 deg F (163 deg C).

2. Refrigerant Coil:

a. Tubes: Copper.
b. Fins:

1) Material: Aluminum.

c. Fin and Tube Joints: Mechanical bond.
d. Headers: Seamless-copper headers with brazed connections.
e. Frames: Galvanized steel.
f. Ratings: Designed, tested, and rated according to ASHRAE 33 and AHRI 410.

1) Working Pressure: Minimum 300 psig (2070 kPa).

2.7 AIR FILTRATION SECTION

A. Particulate air filtration specified in Section 234100 "Particulate Air Filtration."

B. Panel Filters:

1. Description: As directed, Flat, non-pleated or Pleated factory-fabricated, self-supported disposable air filters with holding frames.
2. Filter Unit Class: UL 900.
3. Media: Interlaced glass, synthetic, or cotton fibers coated with nonflammable adhesive.
4. Filter-Media Frame: High wet-strength beverage board with perforated metal retainer, or metal grid, on outlet side.

C. Side-Access Filter Mounting Frames:

1. Particulate Air Filter Frames: Match inner casing and outer casing material, and insulation thickness. Galvanized steel track.

    a. Sealing: Incorporate positive-sealing device to ensure seal between gasketed material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.

2.8 DAMPERS

A. General Requirements for Dampers: Leakage rate, according to AMCA 500, "Laboratory Methods for Testing Dampers for Rating," shall not exceed 4 cfm/sq. ft. (20 L/s per sq. m) at 1-inch wg (250 Pa) and 8 cfm/sq. ft. (40 L/s per sq. m) at 4-inch wg (1.0 MPa).

B. Damper Operators: Comply with requirements in Section 230923.12 "Control Dampers."

C. Electronic Damper Operators:

1. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
2. Electronic damper position indicator shall have visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
3. Operator Motors:

    a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
    b. Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
    c. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.

4. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running torque of 150 in. x lbf (16.9 N x m) and breakaway torque of 300 in. x lbf (33.9 N x m).

5. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running and breakaway torque of 150 in. x lbf (16.9 N x m).
6. Size dampers for running torque calculated as follows:

    a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. (86.8 kg-cm/sq. m) of damper.
    b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. (62 kg-cm/sq. m) of damper.
    c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft (49.6 kg-cm/sq. m) of damper.
    d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. (37.2 kg-cm/sq. m) of damper.
    e. Dampers with 2- to 3-Inch wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 fpm (5 to 13 m/s): Increase running torque by 1.5.
    f. Dampers with 3- to 4-Inch wg (750 to 1000 Pa) of Pressure Drop or Face Velocities of 2500 to 3000 fpm (13 to 15 m/s): Increase running torque by 2.0.

7. Coupling: V-bolt and V-shaped, toothed cradle.
8. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
9. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on nonspring-return actuators.
10. Power Requirements (Two-Position Spring Return): As directed, 24 V dc, 120 V ac or 230 V ac.
11. Power Requirements (Modulating): Maximum 10 VA at 24 V ac or 8 W at 24 V dc.
12. Proportional Signal: 2 to 10 V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
13. Temperature Rating: As directed, Minus 22 to plus 122 deg F (Minus 30 to plus 50 deg C) or 40 to 104 deg F (5 to 40 deg C).
14. Run Time: As directed, 12 seconds open, 5 seconds closed, 30 seconds, 60 seconds or 120 seconds.

D. Outdoor- and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, galvanized-steel dampers with compressible jamb seals and extruded-vinyl blade edge seals in opposed or parallel-blade arrangement as directed, with zinc-plated steel operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed 4 cfm/sq. ft. (20 L/s per sq. m) at 1-inch wg (250 Pa) and 8 cfm/sq. ft. (40 L/s per sq. m) at 4-inch wg (1.0 MPa).

E. Mixing Section: Multiple-blade, air-mixer assembly located immediately downstream of mixing section.

F. Combination Filter and Mixing Section:

1. Cabinet support members shall hold 2-inch- (50-mm-) thick, pleated, flat, permanent or throwaway filters.
2. Multiple-blade, air-mixer assembly shall mix air to prevent stratification, located immediately downstream of mixing box.

2.9 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

D. Aluminum: ASTM B209.

2.10 SOURCE QUALITY CONTROL

A. AHRI 430 Certification: Air-handling units and their components shall be factory tested according to AHRI 430 and shall be listed and labeled by AHRI.

1. AMCA 210 Compliance: Fan performance according to AMCA 210.

B. AMCA 300 and AMCA 301, or AHRI 260 Certification: Air-handling unit fan sound ratings shall comply with AMCA 300, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data" and AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data," or with AHRI 260, "Sound Rating of Ducted Air Moving and Conditioning Equipment."

C. Water Coils: Factory tested to 300 psig (2070 kPa) according to AHRI 410 and ASHRAE 33.

D. Refrigerant Coils: Factory tested to minimum 450-psig (3105-kPa) internal pressure, and to minimum 300-psig (2070-kPa) internal pressure while underwater, according to AHRI 410 and ASHRAE 33.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Examine casing insulation materials and filter media before air-handling unit installation. Replace with new insulation materials and filter media that are wet, moisture damaged, or mold damaged.

B. Equipment Mounting:

1. Install air-handling units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.

2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

C. Suspended Units: Suspend and brace units from structural-steel support frame using threaded steel rods and spring hangers. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC" or Section 230548.13 "Vibration Controls for HVAC" as directed.

D. Arrange installation of units to provide access space around air-handling units for service and maintenance.

E. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.

F. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."

3.2 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to air-handling unit, allow for service and maintenance.

C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.

D. Connect condensate drain pans using NPS 1-1/4 (DN 32), ASTM B88, Type M (ASTM B88M, Type C) copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

E. Hot- and Chilled-Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.

F. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.

3.3 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Leak Test: After installation, fill water and steam coils with water, and test coils and connections for leaks.
2. Charge refrigerant coils with refrigerant and test for leaks.
3. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

D. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.

E. Prepare test and inspection reports.

3.6 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

END OF SECTION 237313.13

SECTION 237313.16 - INDOOR, SEMI-CUSTOM AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulated, double-wall-casing, indoor, semi-custom air-handling units that are factory assembled using multiple section components.

1.2 ACTION SUBMITTALS

A. Product Data: For each air-handling unit.

B. Sustainable Design Submittals:

C. Delegated-Design Submittal: For vibration isolation and seismic restraints indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Include design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, drawn to scale and coordinated with each other, using input from installers of the items involved.

B. Seismic Qualification Data: Certificates for air-handling units, accessories, and components, from manufacturer.

C. Source quality-control reports:

D. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

B. Coordinate sizes and locations of structural-steel support members, if any, with actual equipment provided.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation and seismic restraints, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

F. Structural Performance: Casing panels shall be self-supporting and capable of withstanding positive/negative 8-inch wg (2000 Pa) of internal static pressure, without exceeding a midpoint deflection of 0.0042 inch/inch (0.0042 mm/mm) of panel span.

G. Casing Leakage Performance: ASHRAE 111, Class 6 leakage or better at plus or minus 8 inch wg (2000 Pa).

H. Seismic Performance: Air-handling units shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: As directed, 1.5 or 1.0.

2.2 CAPACITIES AND CHARACTERISTICS

A. Supply Fan:

1. Type: As directed, DWDI, backward-inclined centrifugal fan, DWDI, forward-curved centrifugal fan, DWDI, airfoil centrifugal fan or SWSI, airfoil unhoused centrifugal fan.
2. As directed, Class I, Class II or Class III: AMCA 99-2408.
3. Drive: As directed, V-belt or Direct.
4. Number of Fan Wheels: As directed.
5. Fan Diameter: As directed, inches (mm).
6. Airflow: As directed, cfm (L/s).
7. Total Static Pressure: As directed, inches wg (kPa).
8. External Static Pressure: As directed, inches wg (kPa).

9. Speed: As directed.
10. Maximum Outlet Velocity: As directed, fpm (m/s).
11. Motor:

    a. Size: As directed.
    b. Speed: As directed.
    c. Volts: As directed, 208, 230 or 460 As directed.
    d. Phase: Three.
    e. Hertz: 60 Hz.
    f. Full-Load Amperes: As directed, A.
    g. Minimum Circuit Ampacity: As directed, A.
    h. Maximum Overcurrent Protection: As directed, A.

12. Fan Discharge Sound Power, dB:

    a. 1st Octave: As directed.
    b. 2nd Octave: As directed.
    c. 3rd Octave: As directed.
    d. 4th Octave: As directed.
    e. 5th Octave: As directed.
    f. 6th Octave: As directed.
    g. 7th Octave: As directed.
    h. 8th Octave: As directed.

B. As directed, Return or Exhaust Fan:

1. Type: As directed, DWDI, backward-inclined centrifugal fan, DWDI, forward-curved centrifugal fan, DWDI, airfoil centrifugal fan or SWSI, airfoil unhoused centrifugal plenum fan.
2. As directed, Class I, Class II or Class III: AMCA 99-2408.
3. Drive: As directed, V-belt or Direct.
4. Number of Fan Wheels: As directed.
5. Fan Diameter: As directed, inches (mm).
6. Airflow: As directed, cfm (L/s).
7. Total Static Pressure: As directed, inches wg (kPa).
8. External Static Pressure: As directed, inches wg (kPa).
9. Speed: As directed.
10. Maximum Outlet Velocity: As directed, fpm (m/s).
11. Motor:

    a. Size: As directed.
    b. Speed: As directed.
    c. Volts: As directed, 208, 230 or 460.
    d. Phase: Three.
    e. Hertz: 60 Hz.
    f. Full-Load Amperes: As directed.
    g. Minimum Circuit Ampacity: As directed.
    h. Maximum Overcurrent Protection: As directed.

12. Fan Inlet Sound Power, dB:

a. 1st Octave: As directed.
b. 2nd Octave: As directed.
c. 3rd Octave: As directed.
d. 4th Octave: As directed.
e. 5th Octave: As directed.
f. 6th Octave: As directed.
g. 7th Octave: As directed.
h. 8th Octave: As directed.

C. Preheat Coil:

1. Heat-Transfer Rate: As directed, Btu/h (kW).
2. Entering-Air Temperature: As directed, deg F (deg C).
3. Leaving-Air Temperature: As directed, deg F (deg C).
4. Face Area: As directed, sq. ft. (sq. m).
5. Maximum Face Velocity: As directed, fpm (m/s).
6. Maximum Air-Side, Static-Pressure Drop: As directed, inches wg (Pa).
7. Fin Spacing: Maximum number of fins per inch (per mm) As directed.
8. Minimum Number of Rows: As directed.
9. Integral Face-and-Bypass Dampers: As directed, Horizontal or Vertical, opposed-blade, galvanized-steel, aluminum or extruded-aluminum dampers with zinc-plated steel operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel, aluminum or extruded-aluminum frame as directed, with operating rods connected with a common linkage. Meeting edges of blades shall have gaskets and edge seals, and blades shall be mechanically fastened.
10. Water:

    a. Water Flow: As directed, gpm (L/s).
    b. Maximum Water Pressure Drop: As directed, feet of head (kPa).
    c. Entering-Water Temperature: As directed, deg F (deg C).
    d. Leaving-Water Temperature: As directed, deg F (deg C).
    e. Tube Velocity: As directed, fpm (L/s).

D. Heating Coil:

1. Heat-Transfer Rate: As directed Btu/h (kW).
2. Entering-Air Temperature: As directed, deg F (deg C).
3. Leaving-Air Temperature: As directed, deg F (deg C).
4. Face Area: As directed, sq. ft. (sq. m).
5. Maximum Face Velocity: As directed, fpm (m/s).
6. Maximum Air-Side, Static-Pressure Drop: As directed, inches wg (Pa).
7. Number of Rows: As directed.
8. Fin Spacing: Maximum fins per inch (per mm) As directed.
9. Water:

    a. Water Flow: As directed, gpm (L/s).
    b. Maximum Water Pressure Drop: As directed, feet of head (kPa).
    c. Entering-Water Temperature: As directed, deg F (deg C).
    d. Leaving-Water Temperature: As directed, deg F (deg C).
    e. Tube Velocity: As directed, fpm (L/s).

E. Electric Heating Coil:

1. Heat-Transfer Rate: As directed, Btu/h (kW).
2. Input: As directed, kilowatts.
3. Volts: As directed, 120, 208 or 230 V.
4. Phase: As directed, Single or Three.
5. Full-Load Amperes: As directed.
6. Number of Steps: As directed.

F. Cooling Coil:

1. Sensible Heat-Transfer Rate: As directed, Btu/h (kW).
2. Total Heat-Transfer Rate: As directed, Btu/h (kW).
3. Entering-Air, Dry-Bulb Temperature: As directed, deg F (deg C).
4. Entering-Air, Wet-Bulb Temperature: As directed, deg F (deg C).
5. Leaving-Air, Dry-Bulb Temperature: As directed, deg F (deg C).
6. Leaving-Air, Wet-Bulb Temperature: As directed, deg F (deg C).
7. Face Area: As directed, sq. ft. (sq. m).
8. Maximum Face Velocity: As directed, fpm (m/s).
9. Maximum Air-Side, Static-Pressure Drop: As directed, inches wg (Pa).
10. Number of Rows: As directed.
11. Fin Spacing: As directed, Maximum fins per inch (per mm).
12. Water:
    a. Water Flow: As directed, gpm (L/s).
    b. Maximum Water Pressure Drop: As directed, feet of head (kPa).
    c. Entering-Water Temperature: As directed, deg F (deg C).
    d. Leaving-Water Temperature: As directed, deg F (deg C).
    e. Tube Velocity: As directed, fpm (L/s).
13. Refrigerant:
    a. Refrigerant Type: As directed.

G. Prefilters:

1. Type: As directed.
2. Face Dimensions, each: As directed, inches by inches (mm by mm).
3. Depth: As directed, inches (mm).
4. Number of Filters, Wide by High: As directed.
5. Access Location: As directed, Front, Back, Side or Bottom.
6. Maximum or Rated Face Velocity: As directed, fpm (m/s).
7. Initial Resistance: As directed, inches wg (Pa).
8. Recommended Final Resistance: As directed, inches wg (Pa).
9. Minimum Efficiency Reporting Value and Average Arrestance:
    a. MERV Rating: As directed, MERV 1, MERV 2, MERV 3 or MERV 4, and corresponding average arrestance according to ASHRAE 52.2.
10. Minimum Efficiency Reporting Value:

a. MERV Rating: As directed, MERV 6 or MERV 13, according to ASHRAE 52.2.

H. Final Filters:

1. Type: As directed.
2. Face Dimensions, each: As directed, inches by inches (mm by mm).
3. Depth: As directed, inches (mm).
4. Number of Filters, Wide by High: As directed.
5. Access Location: As directed, Front, Back, Side or Bottom.
6. Maximum or Rated Face Velocity: As directed, fpm (m/s).
7. Initial Resistance: As directed, inches wg (Pa).
8. Recommended Final Resistance: As directed, inches wg (Pa).
9. Minimum Efficiency Reporting Value:

a. MERV Rating: As directed, MERV 6 or MERV 13, according to ASHRAE 52.2.

I. Dampers: As directed, Zone, Mixing dampers or Face and bypass.

J. Sound Attenuators:

1. Configuration: As directed, Straight or Elbow.
2. Shape: As directed, Rectangular or Round.
3. Attenuation Mechanism: As directed, Acoustic glass fiber or Packless.
4. Maximum Pressure Drop: As directed, inches wg (Pa).
5. Length: As directed, inches (mm).
6. Face Dimension: As directed, inches (mm) wide by inches (mm) high.
7. Face Velocity: As directed, fpm (m/s).
8. Dynamic Insertion Loss:

a. 1st Octave: As directed.
b. 2nd Octave: As directed.
c. 3rd Octave: As directed.
d. 4th Octave: As directed.
e. 5th Octave: As directed.
f. 6th Octave: As directed.
g. 7th Octave: As directed.
h. 8th Octave: As directed.

9. Generated Noise:

a. 1st Octave: As directed.
b. 2nd Octave: As directed.
c. 3rd Octave: As directed.
d. 4th Octave: As directed.
e. 5th Octave: As directed.
f. 6th Octave: As directed.
g. 7th Octave: As directed.
h. 8th Octave: As directed.

K. Steam Grid Humidifier:

1. Humidification Rate: As directed, lb/h (g/s).
2. Steam Supply Pressure: As directed, psig (kPa).
3. Dry-Bulb Air Temperature at Discharge: As directed, deg F (deg C).
4. Wet-Bulb Air Temperature at Discharge: As directed, deg F (deg C).
5. Maximum Absorption Distance: As directed, inches (mm).
6. Number of Distribution Tubes or Manifolds: As directed.

L. Self-Contained Electric-Resistance Humidifier.

1. Humidification Rate: As directed, lb/h (g/s).
2. Dry-Bulb Air Temperature at Discharge: As directed, deg F (deg C).
3. Wet-Bulb Air Temperature at Discharge: As directed, deg F (deg C).
4. Maximum Absorption Distance: As directed, inches (mm).
5. Minimum Makeup Water Supply Pressure: As directed, psig (kPa).
6. Electric-Resistance Evaporation Chamber:

    a. Power Input per Chamber: As directed, kW.
    b. Number of Chambers: As directed.

M. Self-Contained Gas-Fired Humidifier:

1. Humidification Rate: As directed, lb/h (g/s).
2. Dry-Bulb Air Temperature at Discharge: As directed, deg F (deg C).
3. Wet-Bulb Air Temperature at Discharge: As directed, deg F (deg C).
4. Maximum Absorption Distance: As directed, inches (mm).
5. Minimum Makeup Water Supply Pressure: As directed, psig (kPa).
6. Gas-Fired Generator:

    a. Fuel Input: As directed, Btu/h (kW).
    b. Fuel Pressure: As directed, inches wg (kPa).

7. Number of Distribution As directed, Tubes or Manifolds: As directed.

N. Heat-Exchanger Humidifier:

1. Humidification Rate: As directed lb/h (g/s).
2. Dry-Bulb Air Temperature at Discharge: As directed deg F (deg C).
3. Wet-Bulb Air Temperature at Discharge: As directed deg F (deg C).
4. Maximum Absorption Distance: As directed inches (mm).
5. Minimum Makeup Water Supply Pressure: As directed psig (kPa).
6. Steam to Heat Exchanger:

    a. Supply Pressure at Control Valve: As directed psig (kPa).
    b. Condensing Rate: As directed lb/h (g/s).

O. Air-to-Air Energy Recovery:

1. Type: As directed Heat-wheel air-to-air energy recovery or Fixed-plate air-to-air energy recovery.
2. Exhaust Air:

a. Airflow: As directed cfm (L/s).
b. Face Velocity: As directed fpm (m/s).
c. Summer:

1) Entering-Air Temperature, Dry Bulb: As directed, deg F (deg C).
2) Entering-Air Temperature, Wet Bulb: As directed, deg F (deg C).
3) Leaving-Air Temperature, Dry Bulb: As directed, deg F (deg C).
4) Leaving-Air Temperature, Wet Bulb: As directed, deg F (deg C).

d. Winter:

1) Entering-Air Temperature, Dry Bulb: As directed, deg F (deg C).
2) Entering-Air Temperature, Wet Bulb: As directed, deg F (deg C).
3) Leaving-Air Temperature, Dry Bulb: As directed, deg F (deg C).
4) Leaving-Air Temperature, Wet Bulb: As directed, deg F (deg C).
5) Air Pressure Drop: As directed, inches wg (Pa).

3. Supply Air:

a. Airflow: As directed cfm (L/s).
b. Face Velocity: As directed fpm (m/s).
c. Summer:

1) Entering-Air Temperature, Dry Bulb: As directed, deg F (deg C).
2) Entering-Air Temperature, Wet Bulb: As directed, deg F (deg C).
3) Leaving-Air Temperature, Dry Bulb: As directed, deg F (deg C).
4) Leaving-Air Temperature, Wet Bulb: As directed, deg F (deg C).

d. Winter:

1) Entering-Air Temperature, Dry Bulb: As directed, deg F (deg C).
2) Entering-Air Temperature, Wet Bulb: As directed, deg F (deg C).
3) Leaving-Air Temperature, Dry Bulb: As directed, deg F (deg C).
4) Leaving-Air Temperature, Wet Bulb: As directed, deg F (deg C).
5) Air Pressure Drop: As directed, inches wg (Pa).

e. Wheel Drive:

1) Motor Size: As directed.
2) Motor Electrical Characteristics:

a) Volts: As directed 120, 208 or 230.
b) Phase: As directed Single or Three.
c) Hertz: 60 Hz.

f. Effectiveness:

4. Air Blender:

a. Airflow: As directed cfm (L/s).
b. Minimum Velocity: As directed fpm (m/s).

c. Air Pressure Drop: As directed inches wg (Pa).

5. Diffuser:

a. Airflow: As directed cfm (L/s).
b. Air Pressure Drop: As directed inches wg (Pa).

2.3 INDOOR, SEMI-CUSTOM AIR-HANDLING UNIT MANUFACTURERS

2.4 UNIT CASINGS

A. Frame: Modular and providing overall structural integrity without reliance on casing panels for structural support.

B. Base Rail:

1. Material: As directed Galvanized steel or Welded structural steel.
2. Height: 6 inches (150 mm).

C. Casing Joints: Hermetically sealed at each corner and around entire perimeter.

D. Outside Casing Wall:

1. Material: Galvanized steel, minimum as directed 18-gauge (1.3 mm), 16-gauge (1.6 mm) or 14-gauge (2.0 mm) thick.
2. Material: Aluminum, minimum as directed 16-gauge (1.3 mm), 14-gauge (1.6 mm) or 12-gauge (2.0 mm) thick.
3. Factory Finish: Provide manufacturer's standard finish.

E. Inside Casing Wall:

1. Material: As directed Galvanized steel, solid or perforated, minimum 18-gauge (1.3 mm) or 16-gauge (1.6 mm) thick.
2. Material: Aluminum, solid or perforated, minimum 16-gauge (1.3 mm) or 14-gauge (1.6 mm) thick.

F. Floor Plate:

1. Material: As directed Galvanized steel, treadplate, minimum 18-gauge (1.3 mm), 16-gauge (1.6 mm), 14-gauge (2.0 mm), 12-gauge (2.7 mm) or 10-gauge (3.5 mm) thick.
2. Material: Aluminum, treadplate, minimum 18-gauge (1.0 mm), 16-gauge (1.3 mm), 14-gauge (1.6 mm), 12-gauge (2.0 mm) or 10-gauge (2.6 mm) thick.

G. Static-Pressure Classifications:

1. For Unit Sections Upstream of Fans: Minus 2-inch wg (500 Pa), 3-inch wg (750 Pa), 4-inch wg (1000 Pa) or 6-inch wg (1500 Pa).
2. For Unit Sections Downstream and Including Fans: As directed 2-inch wg (500 Pa), 3-inch wg (750 Pa), 4-inch wg (1000 Pa) or 6-inch wg (1500 Pa).

H. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

I. Casing Insulation:

1. Materials: As directed Glass-fiber blanket or board insulation, Type I or Type II ASTM C1071, injected polyurethane foam insulation or Glass-fiber insulation layered over injected foam in perforated interior casing sections to meet specified acoustic requirements.
2. Casing Panel R-Value: Minimum As directed R-11 or R-13.
3. Insulation Thickness: 2 inches (50 mm).
4. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roofs of air-handling unit.

J. Panels, Doors and Windows:

1. Panels:

a. Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing.
b. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against airflow
c. Gasket: Neoprene, applied around entire perimeters of panel frames.
d. Size: Large enough to allow unobstructed access for inspection and maintenance of air-handling unit's internal components. As directed At least 18 inches (450 mm) or 24 inches (600 mm) wide by full height of unit casing up to a maximum height of 60 inches (1500 mm) or 72 inches (1800 mm).

2. Doors:

a. Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing.
b. Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and two wedge-lever latches, operable from inside and outside. Arrange doors to be opened against airflow. Provide safety latch retainers on doors so that doors do not open uncontrollably.
c. Gasket: Neoprene, applied around entire perimeters of panel frames.
d. Size: Large enough to allow for unobstructed access for inspection and maintenance of air-handling unit's internal components. At least 18 inches (450 mm) or 24 inches (600 mm) wide by full height of unit casing up to a maximum height of 60 inches (1500 mm) or 72 inches (1800 mm).

3. Windows:

a. Construction: Fabricate windows in access panels and doors of double-glazed, safety glass with an airspace between panes and sealed with interior and exterior rubber seals.
b. Size: Minimum 6 inches (150 mm), square or round.

4. Locations and Applications:

a. Fan Section: As directed, Doors, Panels, with windows.
b. Coil Section: Panels.
c. Access Section: As directed Doors, Panels, with windows.
d. Access Sections Immediately Upstream and Downstream of Coil Sections: As directed Doors, Panels, with windows.
e. Damper Section: As directed Doors, Panels, with viewing windows.
f. Filter Section: As directed Doors or Panels large enough to allow periodic removal and installation of filters.
g. Access Sections Immediately Upstream and Downstream of Filter Sections: As directed Doors, Panels, with windows.
h. Mixing Section: As directed Doors, Panels, with windows.
i. Humidifier Section: As directed Doors, Panels, with windows.

5. Service Lights: LED vaporproof luminaire with individual switched junction box located outside or inside as directed, adjacent to each access door and panel.

   a. Locations: As directed Each section accessed with door or panel or Fan section.

6. Convenience Outlets: One 20-A duplex GFCI receptacle per location with junction box located on outside casing wall.

   a. Locations: As directed Each section accessed with a door or panel or Fan section.

K. Condensate Drain Pans:

1. Construction:

   a. Single-wall, galvanized-steel or noncorrosive polymer sheet.
   b. Double-wall, galvanized-steel or noncorrosive polymer sheet with space between walls filled with foam insulation and moisture-tight seal.

2. Drain Connection:

   a. Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end or both ends of pan as directed.
   b. Minimum Connection Size: As directed NPS 1 (DN 25) or NPS 2 (DN 50).

3. Slope: Minimum 0.125-in./ft. (10-mm/mm) slope, to comply with ASHRAE 62.1, in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.
4. Length: Extend drain pan downstream from leaving face for distance to comply with ASHRAE 62.1.
5. Width: Entire width of water producing device.
6. Depth: A minimum of 2 inches (50 mm) deep.
7. As directed Formed sections or Integral part of floor plating.
8. Pan-Top Surface Coating for Galvanized-Steel Drain Pans: Asphaltic waterproofing compound.
9. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

2.5 FAN, DRIVE, AND MOTOR SECTION

A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.

1. Shafts: With field-adjustable alignment.

a. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
b. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

B. Centrifugal Fan Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.

1. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.
2. Horizontal-Flanged, Split Housing: Bolted construction.
3. Housing for Supply Fan: Attach housing to fan-section casing with metal-edged flexible duct connector.
4. Flexible Connector: As directed Factory fabricated with a fabric strip 3-1/2 inches (89 mm) or 5-3/4 inches (146 mm) wide attached to two strips of 2-3/4 inches (70 mm) wide, 0.028-inch- (0.7-mm-) thick, galvanized-steel sheet or 0.032-inch- (0.8-mm-) thick, aluminum sheets.

a. Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.

1) Fabric Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).
2) Fabric Minimum Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.
3) Fabric Minimum Service Temperature Range: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).

C. Plenum Fan Housings: Steel frame and panel; fabricated without fan scroll and volute housing. Provide inlet screens for Type SWSI fans.

D. Plenum Fan Arrays: As directed Contained or Uncontained as defined in AHRI 430. Steel or aluminum frame with inlet cone and structural framing around each fan built into an array of multiple fans. As directed Provide backdraft or motorized dampers at each fan to prevent short circuiting of flow if one fan is not operating.

E. Backward-Inclined, Centrifugal Fan Wheels: Construction with curved inlet flange, backplate, backward-inclined blades welded or riveted to flange and backplate; as directed steel or aluminum hub riveted to backplate and fastened to shaft with setscrews.

F. Forward-Curved, Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; as directed steel or aluminum hub swaged to backplate and fastened to shaft with setscrews.

G. Airfoil, Centrifugal Fan Wheels: Smooth-curved inlet flange, backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; as directed steel or aluminum hub riveted to backplate and fastened to shaft with setscrews.

H. Fan Shaft Bearings:

1. Prelubricated and Sealed, Ball Bearings: Self-aligning, pillow-block type with an L-50 rated life of 200,000 hours according to ABMA 9.
2. Grease-Lubricated, Tapered-Roller Bearings: Self-aligning, pillow-block type with double-locking collars and two-piece, cast-iron housing with grease lines extended to outside unit and an L-50 rated life of 200,000 hours according to ABMA 11.
3. Grease-Lubricated Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing with grease lines extended to outside unit and an L-50 rated life of 200,000.

I. Belt Drives: Factory mounted, with adjustable alignment and belt tensioning, and with 1.5 or 1.25 service factor based on fan motor as directed.

1. Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
2. Motor Pulleys: Adjustable pitch for use with 5-hp motors and smaller; fixed pitch for use with motors larger than 5 hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.
3. Belts: Oil resistant, nonsparking, and nonstatic; in matched sets for multiple-belt drives.
4. Belt Guards: Comply with requirements specified by OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards"; 0.146 inch- (2.7 mm-) thick, 3/4-inch (20-mm) diamond-mesh wire screen, welded to steel angle frame; prime coated.

J. Discharge Dampers: Heavy-duty steel assembly with channel frame and sealed ball bearings, and opposed or parallel blades as directed constructed of two plates formed around and welded to shaft, with blades linked out of airstream to single control lever.

K. Internal Vibration Isolation and Seismic Control: Fans shall be factory mounted with manufacturer's standard restrained vibration isolation mounting devices having a minimum static deflection of 1 inch (25 mm) or 2 inches (50 mm).

L. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Enclosure Type: Totally enclosed, fan cooled.
2. NEMA Premium Efficient motors as defined in NEMA MG 1.
3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
5. Mount unit-mounted disconnect switches on exterior or interior of unit as directed.

M. Variable-Frequency Motor Controller: Comply with Section 262923 "Variable-Frequency Motor Controllers."

N. Variable-Frequency Motor Controller: As directed Serving each fan individually or all fans combined in fan array.

1. Manufactured Units: Pulse-width modulated; constant torque and variable torque for Design A and Design B or inverter-duty motors as directed.
2. Output Rating: As directed Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range or 66 Hz, with torque constant as speed changes; maximum voltage equals input voltage.
3. Unit Operating Requirements:

    a. Internal Adjustability:

        1) Minimum Speed: 5 to 25 percent of maximum rpm.
        2) Maximum Speed: 80 to 100 percent of maximum rpm.
        3) Acceleration: 0.1 to 999.9 seconds.
        4) Deceleration: 0.1 to 999.9 seconds.
        5) Current Limit: 30 to minimum of 150 percent of maximum rating.

    b. Self-Protection and Reliability Features:

        1) Surge suppression.
        2) Loss of input signal protection.
        3) Under- and overvoltage trips.
        4) Variable-frequency motor controller and motor-overload/overtemperature protection.
        5) Critical frequency rejection.
        6) Loss-of-phase protection.
        7) Reverse-phase protection.
        8) Motor-overtemperature fault.

    c. Bidirectional autospeed search.
    d. Torque boost.
    e. Motor temperature compensation at slow speeds.

        1) Panel-mounted operator station.
        2) Historical logging information and displays.
        3) Digital indicating devices.

    f. Control Signal Interface: Electric.
    g. Proportional Integral Directive (PID) control interface.
    h. DDC system for HVAC Protocols for Network Communications: ASHRAE 135.

4. Line Conditioning:

    a. Input line conditioning.
    b. Output filtering.
    c. EMI/RFI filtering.

5. Bypass Systems:

    a. Bypass Mode: As directed Manual operation only or Field-selectable automatic or manual.
    b. Bypass Controller: Two-contactor style, with bypass and output isolating contactors and isolating switch.
    c. Bypass Controller: Three-contactor style, with bypass and input and output isolating contactors and isolating switch.
    d. Bypass Contactor Configuration: As directed Full-voltage (across the line) or Reduced-voltage (autotransformer) type.

2.6 COIL SECTION

A. General Requirements for Coil Section:

1. Comply with AHRI 410.
2. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
3. For multizone units, provide air deflectors and air baffles to balance airflow across coils.
4. Coils shall not act as structural component of unit.

B. Preheat Coils:

1. Electrical Coils, Controls, and Accessories: Comply with UL 1995.

    a. Casing Assembly: As directed Slip-in or Flanged type with galvanized-steel frame.
    b. Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
    c. Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from coil section.
    d. Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
    e. Control Panel: As directed Unit or Remote mounted with disconnecting means and overcurrent protection.

        1) As directed Magnetic or Mercury contactor.
        2) Solid-state, stepless pulse controller.
        3) Toggle switches, one per step.
        4) Step controller.
        5) Time-delay relay.
        6) Pilot lights, one per step.
        7) Airflow proving switch.

2. Hot-Water Coils: As directed Continuous circuit, Self-draining or Cleanable.

    a. Piping Connections: As directed Threaded, Flanged, same end or opposite ends of coil.

b. Tube Material: Copper.
c. Fin Type: Plate.
d. Fin Material: As directed Aluminum or Copper.
e. Fin Spacing: As directed Maximum 10 or 12 fins per inch (mm).
f. Fin Thickness: Inches (mm) as directed.
g. Fin and Tube Joint: As directed Mechanical bond or Silver brazed.
h. Headers:

1) Cast iron with cleaning plugs and drain and air vent tappings extended to exterior of unit.
2) Seamless copper tube with brazed joints, prime coated.
3) Fabricated steel, with brazed joints, prime coated.
4) Provide insulated cover to conceal exposed outside casings of headers.

i. Frames: Channel frame, As directed 0.052-inch- (1.3-mm-) thick, galvanized steel, 0.064-inch- (1.6-mm-) thick, galvanized steel, 0.079-inch- (2.0-mm-) thick, galvanized steel, 0.0625-inch- (1.58-mm-) thick, galvanized steel or 0.0625-inch- (1.58-mm-) thick, stainless steel.
j. Coil Working-Pressure Ratings: 200 psig (1380 kPa), 325 deg F (163 deg C).
k. Integral Face-and-Bypass Dampers: As directed Horizontal or Vertical, opposed-blade, galvanized-steel, aluminum or extruded-aluminum dampers with zinc-plated steel operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel, aluminum or extruded-aluminum frame, with operating rods connected with a common linkage. Meeting edges of blades shall have gaskets and edge seals, and blades shall be mechanically fastened.
l. Integral Face-and-Bypass Dampers: As directed Horizontal or Vertical opposed-blade, galvanized-steel, aluminum or extruded-aluminum dampers with zinc-plated steel operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel, aluminum or extruded-aluminum frame, with operating rods connected with a common linkage. Meeting edges of blades shall have gaskets and edge seals, and blades shall be mechanically fastened.

C. Heating Coils:

1. Electrical Coils, Controls, and Accessories: Comply with UL 1995.

a. Casing Assembly: As directed Slip-in or Flanged type with galvanized-steel frame.
b. Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
c. Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from coil section.
d. Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
e. Control Panel: As directed Unit or Remote mounted with disconnecting means and overcurrent protection.

1) As directed Magnetic or Mercury contactor.
2) Solid-state, stepless pulse controller.

3) Toggle switches, one per step.
4) Step controller.
5) Time-delay relay.
6) Pilot lights, one per step.
7) Airflow proving switch.

2. Hot-Water Coils: As directed Continuous circuit, Self-draining or Cleaning.

a. Piping Connections: As directed Threaded, Flanged, same end or opposite ends of coil.
b. Tube Material: Copper.
c. Fin Type: Plate.
d. Fin Material: As directed Aluminum or Copper.
e. Fin Spacing: As directed Maximum 10 or 12 fins per inch (mm).
f. Fin Thickness: Inches (mm) as directed.
g. Fin and Tube Joint: As directed Mechanical bond or Silver brazed.
h. Headers:

1) Cast iron with cleaning plugs and drain and air vent tappings extended to exterior of unit.
2) Seamless copper tube with brazed joints, prime coated.
3) Fabricated steel, with brazed joints, prime coated.
4) Provide insulated cover to conceal exposed outside casings of headers.

i. Frames: As directed Channel frame, 0.052-inch- (1.3-mm-) thick, galvanized steel, 0.064-inch- (1.6-mm-) thick, galvanized steel, 0.079-inch- (2.0-mm-) thick, galvanized steel, 0.0625-inch- (1.58-mm-) thick, galvanized steel or 0.0625-inch- (1.58-mm-) thick, stainless steel.
j. Coil Working-Pressure Ratings: 200 psig (1380 kPa), 325 deg F (163 deg C).

D. Cooling Coils:

1. Chilled-Water Coil: As directed Continuous circuit, Self-draining or Cleanable.

a. Piping Connections: As directed Threaded, Flanged, same end or opposite ends of coil.
b. Tube Material: Copper.
c. Tube Thickness: Inches (mm) as directed.
d. Fin Type: Plate.
e. Fin Material: As directed Aluminum or Copper.
f. Fin Spacing: As directed 0.125 inch (3.18 mm), 0.091 inch (2.31 mm) or 0.071 inch (1.80 mm), 0.067 inch (1.70 mm), 0.056 inch (1.42 mm) or 0.0075 inch (0.19 mm).
g. Fin Thickness: Inches (mm) as directed.
h. Fin and Tube Joint: As directed Mechanical bond or Silver brazed.
i. Headers:

1) Cast iron with cleaning plugs and drain and air vent tappings extended to exterior of unit.
2) Seamless copper tube with brazed joints, prime coated.
3) Fabricated steel, with brazed joints, prime coated.

4) Provide insulated cover to conceal exposed outside casings of headers.

j. Frames: As directed Channel frame, 0.052-inch- (1.3-mm-) thick, galvanized steel, 0.064-inch- (1.6-mm-) thick, galvanized steel, 0.079-inch- (2.0-mm-) thick, galvanized steel, 0.0625-inch- (1.58-mm-) thick, galvanized steel or 0.0625-inch- (1.58-mm-) thick, stainless steel.
k. Working-Pressure Ratings: 200 psig (1380 kPa), 325 deg F (163 deg C).

2. Refrigerant Coil:

a. Tubes: Copper.
b. Fins:

1) Material: As directed Aluminum or Copper.
2) Fin Spacing: As directed Maximum 12, 10 or 8 fins per inch (mm).

c. Fin and Tube Joints: Mechanical bond.
d. Headers: Seamless-copper headers with brazed connections.
e. Frames: As directed Galvanized steel or Stainless steel.
f. Ratings: Designed, tested, and rated according to ASHRAE 33 and AHRI 410.

1) Working Pressure: Minimum 300 psig (2070 kPa).

2.7 AIR FILTRATION SECTION

A. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."

B. High-efficiency particulate air (HEPA) filtration is specified in Section 234133 "High-Efficiency Particulate Air Filtration."

C. Gas-phase air filtration is specified in Section 234200 "Gas-Phase Air Filtration."

D. Panel Filters:

1. Description: As directed Flat, non-pleated or Pleated factory-fabricated, self-supported, disposable air filters with holding frames.
2. Filter Unit Class: UL 900.
3. Media: Interlaced glass, synthetic or cotton fibers coated with nonflammable adhesive.
4. Filter-Media Frame: Beverage board with perforated metal retainer, or metal grid, on outlet side.

E. Bag Filters:

1. Description: Factory-fabricated, dry, extended-surface, self-supporting filters with holding frames in steel, basket-type retainers.
2. Filter Unit Class: UL 900.
3. Media: Fibrous material, coated with antimicrobial agent, constructed so individual pockets are maintained in tapered form by flexible internal supports under rated-airflow conditions.

4. Filter-Media Frame: Galvanized steel.

F. Cartridge Filters:

1. Description: Factory-fabricated, adhesive-coated disposable, packaged air filters with media perpendicular to airflow, and with holding frames.
2. Filter Unit Class: UL 900.
3. Media: Fibrous material, coated with antimicrobial agent, constructed so individual pleats are maintained in pleated form under rater-airflow conditions by corrugated aluminum separators.
4. Filter Media Frame: As directed Galvanized steel.

G. Front- or Back-Access Filter Mounting Frames:

1. Particulate Air Filter Frames: As directed Galvanized-steel or Aluminum framing members with access for filter servicing, cut to size and prepunched for assembly into modules. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation or operation.

    a. Prefilters: Incorporate a separate 2-inch- (50-mm-) thick track with spring clips, with same access as primary filter.
    b. Sealing: Full periphery foam gaskets.

2. HEPA Filter Frames: As directed Aluminum or Stainless-steel framing members, cut to size and prepunched for assembly into modules. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation operation. Bolted filter-sealing mechanism shall mount and continuously seal each individual filter.

    a. Prefilters: As directed Incorporate a separate 2-inch- (50-mm-) or 4-inch- (50-mm-) thick track with spring clips with same access as primary filter.
    b. Sealing: Gasketed or gel, hand-crank locking mechanism to provide positive-sealing for each filter to ensure seal between filter elements to prevent bypass of unfiltered air.

3. Gas-Phase Air Filter Frames: As directed Galvanized-steel or Aluminum framing members with access for filter servicing, cut to size and prepunched for assembly into modules. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation or operation.

    a. Prefilters: Incorporate a separate 2-inch- (50-mm-) thick track with spring clips.
    b. Sealing: As directed Full periphery foam gaskets or Positive-sealing-device for each row of filters to ensure seal between gasketed filter elements to prevent bypass of unfiltered air.

H. Side-Access Filter Mounting Frames:

1. Particulate Air Filter Frames: Match inner casing and outer casing material, and insulation thickness. As directed Galvanized steel or Aluminum track.

a. Prefilters: Incorporate an integral 2-inch- (50-mm-) thick track with same access as primary filter.
b. Sealing: Incorporate positive-sealing device to ensure seal between gasketed material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.

2. HEPA Filter Frames:

a. Frames: Match inner casing and outer casing material, and insulation thickness. As directed Aluminum or Stainless steel track.
b. Prefilters: As directed Incorporate an integral 2-inch- (50-mm-) or 4-inch- (100-mm-) thick track,
c. Sealing: Incorporate positive-sealing clamping device on each filter between gasket or gel seal on all sides of filter cartridge frames to prevent bypass of unfiltered air as directed.

3. Gas-Phase Air Filter Frames:

a. Frames: Matching inner casing and outer casing material, and insulation thickness. Galvanized-steel or Aluminum track as directed.
b. Prefilters: Incorporate an integral 2-inch- (50-mm-) thick track.
c. Sealing: Incorporate positive-sealing gasket material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.

2.8 DAMPERS

A. General Requirements for Dampers: Leakage rate, according to AMCA 500, "Laboratory Methods for Testing Dampers for Rating," shall not exceed 4 cfm/sq. ft. (20 L/s per sq. m) at 1-inch wg (250 Pa) and 8 cfm/sq. ft. (40 L/s per sq. m) at 4-inch wg (1.0 MPa).

B. Damper Operators: Comply with requirements in Section 230923.12 "Control Dampers."

C. Electronic Damper Operators:

1. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
2. Electronic damper position indicator shall have visual scale indicating percent of travel and 2 to 10 V dc, feedback signal.
3. Operator Motors:

a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
b. Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
c. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.

4. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running torque of 150 in. x lbf (16.9 N x m) and breakaway torque of 300 in. x lbf (33.9 N x m).
5. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running and breakaway torque of 150 in. x lbf (16.9 N x m).
6. Size dampers for running torque calculated as follows:

    a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. (86.8 kg-cm/sq. m) of damper.
    b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. (62 kg-cm/sq. m) of damper.
    c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft (49.6 kg-cm/sq. m) of damper.
    d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. (37.2 kg-cm/sq. m) of damper.
    e. Dampers with 2- to 3-Inch wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 fpm (5 to 13 m/s): Increase running torque by 1.5.
    f. Dampers with 3- to 4-Inch wg (750 to 1000 Pa) of Pressure Drop or Face Velocities of 2500 to 3000 fpm (13 to 15 m/s): Increase running torque by 2.0.

7. Coupling: V-bolt and V-shaped, toothed cradle.
8. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
9. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on nonspring-return actuators.
10. Power Requirements (Two-Position Spring Return): As directed 24 V dc, 120 V ac or 230 V ac.
11. Power Requirements (Modulating): Maximum 10 VA at 24 V ac or 8 W at 24 V dc.
12. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
13. Temperature Rating: As directed Minus 22 to plus 122 deg F (Minus 30 to plus 50 deg C) or 40 to 104 deg F (5 to 40 deg C).
14. Run Time: As directed 12 seconds open, 5 seconds closed, 30 seconds, 60 seconds or 120 seconds.

D. Zone Dampers: As directed Two single-blade, galvanized-steel, aluminum or extruded-aluminum dampers offset 90 degrees from each other on zinc-plated steel operating rod rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel, aluminum or extruded-aluminum frame. Provide blade gaskets and edge seals, and mechanically fasten blades to operating rod.

E. Face-and-Bypass Dampers: As directed Opposed-blade, galvanized-steel, aluminum or extruded-aluminum dampers with zinc-plated steel operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel, aluminum or extruded-aluminum frame and with operating rods connected with a common linkage. Provide blade gaskets and edge seals, and mechanically fasten blades to operating rod.

F. Outdoor- and Return-Air Dampers: As directed Low-leakage, double-skin, airfoil-blade, galvanized-steel, aluminum or extruded-aluminum dampers with compressible jamb seals and extruded-vinyl blade edge seals in opposed or parallel-blade arrangement with zinc-plated steel operating rods rotating in stainless-steel sleeve or sintered bronze or nylon bearings mounted in a single galvanized-steel, aluminum or extruded-aluminum frame, and with operating rods

connected with a common linkage. Leakage rate shall not exceed 4 cfm/sq. ft. (20 L/s per sq. m) at 1-inch wg (250 Pa) and 8 cfm/sq. ft. (040 L/s per sq. m) at 4-inch wg (1.0 MPa).

G. Mixing Section: Multiple-blade, air-mixer assembly located immediately downstream of mixing section.

H. Combination Filter and Mixing Section:

1. Cabinet support members shall hold 2-inch- (50-mm-) thick, pleated, flat, permanent or throwaway filters.
2. Multiple-blade, air-mixer assembly shall mix air to prevent stratification, located immediately downstream of mixing box.

2.9 SOUND ATTENUATORS

A. General Requirements:

1. Factory fabricated.
2. Fire Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials with flame-spread index not exceeding 25 and smoke-developed index not exceeding 50, ASTM E84.
3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with ASHRAE 62.1.

B. Shape: As directed Rectangular, straight, Round, straight, Rectangular, elbow or Round, elbow.

C. Rectangular Silencer Outer Casing: Galvanized steel.

D. Round Silencer Outer Casing: Galvanized steel.

E. Inner Casing and Baffles: Galvanized steel.

F. Principal Sound-Absorbing Mechanism:

1. Packless Type: Controlled impedance membranes and broadly tuned resonators without adsorptive media.
2. Dissipative Type: Polymer film-lined absorptive fill material.

    a. Fill Material: As directed Inert and vermin-proof fibrous material.

3. Joints: Lock formed and sealed, continuously welded or flanged.

2.10 HUMIDIFIERS

A. Direct-steam-injection humidifiers are specified in Section 238413.23 "Direct-Steam-Injection Humidifiers."

B. Self-contained humidifiers are specified in Section 238413.29 "Self-Contained Humidifiers."

C. Heat-exchanger humidifiers are specified in Section 238413.36 "Heat Exchanger Humidifiers."

2.11 AIR-TO-AIR ENERGY RECOVERY

A. Heat Wheels:

1. Casing:

   a. Galvanized steel, stainless steel, or aluminum with manufacturer's standard finish.
   b. Integral purge section limiting carryover of exhaust air to between 0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg (0.5 percent at 400-Pa and 0.20 percent at 1000-Pa) differential pressure.
   c. Casing seals on periphery of rotor, on duct divider, and on purge section.
   d. Support rotor on grease-lubricated ball bearings with extended grease fittings. Mount horizontal wheels on tapered roller bearing.

2. Rotor: Aluminum or polymer segmented wheel, strengthened with radial spokes, with nontoxic, noncorrosive, silica-gel desiccant coating.
3. Rotor: Aluminum, metallic, or polymer segmented wheel, strengthened with radial spokes impregnated with nonmigrating, water-selective, 3-angstrom molecular-sieve desiccant coating.
4. Drive: Fractional horsepower motor and gear reducer, with speed changed by variable-frequency controller. Permanently lubricated wheel bearings with an L-10400,000 hours.
5. Controls:

   a. Starting relay, factory mounted and wired, and manual motor starter for field wiring.
   b. Variable-frequency controller, factory mounted and wired, permitting input of field connected 4- to 20-mA or 1- to 10-V control signal.
   c. Variable-frequency controller, factory mounted and wired, with exhaust-air sensor to vary rotor speed and maintain exhaust temperature above freezing.
   d. Variable-frequency controller, factory mounted and wired, with exhaust- and outdoor-air sensors, automatic changeover thermostat and set-point adjuster, to vary rotor speed and maintain exhaust temperature above freezing and air differential temperature above set point. Provide maximum rotor speed when exhaust-air temperature is less than outdoor-air temperature.
   e. Pilot-Light Indicator: Display rotor rotation and speed.
   f. Speed Settings: Adjustable settings for maximum and minimum rotor speed limits.

B. Fixed-Plate Sensible Heat Exchangers:

1. Casing: As directed Aluminum or Galvanized steel.
2. Plates: As directed Evenly spaced and sealed and arranged for counter or cross airflow.
3. Plate Material: As directed Embossed aluminum, Stainless steel or High-density plastic.
4. Plate Coating: Epoxy.
5. Bypass: Plenum within casing, with gasketed face-and-bypass dampers that have operating rods extended outside casing.
6. Heat-Exchanger Prefilters: As directed 1 inch (25 mm) thick, disposable, 2 inches (50 mm) thick, disposable or MERV 6.

2.12 AIR BLENDER

A. Description: Static air mixer device to provide mixing of two airstreams to within plus/minus 6 deg F (3 deg C).

B. Material: As directed Galvanized steel or Aluminum.

C. Coating: As directed None or Corrosion-resistant coating.

2.13 DIFFUSER

A. Description: Velocity profile equalizer device for providing equalized airflow profile downstream of Type DWDI fans.

B. Material: As directed Galvanized steel or Aluminum.

2.14 UV-C LAMP SYSTEMS

A. Description:

1. UV-C lamp system consisting of power supply, power supply housing, wiring, ultraviolet lamp(s), lamp plug, lamp plug protector, encapsulated lamp, and lamp holder used for UV germicidal irradiation of cooling coil and condensate drain pan.
2. Factory installed and preengineered.

B. Standard: UL Category Code ABQK, HVAC accessories, air-duct mounted.

C. Lamps: High output, hot cathode.

D. Lamp-Holder Construction:

1. UV- and moisture-resistant materials and designed to connect the lamp to the plug.
2. Adjustable positioning.

E. Lamp-Clamp Construction:

1. UV- and moisture-resistant materials, water-tight connection.
2. Adjustable positioning.

F. Lamp Protection: Hermetically sealed to provide protection against lamp breakage and to ensure lamp contents from a broken lamp are contained.

G. Lamp Output: UV-C energy, primarily at the 254-nm wavelength with a 360-degree energy distribution.

H. Access Door Interlocks: Automatic disconnect on all access doors into UV-installed casing sections to shield servicing personnel from contact with light.

I. Power Supply: UL-listed, single-point electrical connection with service disconnect.

J. Power Consumption: Maximum of 15 W/sq. ft. (161 W/sq. m).

2.15 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for steel sheet.

B. Galvanized Steel: ASTM A653/A653M.

C. Aluminum: ASTM B209 (ASTM B209M).

2.16 SOURCE QUALITY CONTROL

A. AHRI 430 Certification: Air-handling units and their components shall be factory tested according to AHRI 430 and shall be listed and labeled by AHRI.

B. AHRI 1060 Certification: Air-handling units that include air-to-air energy recovery devices shall be factory tested according to AHRI 1060 and shall be listed and labeled by AHRI.

C. AMCA 301 or AHRI 260: Air-handling unit fan sound ratings shall comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data," or AHRI 260, "Sound Rating of Ducted Air Moving and Conditioning Equipment."

D. Fan Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Fans shall bear AMCA-certified sound ratings seal.

E. Fan Performance Rating: Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency. Rate performance according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating."

F. Water Coils: Factory tested to 300 psig (2070 kPa) according to AHRI 410 and ASHRAE 33.

G. Refrigerant Coils: Factory tested to minimum 450-psig (3105-kPa) internal pressure and to minimum 300-psig (2070-kPa) internal pressure while underwater, according to AHRI 410 and ASHRAE 33.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Equipment Mounting:

1. Install air-handling units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.
2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

B. Suspended Units: Suspend and brace units from structural-steel support frame using threaded steel rods and spring hangers. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC" or Section 230548.13 "Vibration Controls for HVAC" as directed.

C. Arrange installation of units to provide access space around air-handling units for service and maintenance.

D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.

E. Install filter-gauge, static-pressure taps upstream and downstream of filters. Mount filter gauges on outside of filter housing or filter plenum in accessible position. Provide filter gauges on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

F. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."

3.3 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to air-handling unit, allow for service and maintenance.

C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.

D. Connect condensate drain pans using NPS 1-1/4 (DN 32), ASTM B88, Type M (ASTM B88M, Type C) copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

E. Hot- and Chilled-Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Install shutoff valve and

union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.

F. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.

3.4 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.5 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Leak Test: After installation, fill water and steam coils with water, and test coils and connections for leaks.
2. Charge refrigerant coils with refrigerant and test for leaks.
3. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. HEPA Filters: Pressurize housing to a minimum of 3-inch wg (750 Pa) or to designed operating pressure, whichever is higher; test housing joints, door seals, and sealing edges of filter with soapy water to check for air leaks.

5. HEPA Filters: Pressurize housing to a minimum of 3-inch wg (750 Pa) or to designed operating pressure, whichever is higher; test housing joints, door seals, and sealing edges of filter for air leaks according to ASME AG-1, pressure-decay method.
6. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.

E. Prepare test and inspection reports.

3.7 DEMONSTRATION

A. As directed Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

END OF SECTION 237313.16

SECTION 237333.16 - INDOOR, INDIRECT, GAS-FIRED HEATING AND VENTILATING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes indirect, gas-fired heating and ventilating units.

1.2 ACTION SUBMITTALS

A. Product Data: For each type and configuration of indoor, indirect, gas-fired heating and ventilating unit.

B. Sustainable Design Submittals:

C. Shop Drawings: For each type and configuration of indoor, indirect, gas-fired heating and ventilating unit.

1. Include plans, elevations, sections, and mounting or attachment details as directed.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

1.3 INFORMATIONAL SUBMITTALS

A. Sample warranty.

B. Seismic Qualification Data: Certificates, for indoor, indirect, gas-fired heating and ventilating units, accessories, and components, from manufacturer.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Comply with NFPA 70.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of indirect, gas-fired heating and ventilating units that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than five or 10 years from date of Substantial Completion as directed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 SYSTEM DESCRIPTION

A. Factory-assembled, prewired, self-contained unit consisting of cabinet, supply fan, controls, filters, and indirect-fired gas burner to be installed inside the building.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 UNIT CASINGS

A. General Fabrication Requirements for Casings:

1. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
2. Casing Joints: Sheet metal screws or pop rivets, factory sealed with water-resistant sealant.
3. Factory Finish for Steel and Galvanized-Steel Casings: Apply manufacturer's standard primer immediately after cleaning and pretreating.
4. Air-Handling-Unit Mounting Frame: Formed galvanized-steel channel or structural channel supports, designed for low deflection, welded with integral lifting lugs.

    a. Seismic Fabrication Requirements: Fabricate mounting base and attachment to air-handling-unit sections, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC" when air-handling-unit frame is anchored to building structure.

5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. Configuration: As directed, Horizontal or Vertical unit with top, horizontal or bottom discharge for floor-mounted or suspended installation.

C. Cabinet: Galvanized-steel panels, formed to ensure rigidity and supported by galvanized-steel channels or structural channel supports with lifting lugs. Duct flanges at inlet and outlet.

D. Outer Casing: 0.0359-inch (0.912-mm) steel with heat-resistant, baked-enamel finish over-corrosion-resistant-treated surface in color to match fan section.

E. Inner Casing:

1. Burner Section Inner Casing: 0.0299-inch (0.759-mm) steel.
2. Double-wall casing with inner wall of perforated or solid steel as directed, for the following sections:

    a. Blower section.
    b. Filter section.
    c. Mixing box.
    d. Inlet plenum.
    e. Discharge plenum.
    f. As directed, Access Doors or Panels: As directed, Lift out, Piano hinged with cam-lock fasteners or Hinged with handles for burner and fan motor assemblies on both sides of unit.

3. Internal Insulation: Fibrous-glass duct lining, neoprene coated, comply with ASTM C1071, Type II, applied on complete unit or burner and fan sections only as directed.

    a. Thickness: As directed, 1 inch (25 mm) or 2 inches (50 mm).
    b. Insulation Adhesive: Comply with ASTM C916, Type I.
    c. Density: As directed, 1.5 lb/cu. ft. (24.0 kg/cu. m), 2.0 lb/cu. ft. (32.0 kg/cu. m) or 3.0 lb/cu. ft. (48.0 kg/cu. m).
    d. Mechanical Fasteners: Galvanized steel suitable for adhesive, mechanical, or welding attachment to casing without damaging liner when applied as recommended by manufacturer and without causing air leakage.

F. Discharge Section: As directed, Galvanized or Aluminized-steel assembly with gravity or individually adjustable, vaned, two-position, motorized, parallel-blade dampers with nylon bushings.

1. Pattern: As directed, Single or Double deflection.
2. Leakage: As directed, Standard or Low leakage.

G. Discharge Section: Trapezoidal cowls with horizontal louvers.

H. Discharge Section: As directed, Plenum with two or four sides louvered.

I. Discharge Section: Down-discharge plenum insulated with 1 inch (25 mm), 1.5 lb/cu. ft. (24.0 kg/cu. m) fibrous glass.

J. Casing Internal Insulation:

1. Materials: ASTM C1071, Type I or Type II as directed.

2. Location and Application: Factory applied with adhesive and mechanical fasteners to the internal surface of section panels downstream from, and including, the heating-coil section.

K. Inspection and Access Panels and Access Doors: Formed and reinforced, single- or double-wall and insulated panels of same materials and thicknesses as casing and complying with requirements in ASHRAE 62.1.

L. Condensate Drain Pans: As directed, fabricated with one or two percent slope in at least two planes to collect condensate from condensate-producing heat exchangers and from humidifiers and to direct water toward drain connection and complying with ASHRAE 62.1.

2.4 ACCESSORIES

A. Service Platform: Galvanized steel, 42 inches (1070 mm) wide running entire length of unit and located on service access side, with angle side rails, 4-inch (100-mm) kick plates, and expanded metal floor. Provide platform with a fixed ladder that extends from the top of the side rail to the floor.

2.5 SUPPLY-AIR FAN

A. Fan Type: Centrifugal, rated according to AMCA 210; statically and dynamically balanced, galvanized steel; mounted on solid-steel shaft with heavy-duty, self-aligning, permanently lubricated ball bearings, pillow-block bearings rated for L50 or 200,000 hours with external grease fittings as directed.

B. Drive: V-belt drive with matching fan pulley and adjustable motor sheaves and belt assembly.

C. Mounting: Fan wheel, motor, and drives shall be mounted in fan casing with restrained, elastomeric or spring isolators as directed.

D. Fan-Shaft Lubrication Lines: Extended to a location outside the casing.

2.6 AIR FILTERS

A. Comply with As directed, NFPA 90A or NFPA 90B.

B. Cleanable Filters: Cleanable metal mesh, 1 inch (25 mm) thick.

C. Disposable Panel Filters: Factory-fabricated, flat-panel-type, disposable air filters, 1 inch (25 mm) thick.

2.7 DAMPERS

A. Outdoor-Air and Return-Air Damper: Galvanized-steel, opposed-blade dampers with vinyl blade seals and stainless-steel jamb seals, having a maximum leakage of 10 cfm/sq. ft. (51 L/s per sq. m) of damper area, at a differential pressure of 2-inch wg (448 Pa).

B. Damper Operator: Direct coupled, electronic with spring return or fully modulating as required by the control sequence.

2.8 INDIRECT-FIRED GAS BURNER

A. Description: Factory assembled, piped, and wired; and complying with ANSI Z21.47, "Gas-Fired Central Furnaces," and with NFPA 54, "National Fuel Gas Code."

1. CSA Approval: Designed and certified by and bearing label of CSA.
2. Burners: Aluminized steel with stainless-steel inserts or Stainless steel as directed.

    a. Gas Control Valve: As directed, Single stage, Two stage or Modulating.
    b. Fuel: As directed, Natural or Propane gas.
    c. Minimum Combustion Efficiency: 80 percent.
    d. Ignition: Electronically controlled electric spark with flame sensor.
    e. High-Altitude Model or Kit as directed: For Project elevation above sea level.

B. Venting: Gravity vented.

C. Combustion-Air Intake: Separate combustion-air intake and vent terminal assembly.

D. Heat Exchanger: As directed, Aluminized or Stainless steel.

E. Heat-Exchanger Drain Pan: Stainless steel.

F. Safety Controls:

1. Vent Flow Verification: Differential pressure switch to verify open vent or Flame rollout switch.
2. Control Transformer: 24-V ac.
3. High Limit: Thermal switch or fuse to stop burner.
4. Gas Train: As directed, Regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, hydraulic or electronic-modulating temperature control valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.
5. Purge-period timer shall automatically delay burner ignition and bypass low-limit control.
6. Gas Manifold: Safety switches and controls complying with ANSI standards and FM Global or XL Insurance as directed.
7. Airflow Proving Switch: Differential pressure switch senses correct airflow before energizing pilot.
8. Automatic-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
9. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.

2.9 UNIT CONTROL PANEL

A. Factory-wired, fuse-protected control transformer, connection for power supply and field-wired unit to remote control panel.

B. Control Panel: As directed, Surface-mounted or Recessed, with trim ring, remote panel, with engraved plastic cover, and the following lights and switches:

1. As directed, On-off or On-off-auto fan switch.
2. Heat-vent-off switch.
3. Supply-fan operation indicating light.
4. Heating operation indicating light.
5. Thermostat.
6. Damper position potentiometer.
7. Dirty-filter indicating light operated by unit-mounted differential pressure switch.
8. Safety-lockout indicating light.
9. Enclosure: As directed, NEMA 250, Type 1, Type 3R, Type 4 or Explosion proof.

2.10 CONTROLS

A. Control Devices:

1. Remote Thermostat: Adjustable room thermostat with temperature readout.
2. Remote Setback Thermostat: Adjustable room thermostat without temperature readout.
3. Fire-Protection Thermostats: Fixed or adjustable settings to operate at not less than 75 deg F (24 deg C) above normal maximum operating temperature.
4. Timers: Seven-day, programming-switch timer with synchronous-timing motor and seven-day dial; continuously charged, nickel-cadmium-battery-driven, eight-hour, power-failure carryover; multiple-switch trippers; minimum of two and maximum of eight signals per day with two normally open and two normally closed output contacts.
5. Ionization-Type Smoke Detectors: 24-V dc, nominal; self-restoring; plug-in arrangement; integral visual-indicating light; sensitivity that can be tested and adjusted in place after installation; integral addressable module; remote controllability; responsive to both visible and invisible products of combustion; self-compensating for changes in environmental conditions.
6. Smoke detectors, located in supply and return air, shall stop fans when the presence of smoke is detected.

B. Fan Control: Interlock fan to start with exhaust fan(s) to which this heating and ventilating unit is associated for makeup air.

C. Outdoor-Air Damper Control, 100 Percent Outdoor-Air Units: Outdoor-air damper shall open when supply fan starts, and close when fan stops.

D. Mixed Outdoor- and Return-Air Damper Control: When fan is running, outdoor- and return-air dampers shall modulate to supply minimum outdoor air.

E. Temperature Control: Operates gas valve to maintain supply-air temperature.

1. Operates gas valve to maintain discharge-air temperature with factory-mounted sensor in blower outlet.
2. Timer shall select remote setback thermostat to maintain space temperature at 50 deg F (10 deg C).
3. Burner Control: Two or four steps of control using one or two burner sections in series.

2.11 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Enclosure: As directed, Open, dripproof, totally enclosed, fan cooled, Totally enclosed, air over, Open, externally ventilated, Totally enclosed, nonventilated, Severe duty, Explosion proof or Dust-ignition-proof machine.
2. Enclosure Materials: As directed, Cast iron, Cast aluminum or Rolled steel.
3. Motor Bearings: As directed.
4. Unusual Service Conditions:

    a. Ambient Temperature: As directed.
    b. Altitude: As directed, feet (m) above sea level.
    c. High humidity.

5. Efficiency: As directed, Premium efficient or EPAct compliant.
6. NEMA Design: As directed.
7. Service Factor: As directed.

2.12 CAPACITIES AND CHARACTERISTICS

A. Fan:

1. Discharge Configuration: As directed, Horizontal or Vertical.
2. Airflow: As directed.
3. External Static Pressure: As directed.
4. Maximum RPM: As directed.
5. Minimum Size: As directed.
6. Altitude: As directed.

B. Fan Motor:

1. Horsepower: As directed.
2. RPM: As directed.
3. Service Factor: As directed.
4. Speed: As directed, Single or Two.

C. Single-Point Electrical Connection:

1. Volts: As directed, 120, 240, 277 or 480.
2. Phase: As directed, Single or Three.
3. Hertz: 60.
4. Full-Load Amperes: As directed.
5. Minimum Circuit Ampacity: As directed.
6. Maximum Overcurrent Protection: As directed.

D. Indirect-Fired Gas Burner:

1. Minimum Combustion Efficiency: As directed.
2. Entering-Air Temperature: As directed, deg F (deg C).
3. Leaving-Air Temperature: As directed, deg F (deg C).
4. Airflow: As directed, cfm (L/s).
5. Gas Input: As directed, MBh (kW).
6. Burner Output: As directed, MBh (kW).
7. Number of Stages: As directed.
8. Minimum Inlet Pressure: As directed, inches wg (Pa).
9. Maximum Inlet Pressure: As directed, inches wg (Pa).
10. Gas Piping Connection Size: As directed, NPS (DN).
11. Vent Diameter: As directed, inches (mm).

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment Mounting:

1. Install heating and ventilating units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

B. Unit Support: Install heating and ventilating unit level on structural curbs or pilings as directed. Coordinate wall penetrations and flashing with wall construction. Secure units to structural support with anchor bolts.

C. Install gas-fired units according to NFPA 54, "National Fuel Gas Code."

D. Install controls and equipment shipped by manufacturer for field installation with indirect-fired heating and ventilating units.

3.2 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

1. Gas Piping: Comply with requirements in Section 231123 "Facility Natural-Gas Piping" or Section 231126 "Facility Liquefied-Petroleum Gas Piping" As directed. Connect gas piping with shutoff valve and union and with sufficient clearance for burner removal and service. Make final connections of gas piping to unit with corrugated, stainless-steel tubing flexible connectors complying with ANSI LC 1/CSA 6.26 equipment connections.

B. Drain: Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for traps and accessories on piping connections to condensate drain pans under condensing heat exchangers.

C. Where installing piping adjacent to heating and ventilating units, allow space for service and maintenance.

D. Duct Connections: Connect supply and return ducts to indirect-fired heating and ventilating units with flexible duct connectors. Comply with requirements in Section 233300 "Air Duct Accessories" for flexible duct connectors.

E. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

F. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. Units will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.4 ADJUSTING

A. Adjust initial temperature set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

3.5 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain heating and ventilating units.

END OF SECTION 237333.16

SECTION 237339 - INDOOR, DIRECT-FIRED HEATING AND VENTILATING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes indoor, direct-fired heating and ventilating units.

1.2 ACTION SUBMITTALS

A. Product Data: For each type and configuration of indoor, direct-fired heating and ventilating unit.

B. Sustainable Design Submittals:

C. Shop Drawings: For each type and configuration of indoor, direct-fired heating and ventilating unit.

1. Include plans, elevations, sections, and mounting or attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

1.3 INFORMATIONAL SUBMITTALS

A. Sample Warranty: For manufacturer's special warranty.

B. Seismic Qualification Certificates: For indoor, direct-fired heating and ventilating units, accessories, and components, from manufacturer.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Comply with NFPA 70.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of direct-fired heating and ventilating units that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Heat Exchangers: As directed, Manufacturer's standard, but not less than five or 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 SYSTEM DESCRIPTION

A. Factory-assembled, prewired, self-contained unit consisting of cabinet, supply fan, controls, filters, and direct-fired gas burner to be installed exterior to the building.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 UNIT CASINGS

A. General Fabrication Requirements for Casings:

1. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
2. Casing Joints: Sheet metal screws or pop rivets, factory sealed with water-resistant sealant.
3. Factory Finish for Steel and Galvanized-Steel Casings: Apply manufacturer's standard primer immediately after cleaning and pretreating.
4. Air-Handling-Unit Mounting Frame: Formed galvanized-steel channel or structural channel supports, designed for low deflection, welded with integral lifting lugs.

    a. Seismic Fabrication Requirements: Fabricate mounting base and attachment to air-handling-unit sections, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC" when air-handling-unit frame is anchored to building structure.

5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. Configuration: As directed, Horizontal unit with top, horizontal or bottom discharge for floor-mounting or suspended installation.

C. Cabinet: Galvanized-steel panels, formed to ensure rigidity and supported by galvanized-steel channels or structural channel supports with lifting lugs. Duct flanges at inlet and outlet.

D. Outer Casing: As directed, 0.0598-inch (1.519-mm), 0.0478-inch (1.214-mm) or 0.0359-inch (0.912-mm) thick steel with heat-resistant, baked-enamel, enamel-painted, baked-on, polyester-powder or unpainted over-corrosion-resistant-treated surface in color to match fan section.

E. Outer Casing: As directed, 0.0598-inch (1.519-mm), 0.0478-inch (1.214-mm) or 0.0359-inch (0.912-mm) thick steel with unpainted finish.

F. Outer Casing: 0.0359-inch (0.912-mm) thick steel with heat-resistant, baked-enamel over-corrosion-resistant-treated surface in color to match fan section.

G. Inner Casing:

1. Burner Section Inner Casing: 0.0299-inch- (0.759-mm-) thick steel. Retain first subparagraph below if double-wall casing is required.
2. As directed, double-wall casing with inner wall of perforated or solid steel, for the following sections:

    a. Blower section.
    b. Filter section.
    c. Mixing box.
    d. Inlet plenum.
    e. Discharge plenum.
    f. Access Doors or Panels As Directed: As directed, Lift out, Piano hinged with cam-lock fasteners or Hinged with handles for burner and fan motor assemblies on both sides of unit.

3. Internal Insulation: Fibrous-glass duct lining, neoprene coated, comply with ASTM C1071, Type II, applied on complete unit or burner and fan sections only as directed.

    a. Thickness: As directed, 1 inch (25 mm) or 2 inches (50 mm).
    b. Insulation Adhesive: Comply with ASTM C916, Type I.
    c. Density: As directed, 1.5 lb/cu. ft. (24.0 kg/cu. m), 2.0 lb/cu. ft. (32.0 kg/cu. m) or 3.0 lb/cu. ft. (48.0 kg/cu. m).
    d. Mechanical Fasteners: Galvanized steel suitable for adhesive, mechanical, or welding attachment to casing without damaging liner when applied as recommended by manufacturer and without causing air leakage.

H. Discharge Section: As directed, Galvanized or Aluminized-steel assembly with gravity, individually adjustable, vaned, two-position, motorized, parallel-blade dampers with nylon bushings.

1. Pattern: As directed, Single or Double deflection.
2. Leakage: As directed, Standard or Low leakage.

I. Discharge Section: Trapezoidal cowls with horizontal louvers.

J. Discharge Section: As directed, Plenum with two or four sides louvered.

K. Discharge Section: Down-discharge plenum insulated with 1-inch (25-mm), 1.5-lb/cu. ft. (24.0-kg/cu. m) fibrous glass.

L. Casing Insulation and Adhesive:

1. Materials: As directed, ASTM C1071, Type I or Type II.
2. Location and Application: Factory applied with adhesive and mechanical fasteners to the internal surface of section panels downstream from, and including, the heating-coil section.

M. Inspection and Access Panels and Access Doors: Formed and reinforced, single- or double-wall and insulated panels of same materials and thicknesses as casing and complying with ASHRAE 62.1.

2.4 ACCESSORIES

A. Service Platform: As directed, Steel, Galvanized steel or Aluminum, 42 inches (1070 mm) wide running entire length of unit and located on service access side, with angle side rails, 4-inch (100-mm) kick plates, and expanded metal floor. Provide platform with a fixed ladder that extends from the top of the side rail to the floor.

2.5 SUPPLY-AIR FAN

A. Fan Type: Centrifugal, rated according to AMCA 210; statically and dynamically balanced, galvanized steel; mounted on solid-steel shaft with heavy-duty, self-aligning, permanently lubricated ball bearings, pillow-block bearings as directed. Bearing rating: As directed, L10 of 60,000 hours, L10 of 120,000 hours or L10 of 150,000 hours.

B. Drive: V-belt drive with matching fan pulley and adjustable motor sheaves and belt assembly.

C. Mounting: Fan wheel, motor, and drives shall be mounted in fan casing with restrained, elastomeric or spring isolators.

D. Fan-Shaft Lubrication Lines: Extended to a location outside the casing.

2.6 AIR FILTERS

A. Comply with NFPA 90A or NFPA 90B as directed.

B. Cleanable Filters: Cleanable metal mesh; As directed, 1 inch (25 mm) or 2 inches (50 mm).

C. Disposable Panel Filters: Factory-fabricated, flat-panel-type, disposable air filters; 1 inch (25 mm).

2.7 DAMPERS

A. Outdoor-Air and Return-Air amper: Galvanized-steel, opposed-blade dampers with vinyl blade seals and stainless-steel jamb seals, having a maximum leakage of 10 cfm/sq. ft. (51 L/s per sq. m) of damper area, at a differential pressure of 2-inch wg (448 Pa).

B. Damper Operator: Direct coupled, electronic with spring return or fully modulating as required by the control sequence.

2.8 DIRECT-FIRED GAS BURNER

A. Description: Factory assembled, piped, and wired; and complying with ANSI Z21.47, "Gas-Fired Central Furnaces," and with NFPA 54, "National Fuel Gas Code."

1. CSA Approval: Designed and certified by and bearing label of CSA.
2. Burners: Aluminized steel with stainless-steel inserts or Stainless steel as directed.

    a. Gas Control Valve: As directed, Single stage, two stage or Modulating.
    b. Rated maximum turndown ratio of 30 to 1.
    c. Fuel: Natural or Propane gas.
    d. Minimum Combustion Efficiency: 95 percent.
    e. Ignition: Electronically controlled electric spark with flame sensor.
    f. High-Altitude Model or Kit as directed: For Project elevation above sea level.

B. Safety Controls:

1. Vent Flow Verification: As directed, Differential pressure switch to verify open vent or Flame rollout switch.
2. Control Transformer: 24-V ac.
3. High Limit: Thermal switch or fuse to stop burner.
4. Gas Train: As directed, Regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, hydraulic or electronic-modulating temperature control valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.
5. Purge-period timer shall automatically delay burner ignition and bypass low-limit control.
6. Gas Manifold: Safety switches and controls complying with ANSI standards and FM Global or XL Insurance as directed.
7. Airflow Proving Switch: Differential pressure switch senses correct airflow before energizing pilot.
8. Automatic-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
9. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.

2.9 UNIT CONTROL PANEL

A. Factory-wired, fuse-protected control transformer, connection for power supply and field-wired unit to remote control panel.

B. Control Panel: As directed, Surface-mounted or Recessed, with trim ring, remote panel, with engraved plastic cover and the following lights and switches:

1. As directed, On-off or On-off-auto fan switch.
2. Heat-vent-off switch.
3. Supply-fan operation indicating light.
4. Heating operation indicating light.
5. Thermostat.
6. Damper position potentiometer.
7. Dirty-filter indicating light operated by unit-mounted differential pressure switch.
8. Safety-lockout indicating light.
9. Enclosure: As directed, NEMA 250, Type 1, Type 3R, Type 4 or Explosion proof.

2.10 CONTROLS

A. Control Devices:

1. Remote Thermostat: Adjustable room thermostat with temperature readout.
2. Remote Setback Thermostat: Adjustable room thermostat without temperature readout.
3. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
4. Fire-Protection Thermostats: Fixed or adjustable settings to operate at not less than 75 deg F (24 deg C) above normal maximum operating temperature.
5. Timers: Seven-day, programming-switch timer with synchronous-timing motor and seven-day dial; continuously charged, nickel-cadmium-battery-driven, eight-hour, power-failure carryover; multiple-switch trippers; minimum of two and maximum of eight signals per day with two normally open and two normally closed output contacts.
6. Ionization-Type Smoke Detectors: 24-V dc, nominal; self-restoring; plug-in arrangement; integral visual-indicating light; sensitivity that can be tested and adjusted in place after installation; integral addressable module; remote controllability; responsive to both visible and invisible products of combustion; self-compensating for changes in environmental conditions.

B. Fan Control: Interlock fan to start with exhaust fan(s) to which this heating and ventilating unit is associated for makeup air.

C. Smoke detectors, located in supply and return air, shall stop fans when the presence of smoke is detected.

D. Outdoor-Air Damper Control, 100 Percent Outdoor-Air Units: Outdoor-air damper shall open when supply fan starts, and close when fan stops.

E. Mixed Outdoor- and Return-Air Damper Control: When fan is running, outdoor- and return-air dampers shall modulate to supply minimum outdoor air.

F. Temperature Control: Operates gas valve to maintain supply-air temperature.

1. Operates gas valve to maintain discharge-air temperature with factory-mounted sensor in blower outlet.

2. Timer shall select remote setback thermostat to maintain space temperature at 50 deg F (10 deg C).
3. Burner Control: Two or four steps of control using one or two burner sections in series.

2.11 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Enclosure: As directed, Open, dripproof, totally enclosed, fan cooled, Totally enclosed, air over, Open, externally ventilated, Totally enclosed, nonventilated, Severe duty, Explosion proof or Dust-ignition-proof machine.
2. Enclosure Materials: As directed, Cast iron, Cast aluminum or Rolled steel.
3. Motor Bearings: As directed.
4. Unusual Service Conditions:

    a. Ambient Temperature: As directed.
    b. Altitude: Feet (m) above sea level as directed.
    c. High humidity.

5. Efficiency: As directed, Premium efficient or EPAct compliant.
6. NEMA Design: As directed.
7. Service Factor: As directed.

2.12 CAPACITIES AND CHARACTERISTICS

A. Fan:

1. Discharge Configuration: As directed, Horizontal or Vertical.
2. Airflow in CFM (L/s): As directed.
3. External Static Pressure: As directed.
4. Maximum RPM: As directed.
5. Minimum Size: As directed.
6. Altitude: As directed.

B. Fan Motor:

1. Horsepower: As directed.
2. RPM: As directed.
3. Service Factor: As directed.
4. Speed: As directed, Single or Two.

C. Single-Point Electrical Connection:

1. Volts: As directed, 120, 240, 277 or 480.
2. Phase: As directed, Single or Three.
3. Hertz: 60.
4. Full-Load Amperes: As directed.

5. Minimum Circuit Ampacity: As directed.
6. Maximum Overcurrent Protection: As directed.

D. Direct-Fired Gas Burner:

1. Minimum Combustion Efficiency: Percent As directed.
2. Entering-Air Temperature: As directed.
3. Leaving-Air Temperature: As directed.
4. Airflow: As directed.
5. Gas Input: As directed.
6. Burner Output: As directed.
7. Number of Stages: As directed.
8. Minimum Inlet Pressure: As directed.
9. Maximum Inlet Pressure: As directed.
10. Gas Piping Connection Size: As directed.
11. Vent Diameter: As directed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment Mounting:

1. Install heating and ventilating units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

B. Unit Support: Install heating and ventilating unit level on structural curbs or pilings As directed. Coordinate wall penetrations and flashing with wall construction. Secure units to structural support with anchor bolts.

C. Install gas-fired units according to NFPA 54, "National Fuel Gas Code."

D. Install controls and equipment shipped by manufacturer for field installation with direct-fired heating and ventilating units.

E. Install seismic restraints according to manufacturer's written instructions.

3.2 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

1. Gas Piping: Comply with requirements in Section 231123 "Facility Natural-Gas Piping" or Section 231126 "Facility Liquefied-Petroleum Gas Piping" As directed, Connect gas

piping with shutoff valve and union, and with sufficient clearance for burner removal and service. Make final connections of gas piping to unit with corrugated, stainless-steel tubing flexible connectors complying with ANSI LC 1/CSA 6.26 equipment connections.

B. Duct Connections: Connect supply and return ducts to direct-fired heating and ventilating units with flexible duct connectors. Comply with requirements in Section 233300 "Air Duct Accessories" for flexible duct connectors.

C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. Units will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.4 ADJUSTING

A. Adjust initial temperature set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

3.5 DEMONSTRATION

A. As directed, Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain heating and ventilating units.

END OF SECTION 237339

SECTION 237343.16 - OUTDOOR, SEMI-CUSTOM AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes outdoor, semi-custom air-handling units that are factory assembled using multiple section components; including:

1. Unit casings.
2. Fan, drive, and motor section.
3. Coil section.
4. Air filtration section.
5. Dampers.
6. Sound attenuators.
7. Humidifiers.
8. Air-to-air energy recovery units.
9. Air blenders.
10. Diffusers.
11. UV-C lamp systems.
12. Roof curbs.
13. Intake and relief air openings.

1.2 ACTION SUBMITTALS

A. Product Data: For each air-handling unit.

B. Sustainable Design Submittals:
1. As directed.

C. Delegated-Design Submittal: For vibration isolation and seismic restraints indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Include design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and other details, drawn to scale and coordinated with each other, using input from installers of the items involved.

B. Seismic Qualification Data: Certificates for air-handling units, accessories, and components, from manufacturer.

C. Source quality-control reports:

D. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation and seismic restraints, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

F. Structural Performance:

1. Casing Panels: Self-supporting and capable of withstanding positive/negative 8-inch wg (2000-Pa) internal static pressure, without exceeding a midpoint deflection of 0.0042 inch/inch (0.0042 mm/mm) of panel span.
2. Floor and Roof Panels: Self-supporting and capable of withstanding 300-lb (136-kg) static load at midspan, without exceeding a midpoint deflection of 0.0042 inch/inch (0.0042 mm/mm).
3. Roof Panels: Self-supporting and capable of withstanding a static snow load of 30 lb/sq. ft. (146 kg/sq. m), without exceeding a midpoint deflection of 0.0042 inch/inch (0.0042 mm/mm).

G. Casing Leakage Performance: ASHRAE 111, Class 6 leakage or better at plus or minus 8-inch wg (2000 Pa).

H. Seismic Performance: Air-handling units shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: As directed, 1.5 or 1.0.

2.2 CAPACITIES AND CHARACTERISTICS

A. Supply Fan:

1. Type: As directed, DWDI, backward-inclined centrifugal fan, DWDI, forward-curved centrifugal fan, DWDI, airfoil centrifugal fan or SWSI, airfoil unhoused centrifugal fan.
2. As directed, Class I, Class II or Class III: AMCA 99-2408.
3. Drive: As directed, V-belt or Direct.
4. Number of Fan Wheels: As directed.
5. Fan Diameter: Inches (mm) V.
6. Airflow: cfm (L/s) As directed.
7. Total Static Pressure: Inches wg (kPa) As directed.
8. External Static Pressure: Inches wg (kPa) As directed.
9. Speed: As directed.
10. Maximum Outlet Velocity: fpm (m/s) As directed.
11. Motor:

    a. Size: As directed.
    b. Speed: As directed.
    c. Volts: As directed, 208, 230 or 460 V.
    d. Phase: Three.
    e. Hertz: 60 Hz.
    f. Full-Load Amperes: As directed.
    g. Minimum Circuit Ampacity: As directed.
    h. Maximum Overcurrent Protection: As directed.

12. Fan Discharge Sound Power, dB:

    a. 1st Octave: As directed.
    b. 2nd Octave: As directed.
    c. 3rd Octave: As directed.
    d. 4th Octave: As directed.
    e. 5th Octave: As directed.
    f. 6th Octave: As directed.
    g. 7th Octave: As directed.
    h. 8th Octave: As directed.

B. Return or Exhaust Fan As directed:

1. Type: As directed, DWDI, backward-inclined centrifugal fan, DWDI, forward-curved centrifugal fan, DWDI, airfoil centrifugal fan or SWSI, airfoil unhoused centrifugal plenum fan.
2. Class I, Class II or Class III: AMCA 99-2408.
3. Drive: As directed, V-belt or Direct.
4. Number of Fan Wheels: As directed.
5. Fan Diameter: Inches (mm) As directed.
6. Airflow: cfm (L/s) As directed.
7. Total Static Pressure: Inches wg (kPa) As directed.
8. External Static Pressure: Inches wg (kPa) As directed.
9. Speed: As directed.
10. Maximum Outlet Velocity: fpm (m/s) As directed.

11. Motor:

    a. Size: hp as directed.
    b. Speed: rpm as directed.
    c. Volts: As directed, 208, 230 or 460 V.
    d. Phase: Three.
    e. Hertz: 60 Hz.
    f. Full-Load Amperes: As directed.
    g. Minimum Circuit Ampacity: As directed.
    h. Maximum Overcurrent Protection: As directed.

12. Fan Inlet Sound Power, dB:

    a. 1st Octave: As directed.
    b. 2nd Octave: As directed.
    c. 3rd Octave: As directed.
    d. 4th Octave: As directed.
    e. 5th Octave: As directed.
    f. 6th Octave: As directed.
    g. 7th Octave: As directed.
    h. 8th Octave: As directed.

C. Preheat Coil:

1. Heat-Transfer Rate: Btu/h (kW) As directed.
2. Entering-Air Temperature: deg F (deg C) As directed.
3. Leaving-Air Temperature: deg F (deg C) As directed.
4. Face Area: sq. ft. (sq. m) As directed.
5. Maximum Face Velocity: As directed, fpm (m/s) As directed.
6. Maximum Air-Side, Static-Pressure Drop: Inches wg (Pa) As directed.
7. Fin Spacing: Maximum Fins per inch (per mm) As directed.
8. Minimum Number of Rows: As directed.
9. Integral Face-and-Bypass Dampers: As directed, Horizontal or Vertical, opposed-blade, galvanized-steel dampers with zinc-plated steel operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel frame, with operating rods connected with a common linkage. Meeting edges of blades shall have gaskets and edge seals, and blades shall be mechanically fastened.
10. Water:

    a. Water Flow: gpm (L/s) As directed.
    b. Maximum Water Pressure Drop: feet of head (kPa) As directed.
    c. Entering-Water Temperature: deg F (deg C) As directed.
    d. Leaving-Water Temperature: deg F (deg C) As directed.
    e. Tube Velocity: fpm (L/s) As directed.

D. Heating Coil:

1. Heat-Transfer Rate: Btu/h (kW) As directed.
2. Entering-Air Temperature: deg F (deg C) As directed.
3. Leaving-Air Temperature: deg F (deg C) As directed.
4. Face Area: sq. ft. (sq. m) As directed.

5. Maximum Face Velocity: fpm (m/s) As directed.
6. Maximum Air-Side, Static-Pressure Drop: Inches wg (Pa) As directed.
7. Number of Rows: As directed.
8. Fin Spacing: Maximum Fins per inch (per mm) As directed.
9. Water:

    a. Water Flow: gpm (L/s) As directed.
    b. Maximum Water Pressure Drop: feet of head (kPa) As directed.
    c. Entering-Water Temperature: deg F (deg C) As directed.
    d. Leaving-Water Temperature: deg F (deg C) As directed.
    e. Tube Velocity: fpm (L/s) As directed.

E. Electric Heating Coil:

1. Heat-Transfer Rate: Btu/h (kW) As directed.
2. Input: As directed.
3. Volts: As directed, 120, 208 or 230 V.
4. Phase: As directed, Single or Three.
5. Full-Load Amperes: As directed.
6. Number of Steps: As directed.

F. Cooling Coil:

1. Sensible Heat-Transfer Rate: As directed, Btu/h (kW).
2. Total Heat-Transfer Rate: As directed, Btu/h (kW).
3. Entering-Air, Dry-Bulb Temperature: deg F (deg C) As directed.
4. Entering-Air, Wet-Bulb Temperature: deg F (deg C) As directed.
5. Leaving-Air, Dry-Bulb Temperature: deg F (deg C) As directed.
6. Leaving-Air, Wet-Bulb Temperature: deg F (deg C) As directed.
7. Face Area: sq. ft. (sq. m) As directed.
8. Maximum Face Velocity: fpm (m/s) As directed.
9. Maximum Air-Side, Static-Pressure Drop: inches wg (Pa) As directed.
10. Number of Rows: As directed.
11. Fin Spacing: Maximum As directed, fins per inch (per mm) As directed.
12. Water:

    a. Water Flow: gpm (L/s) As directed.
    b. Maximum Water Pressure Drop: feet of head (kPa) As directed.
    c. Entering-Water Temperature: deg F (deg C) As directed.
    d. Leaving-Water Temperature: deg F (deg C) As directed.
    e. Tube Velocity: fpm (L/s) As directed.

13. Refrigerant:

    a. Refrigerant Type: As directed.

G. Prefilters:

1. Type: As directed.
2. Face Dimensions, each: Inches by inches (mm by mm) As directed.
3. Depth: Inches (mm) As directed.

4. Number of Filters, Wide by High: As directed.
5. Access Location: As directed, Front, Back, Side or Bottom.
6. Maximum or Rated Face Velocity: fpm (m/s) As directed.
7. Initial Resistance: Inches wg (Pa) As directed.
8. Recommended Final Resistance: Inches wg (Pa) As directed.
9. Minimum Efficiency Reporting Value and Average Arrestance:

    a. MERV Rating: As directed, MERV 1, MERV 2, MERV 3 or MERV 4, and corresponding average arrestance according to ASHRAE 52.2.

10. Minimum Efficiency Reporting Value:

    a. MERV Rating: As directed, MERV 6 or MERV 13, according to ASHRAE 52.2.

H. Final Filters:

1. Type: As directed.
2. Face Dimensions, each: Inches by inches (mm by mm) As directed.
3. Depth: Inches (mm) As directed.
4. Number of Filters, Wide by High: As directed.
5. Access Location: As directed, Front, Back, Side or Bottom.
6. Maximum or Rated Face Velocity: fpm (m/s) As directed.
7. Initial Resistance: Inches wg (Pa) As directed.
8. Recommended Final Resistance: Inches wg (Pa) As directed.
9. Minimum Efficiency Reporting Value:

    a. MERV Rating: As directed, MERV 6 or MERV 13, according to ASHRAE 52.2.

I. Dampers: As directed, Zone, Mixing dampers or Face and bypass.

J. Sound Attenuators:

1. Configuration: As directed, Straight Elbow.
2. Shape: As directed, Rectangular or Round.
3. Attenuation Mechanism: Acoustic glass fiber.
4. Maximum Pressure Drop: Inches wg (Pa) As directed.
5. Length: Inches (mm) As directed.
6. Face Dimension: Inches (mm) wide by inches (mm) high As directed.
7. Face Velocity: fpm (m/s) As directed.
8. Dynamic Insertion Loss:

    a. 1st Octave: As directed.
    b. 2nd Octave: As directed.
    c. 3rd Octave: As directed.
    d. 4th Octave: As directed.
    e. 5th Octave: As directed.
    f. 6th Octave: As directed.
    g. 7th Octave: As directed.
    h. 8th Octave: As directed.

9. Generated Noise:

a. 1st Octave: As directed.
b. 2nd Octave: As directed.
c. 3rd Octave: As directed.
d. 4th Octave: As directed.
e. 5th Octave: As directed.
f. 6th Octave: As directed.
g. 7th Octave: As directed.
h. 8th Octave: As directed.

10. Number of Distribution As directed, Tubes or Manifolds: As directed.

K. Self-Contained Electric-Resistance Humidifier.

1. Humidification Rate: lb/h (g/s) As directed.
2. Dry-Bulb Air Temperature at Discharge: deg F (deg C) As directed.
3. Wet-Bulb Air Temperature at Discharge: deg F (deg C) As directed.
4. Maximum Absorption Distance: inches (mm) As directed.
5. Minimum Makeup Water Supply Pressure: psig (kPa) As directed.
6. Electric-Resistance Evaporation Chamber:

a. Power Input per Chamber: kW As directed.
b. Number of Chambers: As directed.

L. Self-Contained Gas-Fired Humidifier:

1. Humidification Rate: lb/h (g/s) As directed.
2. Dry-Bulb Air Temperature at Discharge: deg F (deg C) As directed.
3. Wet-Bulb Air Temperature at Discharge: deg F (deg C) As directed.
4. Maximum Absorption Distance: inches (mm) As directed.
5. Minimum Makeup Water Supply Pressure: psig (kPa) As directed.
6. Gas-Fired Generator:

a. Fuel Input: Btu/h (kW) As directed.
b. Fuel Pressure: inches wg (kPa) As directed.

7. Number of Distribution As directed, Tubes or Manifolds: As directed.

M. Heat-Exchanger Humidifier:

1. Humidification Rate: lb/h (g/s).
2. Dry-Bulb Air Temperature at Discharge: As directed, deg F (deg C).
3. Wet-Bulb Air Temperature at Discharge: As directed, deg F (deg C).
4. Maximum Absorption Distance: As directed, inches (mm).
5. Minimum Makeup Water Supply Pressure: As directed, psig (kPa).
6. Steam to Heat Exchanger:

a. Supply Pressure at Control Valve: psig (kPa) As directed.
b. Condensing Rate: lb/h (g/s) As directed.

N. Air-to-Air Energy Recovery:

1. Type: As directed, Heat-wheel air-to-air energy recovery or Fixed-plate air-to-air energy recovery.
2. Exhaust Air:

    a. Airflow: cfm (L/s) As directed.
    b. Face Velocity: fpm (m/s) As directed.
    c. Summer:

        1) Entering-Air Temperature, Dry Bulb: deg F (deg C) As directed.
        2) Entering-Air Temperature, Wet Bulb: deg F (deg C) As directed.
        3) Leaving-Air Temperature, Dry Bulb: deg F (deg C) As directed.
        4) Leaving-Air Temperature, Wet Bulb: deg F (deg C) As directed.

    d. Winter:

        1) Entering-Air Temperature, Dry Bulb: deg F (deg C) As directed.
        2) Entering-Air Temperature, Wet Bulb: deg F (deg C) As directed.
        3) Leaving-Air Temperature, Dry Bulb: deg F (deg C) As directed.
        4) Leaving-Air Temperature, Wet Bulb: deg F (deg C) As directed.
        5) Air Pressure Drop: As directed, inches wg (Pa).

3. Supply Air:

    a. Airflow: cfm (L/s) As directed.
    b. Face Velocity: fpm (m/s) As directed.
    c. Summer:

        1) Entering-Air Temperature, Dry Bulb: deg F (deg C) As directed.
        2) Entering-Air Temperature, Wet Bulb: deg F (deg C) As directed.
        3) Leaving-Air Temperature, Dry Bulb: deg F (deg C) As directed.
        4) Leaving-Air Temperature, Wet Bulb: deg F (deg C) As directed.

    d. Winter:

        1) Entering-Air Temperature, Dry Bulb: deg F (deg C) As directed.
        2) Entering-Air Temperature, Wet Bulb: deg F (deg C) As directed.
        3) Leaving-Air Temperature, Dry Bulb: deg F (deg C) As directed.
        4) Leaving-Air Temperature, Wet Bulb: deg F (deg C) As directed.
        5) Air Pressure Drop: Inches wg (Pa) As directed.

    e. Wheel Drive:

        1) Motor Size: As directed.
        2) Motor Electrical Characteristics:

            a) Volts: As directed, 120, 208 or 230V.
            b) Phase: As directed, Single or Three.
            c) Hertz: 60 Hz.

    f. Effectiveness: As directed.

4. Air Blender:

    a. Airflow: cfm (L/s) As directed.
    b. Minimum Velocity: fpm (m/s) As directed.
    c. Air Pressure Drop: inches wg (Pa) As directed.

5. Diffuser:

    a. Airflow: cfm (L/s) As directed.
    b. Air Pressure Drop: inches wg (Pa) As directed.

2.3 MANUFACTURERS

2.4 UNIT CASINGS

A. Frame: Modular and providing overall structural integrity without reliance on casing panels for structural support.

B. Base Rail:

1. Material: Galvanized steel.
2. Height: 6 inches (150 mm).

C. Casing Joints: Hermetically sealed at each corner and around entire perimeter.

D. Outside Casing Wall:

1. Material: As directed, Galvanized steel, minimum 18 gauge (1.3 mm), 16 gauge (1.6 mm) or 14 gauge (2.0 mm) thick.
2. Material: As directed, Aluminum, minimum 16 gauge (1.3 mm), 14 gauge (1.6 mm) or 12 gauge (2.0 mm) thick.
3. Factory Finish: Provide manufacturer's standard finish.

E. Inside Casing Wall:

1. Material: As directed, Galvanized steel, solid or perforated, minimum 18 gauge (1.3 mm) or 16 gauge (1.6 mm) thick.
2. Material: As directed, Aluminum, solid or perforated, minimum 16 gauge (1.3 mm) or 14 gauge (1.6 mm) thick.

F. Floor Plate:

1. Material: As directed, Galvanized steel, treadplate, minimum 18 gauge (1.3 mm), 16 gauge (1.6 mm), 14 gauge (2.0 mm), 12 gauge (2.7 mm) or 10 gauge (3.5 mm) thick.
2. Material: As directed, Aluminum, treadplate, minimum 18 gauge (1.0 mm), 16 gauge (1.3 mm), 14 gauge (1.6 mm), 12 gauge (2.0 mm) or 10 gauge (2.6 mm) thick.

G. Roof: Cross-broken and pitched with "C" caps over joints to provide watertight seal.

H. Piping Vestibule: As directed, Insulated with same insulation and thickness as casing, 18 inches (450 mm), 24 inches (600 mm) or 30 inches (750 mm) deep by full width of piping connections.

I. Static-Pressure Classifications:

1. For Unit Sections Upstream of Fans: As directed, Minus 2-inch wg (500 Pa), 3-inch wg (750 Pa), 4-inch wg (1000 Pa) or 6-inch wg (1500 Pa).
2. For Unit Sections Downstream and Including Fans: As directed, 2-inch wg (500 Pa), 3-inch wg (750 Pa), 4-inch wg (1000 Pa) or 6-inch wg (1500 Pa).

J. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

K. Casing Insulation:

1. Materials: Glass-fiber blanket or board insulation, Type I or Type II ASTM C1071 or injected polyurethane foam insulation.
2. Casing Panel R-Value: Minimum As directed, R-6.5, R-11 or R-13.
3. Insulation Thickness: As directed, 1 inch (25 mm) or 2 inches (50 mm).
4. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roofs of air-handling unit.

L. Panels, Doors, and Windows:

1. Panels:

a. Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing.
b. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against airflow.
c. Gasket: Neoprene, applied around entire perimeters of panel frames.
d. Size: Large enough to allow unobstructed access for inspection and maintenance of air-handling unit's internal components. As directed, At least 18 inches (450 mm) or 24 inches (600 mm) wide by full height of unit casing up to a maximum height of 60 inches (1500 mm) or 72 inches (1800 mm).

2. Doors:

a. Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing.
b. Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and two wedge-lever latches, operable from inside and outside. Arrange doors to be opened against airflow. Provide safety latch retainers on doors so that doors do not open uncontrollably.
c. Gasket: Neoprene, applied around entire perimeters of panel frames.
d. Size: Large enough to allow for unobstructed access for inspection and maintenance of air-handling unit's internal components. As directed, At least 18 inches (450 mm) or 24 inches (600 mm) wide by full height of unit casing up to a maximum height of 60 inches (1500 mm) or 72 inches (1800 mm).

3. Windows:

    a. Construction: Fabricate windows in access panels and doors of double-glazed, safety glass with an airspace between panes and sealed with interior and exterior rubber seals.
    b. Size: Minimum 6 inches (150 mm), square or round.

4. Locations and Applications:

    a. Fan Section: Doors, with windows.
    b. Coil Section: Panels.
    c. Access Section: Doors, with windows.
    d. Access Sections Immediately Upstream and Downstream of Coil Sections: Doors, with windows.
    e. Damper Section: Doors, with windows.
    f. Filter Section: As directed, Doors or Panels large enough to allow periodic removal and installation of filters.
    g. Access Sections Immediately Upstream and Downstream of Filter Sections: Doors, Panels, with windows as directed.
    h. Mixing Section: Doors, Panels, with windows as directed.
    i. Humidifier Section: Doors, Panels, with windows as directed.

5. Service Lights: As directed, LED vaporproof luminaire with individual switched junction box located outside or inside, adjacent to each access door and panel.

    a. Locations: As directed, Each section accessed with door or panel or Fan section.

6. Convenience Outlets: One 20-A duplex GFCI receptacle per location with junction box located on outside casing wall.

    a. Locations: As directed, Each section accessed with a door or panel or Fan section.

M. Condensate Drain Pans:

1. Construction:

    a. As directed, single-wall, galvanized-steel or noncorrosive polymer or stainless-steel sheet.
    b. As directed, double-wall, galvanized-steel or noncorrosive polymer or stainless-steel sheet with space between walls filled with foam insulation and moisture-tight seal.

2. Drain Connection:

    a. Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end or both ends of pan As directed.
    b. Minimum Connection Size: As directed, NPS 1 (DN 25) or NPS 2 (DN 50).

3. Slope: Minimum 0.125-in./ft. (10-mm/mm) slope, to comply with ASHRAE 62.1, in at least two planes to collect condensate from cooling coils (including coil piping

connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.

4. Length: Extend drain pan downstream from leaving face for distance to comply with ASHRAE 62.1.
5. Width: Entire width of water producing device.
6. Depth: A minimum of 2 inches (50 mm) deep.
7. Formed sections or Integral part of floor plating.
8. Pan-Top Surface Coating for Galvanized-Steel Drain Pans: Asphaltic waterproofing compound.
9. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

2.5 FAN, DRIVE, AND MOTOR SECTION

A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.

1. Shafts: With field-adjustable alignment.

a. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
b. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

B. Centrifugal Fan Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.

1. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.
2. Horizontal-Flanged, Split Housing: Bolted construction.
3. Housing for Supply Fan: Attach housing to fan-section casing with metal-edged flexible duct connector.
4. Flexible Connector: As directed, Factory fabricated with a fabric strip 3-1/2 inches (89 mm) or 5-3/4 inches (146 mm) wide attached to two strips of 2-3/4 inches (70 mm) wide, 0.028-inch- (0.7-mm-) thick, galvanized-steel sheet or 0.032-inch- (0.8-mm-) thick, aluminum sheets.

a. Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.

1) Fabric Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).
2) Fabric Minimum Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.
3) Fabric Minimum Service Temperature Range: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).

C. Plenum Fan Housings: Steel frame and panel; fabricated without fan scroll and volute housing. Provide inlet screens for Type SWSI fans.

D. Plenum Fan Arrays: As directed, Contained or Uncontained as defined in AHRI 430. Steel or aluminum frame with inlet cone and structural framing around each fan built into an array of multiple fans. As directed, Provide backdraft or motorized dampers at each fan to prevent short circuiting of flow if one fan is not operating.

E. Backward-Inclined, Centrifugal Fan Wheels: Construction with curved inlet flange, backplate, backward-inclined blades welded or riveted to flange and backplate; As directed, steel or aluminum hub riveted to backplate and fastened to shaft with setscrews.

F. Forward-Curved, Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; As directed, steel or aluminum hub swaged to backplate and fastened to shaft with setscrews.

G. Airfoil, Centrifugal Fan Wheels: Smooth-curved inlet flange, backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; As directed, steel or aluminum hub riveted to backplate and fastened to shaft with setscrews.

H. Fan Shaft Bearings:

1. Prelubricated and Sealed, Ball Bearings: Self-aligning, pillow-block type with an L-50 rated life of 200,000 hours according to ABMA 9.
2. Grease-Lubricated, Tapered-Roller Bearings: Self-aligning, pillow-block type with double-locking collars and two-piece, cast-iron housing with grease lines extended to outside unit and an L-50 rated life of 200,000 hours according to ABMA 11.
3. Grease-Lubricated Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing with grease lines extended to outside unit and an L-50 rated life of 200,000.

I. Belt Drives: Factory mounted, with adjustable alignment and belt tensioning, and with 1.5 or 1.25 service factor based on fan motor As directed.

1. Pulleys: Cast iron or steel with split, tapered bushing; dynamically balanced at factory.
2. Motor Pulleys: Adjustable pitch for use with 5-hp motors and smaller; fixed pitch for use with motors larger than 5 hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.
3. Belts: Oil resistant, nonsparking, and nonstatic; in matched sets for multiple-belt drives.
4. Belt Guards: Comply with requirements specified by OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards"; 0.146-inch- (2.7-mm-) thick, 3/4-inch (20-mm) diamond-mesh wire screen, welded to steel angle frame; prime coated.

J. Internal Vibration Isolation and Seismic Control: Fans shall be factory mounted with manufacturer's standard restrained vibration isolation mounting devices having a minimum static deflection of 1 inch (25 mm) or 2 inches (50 mm).

K. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Enclosure Type: Totally enclosed, fan cooled.
2. NEMA Premium Efficient motors as defined in NEMA MG 1.

3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
5. Mount unit-mounted disconnect switches on exterior or interior of unit As directed.

    a. Listed and labeled disconnects and components, complying with applicable provisions of NFPA 70.
    b. As directed, Fused, Non-fused, NEMA 3R or NEMA 4.

L. Variable-Frequency Motor Controller: Comply with Section 262923 "Variable-Frequency Motor Controllers."

M. Variable-Frequency Motor Controller: Serving each fan individually or all fans combined in fan array as directed.

1. Manufactured Units: Pulse-width modulated; As directed, constant torqueand or variable torque for Design A and Design B or inverter-duty motors.
2. Output Rating: As directed, Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range or 66 Hz, with torque constant as speed changes; maximum voltage equals input voltage.
3. Unit Operating Requirements:

    a. Internal Adjustability:

        1) Minimum Speed: 5 to 25 percent of maximum rpm.
        2) Maximum Speed: 80 to 100 percent of maximum rpm.
        3) Acceleration: 0.1 to 999.9 seconds.
        4) Deceleration: 0.1 to 999.9 seconds.
        5) Current Limit: 30 to minimum of 150 percent of maximum rating.

    b. Self-Protection and Reliability Features:

        1) Surge suppression.
        2) Loss of input signal protection.
        3) Under- and overvoltage trips.
        4) Variable-frequency motor controller and motor-overload/overtemperature protection.
        5) Critical frequency rejection.
        6) Loss-of-phase protection.
        7) Reverse-phase protection.
        8) Motor-overtemperature fault.

    c. Bidirectional autospeed search.
    d. Torque boost.
    e. Motor temperature compensation at slow speeds.

        1) Panel-mounted operator station.

2) Historical logging information and displays.
3) Digital indicating devices.

f. Control Signal Interface: Electric.
g. Proportional Integral Directive (PID) control interface.
h. DDC system for HVAC Protocols for Network Communications: ASHRAE 135.

4. Line Conditioning:

a. Input line conditioning.
b. Output filtering.
c. EMI/RFI filtering.

5. Bypass Systems:

a. Bypass Mode: As directed, Manual operation only or Field-selectable automatic or manual.
b. Bypass Controller: Two-contactor style, with bypass and output isolating contactors and isolating switch.
c. Bypass Controller: Three-contactor style, with bypass and input and output isolating contactors and isolating switch.
d. Bypass Contactor Configuration: Full-voltage (across the line) or Reduced-voltage (autotransformer) type.

2.6 COIL SECTION

A. General Requirements for Coil Section:

1. Comply with AHRI 410.
2. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
3. For multizone units, provide air deflectors and air baffles to balance airflow across coils.
4. Coils shall not act as structural component of unit.

B. Preheat Coils:

1. Electrical Coils, Controls, and Accessories: Comply with UL 1995.

a. Casing Assembly: As directed, Slip-in or Flanged type with galvanized-steel frame.
b. Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
c. Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from coil section.
d. Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.

e. Control Panel: As directed, Unit or Remote mounted with disconnecting means and overcurrent protection.

1) As directed, Magnetic or Mercury contactor.
2) Solid-state, stepless pulse controller.
3) Toggle switches, one per step.
4) Step controller.
5) Time-delay relay.
6) Pilot lights, one per step.
7) Airflow proving switch.

2. Hot-Water Coils; As directed, Continuous circuit, Self-draining or Cleanable.

a. Piping Connections: As directed, Threaded, Flanged, same end or opposite ends of coil.
b. Tube Material: Copper.
c. Fin Type: Plate.
d. Fin Material: Aluminum.
e. Fin Spacing: Maximum 10 or 12 fins per inch (mm).
f. Fin Thickness: Inches (mm) As directed.
g. Fin and Tube Joint: As directed, Mechanical bond or Silver brazed.
h. Headers:

1) Cast iron with cleaning plugs and drain and air vent tappings extended to exterior of unit.
2) Seamless copper tube with brazed joints, prime coated.
3) Fabricated steel, with brazed joints, prime coated.
4) Provide insulated cover to conceal exposed outside casings of headers.

i. Frames: As directed, Channel frame, 0.052-inch- (1.3-mm-) thick, galvanized steel, 0.064-inch- (1.6-mm-) thick, galvanized steel, 0.079-inch- (2.0-mm-) thick, galvanized steel, 0.0625-inch- (1.58-mm-) thick, galvanized steel or 0.0625-inch- (1.58-mm-) thick, stainless steel.
j. Coil Working-Pressure Ratings: 200 psig (1380 kPa), 325 deg F (163 deg C).
k. Integral Face-and-Bypass Dampers: As directed, Horizontal or Vertical, opposed-blade, galvanized-steel dampers with zinc-plated steel operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel frame, with operating rods connected with a common linkage. Meeting edges of blades shall have gaskets and edge seals, and blades shall be mechanically fastened.

C. Heating Coils:

1. Electrical Coils, Controls, and Accessories: Comply with UL 1995.

a. Casing Assembly: As directed, Slip-in or Flanged type with galvanized-steel frame.
b. Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.

c. Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from coil section.
d. Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
e. Control Panel: As directed, Unit or Remote mounted with disconnecting means and overcurrent protection.

1) As directed, Magnetic or Mercury contactor.
2) Solid-state, stepless pulse controller.
3) Toggle switches, one per step.
4) Step controller.
5) Time-delay relay.
6) Pilot lights, one per step.
7) Airflow proving switch.

2. Hot-Water Coils: As directed, Continuous circuit, Self-draining or Cleaning.

a. Piping Connections: As directed, Threaded, Flanged, same end or opposite ends of coil.
b. Tube Material: Copper.
c. Fin Type: Plate.
d. Fin Material: Aluminum.
e. Fin Spacing: As directed, Maximum 10 or 12 fins per inch (mm).
f. Fin Thickness: Inches (mm) As directed.
g. Fin and Tube Joint: As directed, Mechanical bond or Silver brazed.
h. Headers:

1) Cast iron with cleaning plugs and drain and air vent tappings extended to exterior of unit.
2) Seamless copper tube with brazed joints, prime coated.
3) Fabricated steel, with brazed joints, prime coated.
4) Provide insulated cover to conceal exposed outside casings of headers.

i. Frames: As directed, Channel frame, 0.052-inch- (1.3-mm-) thick, galvanized steel, 0.064-inch- (1.6-mm-) thick, galvanized steel, 0.079-inch- (2.0-mm-) thick, galvanized steel, 0.0625-inch- (1.58-mm-) thick, galvanized steel or 0.0625-inch- (1.58-mm-) thick, stainless steel.
j. Coil Working-Pressure Ratings: 200 psig (1380 kPa), 325 deg F (163 deg C).

D. Cooling Coils:

1. Chilled-Water Coil: As directed, Continuous circuit, Self-draining or Cleanable.

a. Piping Connections: As directed, Threaded, Flanged, same end or opposite ends of coil.
b. Tube Material: Copper.
c. Tube Thickness: Inches (mm) As directed.
d. Fin Type: Plate.
e. Fin Material: Aluminum.

f. Fin Spacing: As directed, 0.125 inch (3.18 mm), 0.091 inch (2.31 mm), 0.071 inch (1.80 mm), 0.067 inch (1.70 mm), 0.056 inch (1.42 mm) or 0.0075 inch (0.19 mm).
g. Fin Thickness: Inches (mm) As directed.
h. Fin and Tube Joint: As directed, Mechanical bond or Silver brazed.
i. Headers:

1) Cast iron with cleaning plugs and drain and air vent tappings extended to exterior of unit.
2) Seamless copper tube with brazed joints, prime coated.
3) Fabricated steel, with brazed joints, prime coated.
4) Provide insulated cover to conceal exposed outside casings of headers.

j. Frames: As directed, Channel frame, 0.052-inch- (1.3-mm-) thick, galvanized steel, 0.064-inch- (1.6-mm-) thick, galvanized steel, 0.079-inch- (2.0-mm-) thick, galvanized steel, 0.0625-inch- (1.58-mm-) thick, galvanized steel or 0.0625-inch- (1.58-mm-) thick, stainless steel.
k. Working-Pressure Ratings: 200 psig (1380 kPa), 325 deg F (163 deg C).

2. Refrigerant Coil:

a. Tubes: Copper.
b. Fins:

1) Material: Aluminum.
2) Fin Spacing: As directed, Maximum 12, 10 or 8 fins per inch (mm).

c. Fin and Tube Joints: Mechanical bond.
d. Headers: Seamless-copper headers with brazed connections.
e. Frames: Galvanized steel.
f. Ratings: Designed, tested, and rated according to ASHRAE 33 and AHRI 410.

1) Working Pressure: Minimum 300 psig (2070 kPa).

2.7 AIR FILTRATION SECTION

A. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."

B. Panel Filters:

1. Description: As directed, Flat, non-pleated or Pleated factory-fabricated, self-supported, disposable air filters with holding frames.
2. Filter Unit Class: UL 900.
3. Media: Interlaced glass, synthetic, or cotton fibers coated with nonflammable adhesive.
4. Filter-Media Frame: As directed, Beverage board with perforated metal retainer, or metal grid, on outlet side.

C. Bag Filters:

1. Description: Factory-fabricated, dry, extended-surface, self-supporting filters with holding frames in steel, basket-type retainers.
2. Filter Unit Class: UL 900.
3. Media: Fibrous material, coated with antimicrobial agent, constructed so individual pockets are maintained in tapered form by flexible internal supports under rated-airflow conditions.
4. Filter-Media Frame: As directed, Galvanized steel.

D. Cartridge Filters:

1. Description: Factory-fabricated, adhesive-coated disposable, packaged air filters with media perpendicular to airflow, and with holding frames.
2. Filter Unit Class: UL 900.
3. Media: Fibrous material, coated with antimicrobial agent, constructed so individual pleats are maintained in pleated form under rater-airflow conditions by corrugated aluminum separators.
4. Filter Media Frame: Galvanized steel.

E. Front- or Back-Access Filter Mounting Frames:

1. Particulate Air Filter Frames: As directed, Galvanized-steel or Aluminum framing members with access for filter servicing, cut to size and prepunched for assembly into modules. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation or operation.

    a. Prefilters: Incorporate a separate 2-inch- (50-mm-) thick track with spring clips, with same access as primary filter.
    b. Sealing: Full periphery foam gaskets.

F. Side-Access Filter Mounting Frames:

1. Particulate Air Filter Frames: Match inner casing and outer casing material, and insulation thickness. As directed, Galvanized steel or Aluminum track.

    a. Prefilters: Incorporate an integral 2-inch- (50-mm-) thick track with same access as primary filter.
    b. Sealing: Incorporate positive-sealing device to ensure seal between gasketed material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.

2.8 DAMPERS

A. General Requirements for Dampers: Leakage rate, according to AMCA 500, "Laboratory Methods for Testing Dampers for Rating," shall not exceed 4 cfm/sq. ft. (20 L/s/sq. m) at 1-inch wg (250 Pa) and 8 cfm/sq. ft. (40 L/s/sq. m) at 4-inch wg (1.0-MPa), leakage Class 1 pressure differential.

B. Damper Operators: Comply with requirements in Section 230923.12 "Control Dampers."

C. Electronic Damper Operators:

1. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
2. Electronic damper position indicator shall have visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
3. Operator Motors:

    a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
    b. Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
    c. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.

4. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running torque of 150 in. x lbf (16.9 N x m) and breakaway torque of 300 in. x lbf (33.9 N x m).
5. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running and breakaway torque of 150 in. x lbf (16.9 N x m).
6. Size dampers for running torque calculated as follows:

    a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. (86.8 kg-cm/sq. m) of damper.
    b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. (62 kg-cm/sq. m) of damper.
    c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft (49.6 kg-cm/sq. m) of damper.
    d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. (37.2 kg-cm/sq. m) of damper.
    e. Dampers with 2- to 3-Inch wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 fpm (5 to 13 m/s): Increase running torque by 1.5.
    f. Dampers with 3- to 4-Inch wg (750 to 1000 Pa) of Pressure Drop or Face Velocities of 2500 to 3000 fpm (13 to 15 m/s): Increase running torque by 2.0.

7. Coupling: V-bolt and V-shaped, toothed cradle.
8. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
9. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on nonspring-return actuators.
10. Power Requirements (Two-Position Spring Return): As directed, 24 V dc, 120 V ac or 230 V ac.
11. Power Requirements (Modulating): Maximum 10 VA at 24 V ac or 8 W at 24 V dc.
12. Proportional Signal: 2 to 10 V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
13. Temperature Rating: As directed, Minus 22 to plus 122 deg F (Minus 30 to plus 50 deg C) or 40 to 104 deg F (5 to 40 deg C).
14. Run Time: As directed, 12 seconds open, 5 seconds closed, 30 seconds, 60 seconds or 120 seconds.

D. Zone Dampers: Two single-blade, galvanized-steel dampers offset 90 degrees from each other on zinc-plated steel operating rod rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel frame. Provide blade gaskets and edge seals, and mechanically fasten blades to operating rod.

E. Face-and-Bypass Dampers: Opposed-blade, galvanized-steel dampers with zinc-plated steel operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel frame and with operating rods connected with a common linkage. Provide blade gaskets and edge seals, and mechanically fasten blades to operating rod.

F. Outdoor- and Return-Air Dampers: As directed, Low-leakage, double-skin, airfoil-blade, galvanized-steel dampers with compressible jamb seals and extruded-vinyl blade edge seals in opposed or parallel-blade arrangement with zinc-plated steel operating rods rotating in stainless-steel sleeve or sintered bronze or nylon bearings mounted in a single galvanized-steel frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed 4 cfm/sq. ft. (20 L/s/sq. m) at 1-inch wg (250 Pa) and 8 cfm/sq. ft. (40 L/s/sq. m) at 4-inch wg (1.0 MPa), leakage Class 1.

G. Mixing Section: Multiple-blade, air-mixer assembly located immediately downstream of mixing section.

H. Combination Filter and Mixing Section:

1. Cabinet support members shall hold 2-inch- (50-mm-) thick, pleated, flat, permanent or throwaway filters.
2. Multiple-blade, air-mixer assembly shall mix air to prevent stratification, located immediately downstream of mixing box.

2.9 SOUND ATTENUATORS

A. General Requirements:

1. Factory fabricated.
2. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials with flame-spread index not exceeding 25 and smoke-developed index not exceeding 50; ASTM E84.
3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with ASHRAE 62.1.

B. Shape: As directed, Rectangular, straight, Round, straight, Rectangular, elbow or Round, elbow.

C. Rectangular Silencer Outer Casing: Galvanized steel.

D. Round Silencer Outer Casing: Galvanized steel.

E. Inner Casing and Baffles: Galvanized steel

F. Principal Sound-Absorbing Mechanism:

1. Dissipative Type: Polymer film-lined absorptive fill material.

a. Fill Material: Inert and vermin-proof fibrous material.

2. Joints: Lock formed and sealed, continuously welded or flanged.

2.10 HUMIDIFIERS

A. Self-contained humidifiers are specified in Section 238413.29 "Self-Contained Humidifiers."

B. Heat-exchanger humidifiers are specified in Section 238413.36 "Heat Exchanger Humidifiers."

2.11 AIR-TO-AIR ENERGY RECOVERY UNITS

A. Heat Wheels:

1. Casing:

a. Galvanized steel, stainless steel, or aluminum with manufacturer's standard finish.
b. Integral purge section limiting carryover of exhaust air to between 0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg (0.5 percent at 400-Pa and 0.20 percent at 1000-Pa) differential pressure.
c. Casing seals on periphery of rotor, on duct divider, and on purge section.
d. Support rotor on grease-lubricated ball bearings with extended grease fittings. Mount horizontal wheels on tapered roller bearing.

2. Rotor: Aluminum or polymer segmented wheel, strengthened with radial spokes, with nontoxic, noncorrosive, silica-gel desiccant coating.
3. Rotor: Aluminum, metallic, or polymer segmented wheel, strengthened with radial spokes impregnated with nonmigrating, water-selective, 3-angstrom molecular-sieve desiccant coating. Drive: Fractional horsepower motor and gear reducer, with speed changed by variable-frequency controller. Permanently lubricated wheel bearings with an L-10 or 400,000 hours As directed.
4. Controls:

a. Starting relay, factory mounted and wired, and manual motor starter for field wiring.
b. Variable-frequency controller, factory mounted and wired, permitting input of field connected 4- to 20-mA or 1- to 10-V control signal.
c. Variable-frequency controller, factory mounted and wired, with exhaust-air sensor to vary rotor speed and maintain exhaust temperature above freezing.
d. Variable-frequency controller, factory mounted and wired, with exhaust- and outdoor-air sensors, automatic changeover thermostat and set-point adjuster, to vary rotor speed and maintain exhaust temperature above freezing and air differential temperature above set point. Provide maximum rotor speed when exhaust-air temperature is less than outdoor-air temperature.
e. Pilot-Light Indicator: Display rotor rotation and speed.
f. Speed Settings: Adjustable settings for maximum and minimum rotor speed limits.

B. Fixed-Plate Sensible Heat Exchangers:

1. Casing: As directed, Aluminum or Galvanized steel.
2. Plates: Evenly spaced and sealed and arranged for counter or cross airflow.
3. Plate Material: As directed, Embossed aluminum, Stainless steel or High-density plastic.
4. Bypass: Plenum within casing, with gasketed face-and-bypass dampers that have operating rods extended outside casing.
5. Heat-Exchanger Prefilters:

    a. Thickness: 1 inch (25 mm) thick, disposable or 2 inches (50 mm) thick, disposable.
    b. MERV Rating: MERV 6.

2.12 AIR BLENDERS

A. Description: Static air mixer device to provide mixing of two airstreams to within plus/minus 6 deg F (3 deg C).

B. Material: Galvanized steel.

2.13 DIFFUSERS

A. Description: Velocity profile equalizer device for providing equalized airflow profile downstream of Type DWDI fans.

B. Material: Galvanized steel.

2.14 ROOF CURBS

A. Roof curbs with vibration isolators and wind or seismic restraints are specified in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Materials: Galvanized steel with corrosion-resistant coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.

1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.

    a. Materials: ASTM C1071, Type I or II.
    b. Thickness: As directed, 1 inch (25 mm), 1-1/2 inches (38 mm) or 2 inches (50 mm).

2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.

    a. Liner Adhesive: Comply with ASTM C916, Type I.
    b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
    c. Liner materials applied in this location shall have airstream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.

d. Liner Adhesive: Comply with ASTM C916, Type I.

C. Curb Dimensions: As directed, Height of 14 inches (355 mm), 24 inches (610 mm) or 36 inches (910 mm). Adaptable horizontal dimensions as required for existing roof openings.

2.15 INTAKE AND RELIEF AIR OPENINGS

A. Provide hood, including moisture eliminator, over all unit intake and relief openings. Match material and finish of casing exterior.

2.16 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

D. Aluminum: ASTM B209 (ASTM B209M).

2.17 SOURCE QUALITY CONTROL

A. AHRI 430 Certification: Air-handling units and their components shall be factory tested according to AHRI 430 and shall be listed and labeled by AHRI.

B. AHRI 1060 Certification: Air-handling units that include air-to-air energy recovery devices shall be factory tested according to AHRI 1060 and shall be listed and labeled by AHRI.

C. AMCA 301 or AHRI 260: Air-handling unit fan sound ratings shall comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data," or AHRI 260, "Sound Rating of Ducted Air Moving and Conditioning Equipment."

D. Fan Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Fans shall bear AMCA-certified sound ratings seal.

E. Fan Performance Rating: Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency. Rate performance according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating."

F. Water Coils: Factory tested to 300 psig (2070 kPa) according to AHRI 410 and ASHRAE 33.

G. Refrigerant Coils: Factory tested to minimum 450-psig (3105-kPa) internal pressure and to minimum 300-psig (2070-kPa) internal pressure while underwater, according to AHRI 410 and ASHRAE 33.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for hydronic and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

A. Equipment Mounting:

B. Roof Curb: As directed, install on roof structure or concrete base, level and secure, according to NRCA's "NRCA Roofing Manual: Membrane Roof Systems" or AHRI Guideline B. Install units on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 077200 "Roof Accessories." Secure units to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts.

C. Unit Support: As directed, Install unit level on structural curbs or steel supports. Coordinate wall penetrations and flashing with wall construction. Secure units to structural support with anchor bolts.

1. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

D. Arrange installation of units to provide access space around air-handling units for service and maintenance.

E. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.

F. Install filter-gauge, static-pressure taps upstream and downstream of filters. Mount filter gauges on outside of filter housing or filter plenum in accessible position. Provide filter gauges on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

G. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."

3.3 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to air-handling unit, allow space for service and maintenance.

C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.

D. Connect condensate drain pans using NPS 1-1/4 (DN 32), ASTM B88, Type M (ASTM B88M, Type C) copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

E. Hot- and Chilled-Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.

F. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.

3.4 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.5 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Leak Test: After installation, fill water and steam coils with water, and test coils and connections for leaks.
2. Charge refrigerant coils with refrigerant and test for leaks.
3. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.

F. Prepare test and inspection reports.

3.7 DEMONSTRATION

A. As directed, Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

END OF SECTION 237343.16

SECTION 237416.11 - PACKAGED, SMALL-CAPACITY, ROOFTOP AIR-CONDITIONING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes packaged, small-capacity, rooftop air-conditioning units (RTUs) with the following components and accessories:

1. Casings.
2. Fans.
3. Motors.
4. Rotary heat exchangers.
5. Coils.
6. Refrigerant circuit components.
7. Air filtration.
8. Gas furnaces.
9. Dampers.
10. Electrical power connections.
11. Controls.
12. Accessories.
13. Roof curbs.

1.2 ACTION SUBMITTALS

A. Product Data: For each RTU.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings:

1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.

D. Delegated-Design Submittal: For RTU supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans and other details, drawn to scale and coordinated with each other, using input from installers of the items involved.

B. Seismic Qualification Data: Certificates, for RTUs, accessories, and components, from manufacturer.

C. Product Certificates: Submit certification that specified equipment will withstand wind forces identified in "Performance Requirements" Article and in Section 230548 "Vibration and Seismic Controls for HVAC."

D. Field quality-control reports.

E. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of RTUs that fail in materials or workmanship within specified warranty period.

PART 2 - PRODUCTS

2.1 DESCRIPTION

A. AHRI Compliance:

1. Comply with AHRI 210/240 for testing and rating energy efficiencies for RTUs.
2. Comply with AHRI 340/360 for testing and rating energy efficiencies for RTUs.
3. Comply with AHRI 270 for testing and rating sound performance for RTUs.
4. Comply with AHRI 1060 for testing and rating performance for air-to-air exchanger.

B. AMCA Compliance:

1. Comply with AMCA 11 and bear the AMCA-Certified Ratings Seal for air and sound performance according to AMCA 211 and AMCA 311.
2. Damper leakage tested according to AMCA 500-D.
3. Operating Limits: Classify according to AMCA 99.

C. ASHRAE Compliance:

1. Comply with ASHRAE 15 for refrigeration system safety.
2. Comply with ASHRAE 33 for methods of testing cooling and heating coils.
3. Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IES Compliance: Comply with applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. NFPA Compliance: Comply with NFPA 90A or NFPA 90B.

F. UL Compliance: Comply with UL 1995.

G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 MANUFACTURERS

2.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design mounting and restraints for RTUs, including comprehensive engineering analysis.

1. Design RTU supports to comply with wind and seismic performance requirements.

B. Wind-Restraint Performance:

1. Basic Wind Speed: As directed.
2. Building Classification Category: As directed I, II, III or IV.
3. Minimum 10 lb/sq. ft. (48.8 kg/sq. m) multiplied by the maximum area of the mechanical component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

C. Seismic Performance: RTUs, accessories, and components shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.4 CAPACITIES AND CHARACTERISTICS

A. Exterior Casing Thickness: As directed 0.052 inch (1.3 mm), 0.0626 inch (1.6 mm) or 0.079 inch (2.0 mm) thick.

B. Supply-Air Fan:

1. Fan Type: As directed Belt driven, double width, forward curved or backward inclined, centrifugal.
2. Fan Type: Double width, forward curved, centrifugal.
3. Airflow: As directed.
4. External Static Pressure: As directed.
5. Fan Speed: Variable.
6. Enclosure Type: As directed Open, dripproof, totally enclosed, fan cooled, Totally enclosed, air over, Open, externally ventilated, Totally enclosed, nonventilated, Severe duty, Explosion proof or Dust-ignition-proof machine.
7. Enclosure Materials: As directed Cast iron, Cast aluminum or Rolled steel.

8. Motor Characteristics:

    a. Horsepower: As directed.
    b. Motor Speed: As directed Multispeed, ECM or Constant.
    c. Volts: As directed 120, 208, 230 or 460.
    d. Phase: As directed Single or Poly.
    e. Hertz: 60.
    f. Full-Load Amperes: As directed.
    g. Minimum Circuit Ampacity: As directed.
    h. Maximum Overcurrent Protection: As directed.

C. Relief (Exhaust)-Air Fan:

1. Airflow: As directed.
2. External Static Pressure: As directed.
3. Fan Speed: As directed.
4. Enclosure Type: As directed Open, dripproof, totally enclosed, fan cooled, Totally enclosed, air over, Open, externally ventilated, Totally enclosed, nonventilated, Severe duty, Explosion proof or Dust-ignition-proof machine.
5. Enclosure Materials: As directed Cast iron, Cast aluminum or Rolled steel.
6. Motor Characteristics:

    a. Horsepower: As directed.
    b. Motor Speed: As directed.
    c. Volts: As directed 120, 208, 230 or 460.
    d. Phase: As directed Single or Poly.
    e. Hertz: 60.
    f. Full-Load Amperes: As directed.
    g. Minimum Circuit Ampacity: As directed.
    h. Maximum Overcurrent Protection: As directed.

D. Outdoor-Air-Intake Relief-Air Fan:

1. Airflow: As directed.
2. Static Pressure: As directed.
3. Fan Speed: As directed.
4. Enclosure Type: As directed Open, dripproof, totally enclosed, fan cooled, Totally enclosed, air over, Open, externally ventilated, Totally enclosed, nonventilated, Severe duty, Explosion proof or Dust-ignition-proof machine.
5. Enclosure Materials: As directed Cast iron, Cast aluminum or Rolled steel.
6. Motor Characteristics:

    a. Horsepower: As directed.
    b. Motor Speed: As directed.
    c. Volts: As directed 120, 208, 230, 460.
    d. Phase: As directed Single or Polyh.
    e. Hertz: 60.
    f. Full-Load Amperes: As directed.
    g. Minimum Circuit Ampacity: As directed.
    h. Maximum Overcurrent Protection: As directed.

E. Rotary Heat Exchanger:

1. Effectiveness: Percent as directed.
2. Intake Airflow: As directed.
3. Pressure Differential: As directed.
4. Entering Supply-Air Dry-Bulb Temperature: As directed.
5. Entering Supply-Air Wet-Bulb Temperature: As directed.
6. Leaving-Air Dry-Bulb Temperature: As directed.
7. Leaving-Air Wet-Bulb Temperature: As directed.
8. Exhaust Airflow: As directed.
9. Pressure Differential: As directed.
10. Entering Exhaust-Air Dry-Bulb Temperature: As directed.
11. Entering Exhaust-Air Wet-Bulb Temperature: As directed.
12. Leaving Exhaust-Air Dry-Bulb Temperature: As directed.
13. Leaving Exhaust-Air Wet-Bulb Temperature: As directed.

F. Supply-Air Refrigerant Coil:

1. Total Cooling Capacity: As directed.
2. Sensible Cooling Capacity: As directed.
3. Entering-Air Dry-Bulb Temperature: As directed.
4. Entering-Air Wet-Bulb Temperature: As directed.

G. Outdoor-Air Refrigerant Coil:

1. Ambient-Air Temperature: As directed.
2. Fan Motor: As directed.
3. Number of Fans: As directed.

H. Electric-Resistance Heating Coil:

1. Capacity: As directed.
2. Number of Steps: As directed.

I. Compressors:

1. Number of Refrigerant Circuits: As directed One or Two.
2. Compressor Speed: As directed Single or Variable.
3. Suction Temperature: As directed.
4. Power Input: As directed.
5. Seasonal Energy-Efficiency Ratio (SEER): As directed.

J. Gas Furnace:

1. Airflow: As directed.
2. Gas Control Valve: As directed Single stage, two stage, Modulating.
3. Minimum AFUE: Percent As directed.
4. Minimum Thermal Efficiency: Percent As directed.
5. Minimum Combustion Efficiency: Percent As directed.
6. Input: As directed.
7. Output: As directed.

8. Entering-Air Temperature: As directed.
9. Air-Temperature Rise: As directed.

K. Dampers:

1. Outdoor-Air Damper: As directed Linked damper blades, for zero to 25 or 30 percent outdoor air, with manual or motorized damper filter.
2. Outdoor- and Return-Air Mixing Dampers: As directed Parallel- or Opposed-blade galvanized-steel dampers mechanically fastened to cadmium plated for galvanized-steel operating rod in reinforced cabinet. Connect operating rods with common linkage or gears and interconnect so dampers operate simultaneously.
3. Relief-Air Damper: Gravity actuated or motorized, as required by ASHRAE/IES 90.1.
4. Barometric relief dampers.

L. Recirculating-Air Filters:

1. Minimum Face Area: As directed.
2. As directed One- or Two-wide filter racks.
3. Thickness: As directed 1 inch (25 mm) or 2 inches (50 mm).
4. Filter Type: Glass fiber with minimum 80 percent arrestance, and MERV 8.
5. Pleated with minimum 90 percent arrestance, and MERV 13.
6. Initial Resistance: As directed.
7. Final Resistance: As directed.

M. Outdoor-Air Filters:

1. Minimum Face Area: As directed.
2. As directed One- or Two-wide filter racks.
3. Thickness: As directed 1 inch (25 mm) or 2 inches (50 mm).
4. Filter Type: Glass fiber with minimum 80 percent arrestance, and MERV 8.
5. Pleated with minimum 90 percent arrestance, and MERV 13.
6. Initial Resistance: As directed.
7. Final Resistance: As directed.

N. Vibration Isolation and Seismic-Control Devices: Device type, with minimum value deflection as directed.

O. RTU Electrical Characteristics for Single-Point Connection:

1. Voltage: As directed 120, 208, 230 or 460.
2. Phase: As directed Single or Poly.
3. Hertz: 60.
4. Full-Load Amperes: As directed.
5. Minimum Circuit Ampacity: As directed.
6. Maximum Overcurrent Protection: As directed.

P. Sound Power: Radiated from condenser casing.

1. 1st Octave: As directed dB.
2. 2nd Octave: As directed dB.
3. 3rd Octave: As directed dB.

4. 4th Octave: As directed dB.
5. 5th Octave: As directed dB.
6. 6th Octave: As directed dB.
7. 7th Octave: As directed dB.
8. 8th Octave: As directed dB.

2.5 CASINGS

A. General Fabrication Requirements for Casings: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.

B. Double-Wall Construction: As directed Fill space between walls with 1-inch (25-mm) or 2-inch (50-mm) foam insulation and seal moisture tight for R-7 or R-13 performance.

C. Exterior Casing Material: Galvanized steel with factory-painted finish, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.

D. Inner Casing Fabrication Requirements:

1. Inside Casing: As directed G-90-coated galvanized steel, 0.034 inch (0.86 mm) or 0.028 inch (0.7 mm) thick, perforated 40 percent free area.

E. Casing Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.

1. Materials: ASTM C1071, Type I.
2. Thickness: As directed 1/2 inch (13 mm) or 1 inch (25 mm).
3. Liner materials shall have airstream surface coated with erosion- and temperature-resistant coating or faced with a plain or coated fibrous mat or fabric.
4. Liner Adhesive: Comply with ASTM C916, Type I.

F. Plastic Condensate Drain Pans: Fabricated using rigid heavy plastic polymer, a minimum of 2 inches (50 mm) deep, and complying with ASHRAE 62.1 for design and construction of drain pans.

G. Condensate Drain Pans: As directed Fabricated using G-90-coated galvanized-steel sheet 0.028 inch (0.70 mm) thick or stainless-steel sheet 0.025 inch (0.715 mm) thick, a minimum of 2 inches (50 mm) deep, and complying with ASHRAE 62.1 for design and construction of drain pans.

1. Double-Wall Construction: Fill space between walls with foam insulation and seal moisture tight.
2. Drain Connections: Threaded nipple.

H. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

2.6 FANS

A. Supply-Air Fans: Aluminum or painted-steel wheels, and galvanized- or painted-steel fan scrolls.

1. Direct-Driven Supply-Air Fans: Motor shall be resiliently mounted in the fan inlet.
2. Belt-Driven Supply-Air Fans: Motors shall be installed on an adjustable fan base resiliently mounted in the casing.

B. Condenser-Coil Fan: Variable-speed propeller, mounted on shaft of permanently lubricated multispeed or ECM motors As directed.

C. Relief-Air Fan: As directed, Propeller, Forward curved or Backward inclined, shaft mounted on permanently lubricated motor.

2.7 MOTORS

A. Comply with Section 230513 "Common Motor Requirements for HVAC Equipment" and the requirements of this Article.

B. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

C. Service Factor: 1.15.

D. Motor Bearings: As directed.

E. Unusual Service Conditions:

1. Ambient Temperature: As directed.
2. Altitude: Feet (m) above sea level as directed.
3. High humidity.

F. Efficiency: Premium efficient.

G. NEMA Design: As directed.

2.8 ROTARY HEAT EXCHANGER

A. Heat exchanger integral with unit.

B. Casing:

1. Steel with standard factory-painted finish.
2. Integral purge section limiting carryover of exhaust air to between 0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg (0.05 percent at 400-Pa and 0.20 percent at 1000-Pa) differential pressure.
3. Casing seals on periphery of rotor and on duct divider and purge section.

4. Support vertical rotors on grease-lubricated ball bearings having extended grease fittings or permanently lubricated bearings. Support horizontal rotors on tapered roller bearing.

C. Rotor: Aluminum segmented wheel strengthened with radial spokes, with nontoxic, noncorrosive, silica-gel desiccant coating.

1. Maximum Solid Size for Media to Pass: As directed 500, 800 or 1200 micrometer.

D. Rotor: As directed Glass-fiber or Polymer segmented wheel strengthened with radial spokes impregnated with nonmigrating, water-selective, molecular-sieve desiccant coating.

1. Maximum Solid Size for Media to Pass: As directed 800 or 1200 micrometer.

E. Drive: Fractional horsepower motor and gear reducer, with speed changed by variable-frequency controller and self-adjusting multilink belt around outside of rotor.

F. Controls:

1. Starting relay, factory mounted and wired, and manual motor starter for field wiring.
2. Variable-frequency controller, factory mounted and wired, permitting input of field connected 4-20 mA or 1-10-V control signal.
3. Variable-frequency controller, factory mounted and wired, with exhaust-air sensor to vary rotor speed and maintain exhaust temperature above freezing.
4. Control energy recovery to permit air economizer operation.

    a. Bypass dampers to assist energy recovery control.

5. Pilot-Light Indicator: Display rotor rotation and speed.
6. Speed Settings: Adjustable settings for maximum and minimum rotor speed limits.
7. Defrost cycle.

2.9 COILS

A. Supply-Air Refrigerant Coil:

1. As directed Aluminum or Copper-plate fin and seamless internally grooved copper tube in steel casing with equalizing-type vertical distributor.
2. Polymer strip shall prevent all copper coils from contacting steel coil frame or condensate pan.
3. Coil Split: Interlaced.
4. Coated.

B. Outdoor-Air Refrigerant Coil:

1. As directed Aluminum or Copper-plate fin and seamless internally grooved copper tube in steel casing with equalizing-type vertical distributor.
2. Polymer strip shall prevent all copper coils from contacting steel coil frame or condensate pan.

C. Electric-Resistance Heating:

1. Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium, supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.
2. Overtemperature Protection: Disk-type, automatically reset, thermal-cutout, safety device; serviceable through terminal box.
3. Overcurrent Protection: Manual-reset thermal cutouts, factory wired in each heater stage.
4. Control Panel: Unit mounted with disconnecting means and overcurrent protection. Include the following controls:

    a. As directed Magnetic or Mercury contactors.
    b. Step Controller: Pilot lights and override toggle switch for each step.
    c. SCR Controller: Pilot lights operate on load ratio, a minimum of five steps.
    d. Time-delay relay.
    e. Airflow proving switch.

2.10 REFRIGERANT CIRCUIT COMPONENTS

A. Compressor: Hermetic, variable-speed scroll, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief, and crankcase heater.

B. Refrigeration Specialties:

1. Refrigerant: R-410A.
2. Expansion valve with replaceable thermostatic element.
3. Refrigerant filter/dryer.
4. Manual-reset high-pressure safety switch.
5. Automatic-reset low-pressure safety switch.
6. Minimum off-time relay.
7. Automatic-reset compressor motor thermal overload.
8. Brass service valves installed in compressor suction and liquid lines.

2.11 AIR FILTRATION

A. Minimum arrestance and MERV according to ASHRAE 52.2.

2.12 GAS FURNACE

A. Description: Factory assembled, piped, and wired; complying with ANSI Z21.47/CSA 2.3 and NFPA 54.

1. CSA Approval: Designed and certified by and bearing label of CSA.

B. Burners: Stainless steel.

1. Fuel: As directed Natural or Propane gas.
2. Ignition: Electronically controlled electric spark or hot-surface igniter with flame sensor.

C. Heat-Exchanger and Drain Pan: Stainless steel.

D. Venting: Gravity vented with vertical extension.

E. Power Vent: Integral, motorized centrifugal fan interlocked with gas valve with vertical extension.

F. Gas Valve Train: Single-body, regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff.

2.13 DAMPERS

A. Leakage Rate: Comply with ASHRAE/IES 90.1.

B. Damper Motor: Modulating with adjustable minimum position.

2.14 ELECTRICAL POWER CONNECTIONS

A. RTU shall have a single connection of power to unit with unit-mounted disconnect switch accessible from outside unit and control-circuit transformer with built-in overcurrent protection.

2.15 CONTROLS

A. Control equipment and sequence of operation are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

B. Basic Unit Controls:

1. Control-voltage transformer.
2. Wall-mounted thermostat or sensor with the following features:

    a. Heat-cool-off switch.
    b. Fan on-auto switch.
    c. Fan-speed switch.
    d. As directed Manual or Automatic changeover.
    e. Adjustable deadband.
    f. As directed Concealed or Exposed set point.
    g. As directed Concealed or Exposed indication.
    h. As directed Degree F or Degree C indication.
    i. Unoccupied-period-override push button.
    j. Data entry and access port to input temperature and humidity set points, occupied and unoccupied periods, and output room temperature and humidity, supply-air temperature, operating mode, and status.

3. Wall-mounted humidistat or sensor with the following features:

    a. As directed Concealed or Exposed set point.
    b. As directed Concealed or Exposed indication.

4. As directed Remote Wall or Unit-Mounted Annunciator Panel for Each Unit:

    a. Lights to indicate power on, cooling, heating, fan running, filter dirty, and unit alarm or failure.
    b. DDC controller or programmable timer and interface with HVAC instrumentation and control system.
    c. Digital display of outdoor-air temperature, supply-air temperature, return-air temperature, economizer damper position, indoor-air quality, and control parameters.

C. As directed Electronic or DDC Controller:

1. Controller shall have volatile-memory backup.
2. Safety Control Operation:

    a. Smoke Detectors: Stop fan and close outdoor-air damper if smoke is detected. Provide additional contacts for alarm interface to fire-alarm control panel.
    b. Firestats: Stop fan and close outdoor-air damper if air greater than 130 deg F (54 deg C) enters unit. Provide additional contacts for alarm interface to fire-alarm control panel.
    c. Fire-Alarm Control Panel Interface: Provide control interface to coordinate with operating sequence described in Section 284621.11 "Addressable Fire-Alarm Systems" or Section 284621.13 "Conventional Fire-Alarm Systems" As directed
    d. Defrost Control for Condenser Coil: Pressure differential switch to initiate defrost sequence.

3. Scheduled Operation: As directed Occupied and unoccupied periods on seven or 365-day clock with a minimum of two or four programmable periods per day.
4. Unoccupied Period:

    a. Heating Setback: 10 deg F (5.6 deg C).
    b. Cooling Setback: System off.
    c. Override Operation: Two hours.

5. Supply Fan Operation:

    a. Occupied Periods: Run fan continuously.
    b. Unoccupied Periods: Cycle fan to maintain setback temperature.

6. Refrigerant Circuit Operation:

    a. Occupied Periods: Cycle or stage compressors to match compressor output to cooling load to maintain room or discharge temperature and humidity. Cycle condenser fans to maintain maximum hot-gas pressure.
    b. Unoccupied Periods: Compressors off.

7. Gas Furnace Operation:

    a. Occupied Periods: As directed Cycle, Stage or Modulate burner to maintain room or discharge temperature.

b. Unoccupied Periods: Cycle burner to maintain setback temperature.

8. Electric-Heating-Coil Operation:

a. Occupied Periods: As directed Cycle, Stage or Modulate coil to maintain room or discharge temperature.
b. Unoccupied Periods: Energize coil to maintain setback temperature.

9. Fixed Minimum Outdoor-Air Damper Operation:

a. Occupied Periods: Open to 25 percent.
b. Unoccupied Periods: Close the outdoor-air damper.

10. Economizer Outdoor-Air Damper Operation:

a. As directed Morning warm-up, cool-down or building outdoor-air flush cycles.
b. Occupied Periods: As directed Open to 10 or 25 percent fixed minimum intake, and maximum 100 percent of the fan capacity. Controller shall permit air-side economizer operation when outdoor air is less than 60 deg F (15 deg C). As directed Use outdoor-air temperature, mixed-air and outdoor-air temperature, outdoor-air enthalpy or mixed-air temperature and select between outdoor-air and return-air enthalpy to adjust mixing dampers. Start relief-air fan with end switch on outdoor-air damper. During economizer cycle operation, lock out cooling.
c. Unoccupied Periods: Close outdoor-air damper and open return-air damper.

11. Terminal-Unit Relays:

a. Provide heating- and cooling-mode changeover relays compatible with terminal control system required in Section 233600 "Air Terminal Units" and Section 230923 "Direct Digital Control (DDC) System for HVAC."

D. Interface Requirements for HVAC Instrumentation and Control System:

1. Interface relay for scheduled operation.
2. Interface relay to provide indication of fault at the central workstation and diagnostic code storage.
3. Provide BACnet or LonWorks compatible interface for central HVAC control workstation for the following:

a. Adjusting set points.
b. Monitoring supply fan start, stop, and operation.
c. Inquiring data to include outdoor-air damper position, supply- and room-air temperature and humidity.
d. Monitoring occupied and unoccupied operations.
e. Monitoring constant and variable motor loads.
f. Monitoring variable-frequency drive operation.
g. Monitoring cooling load.
h. Monitoring economizer cycles.
i. Monitoring air-distribution static pressure and ventilation air volume.

2.16 ACCESSORIES

A. Electric heater with integral thermostat maintains minimum 50 deg F (10 deg C) temperature in gas burner compartment.

B. Duplex, 115-V, ground-fault-interrupter outlet with 15-A overcurrent protection. Include transformer if required. Outlet shall be energized even if the unit main disconnect is open.

C. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.

D. Remote potentiometer to adjust minimum economizer damper position.

E. Return-air bypass damper.

F. Factory- or field-installed, demand-controlled ventilation.

G. Safeties:

1. Smoke detector.
2. Condensate overflow switch.
3. Phase-loss reversal protection.
4. High and low pressure control.
5. As directed Gas furnace or Electric coil airflow-proving switch.

H. Coil guards of painted, galvanized-steel wire.

I. Hail guards of galvanized steel painted to match casing.

J. Concentric diffuser with white louvers and polished aluminum return grilles, insulated diffuser box with mounting flanges, and interior transition.

K. Door switches to disable heating or reset set point when open.

L. Outdoor-air intake weather hood with moisture eliminator.

M. Oil separator.

N. Service Lights and Switch: Factory installed in fan section, fan and coil sections or each accessible section with weatherproof cover. Factory wire lights to a single-point field connection.

2.17 ROOF CURBS

A. Roof curbs with vibration isolators and wind or seismic restraints are specified in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.

1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.

a. Materials: ASTM C1071, Type I or II.
b. Thickness: As directed 1 inch (25 mm), 1-1/2 inches (38 mm) or 2 inches (50 mm).

2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.

a. Liner Adhesive: Comply with ASTM C916, Type I.
b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
c. Liner materials applied in this location shall have airstream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
d. Liner Adhesive: Comply with ASTM C916, Type I.

C. Curb Dimensions: As directed Height of 14 inches (355 mm), 24 inches (610 mm) or 36 inches (910 mm). Adaptable horizontal dimensions as required for existing roof openings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Roof Curb: Install on roof structure or concrete base, level and secure, according to NRCA's "NRCA Roofing Manual: Membrane Roof Systems" or AHRI Guideline B As directed. Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 077200 "Roof Accessories." Secure RTUs to upper curb rail, and secure curb base to roof framing with anchor bolts.

B. Unit Support: As directed Install unit level on structural curbs or steel supports. Coordinate wall penetrations and flashing with wall construction. Secure RTUs to structural support with anchor bolts.

3.2 CONNECTIONS

A. Comply with duct installation requirements specified in other HVAC Sections. Drawings indicate general arrangement of ducts. The following are specific connection requirements:

1. Install ducts to termination at top of roof curb.
2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
3. Connect supply ducts to RTUs with flexible duct connectors specified in Section 233300 "Air Duct Accessories."
4. Install return-air duct continuously through roof structure.
5. Install normal-weight, 3000-psi (20.7-MPa), compressive strength (28-day) concrete mix inside roof curb, 4 inches (100 mm) thick. Concrete, formwork, and reinforcement are specified with concrete.

B. Install condensate drain, minimum connection size, with trap and indirect connection to nearest roof drain or area drain.

C. Where installing piping adjacent to RTUs, allow space for service and maintenance.

1. Gas Piping: Comply with applicable requirements in Section 231123 "Facility Natural-Gas Piping" or Section 231126 "Facility Liquefied-Petroleum Gas Piping" As directed Connect gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.

D. Connect electrical wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

E. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

F. Install nameplate for each electrical connection indicating electrical equipment designation and circuit number feeding connection.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. Tests and Inspections:

1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. RTU will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.4 CLEANING AND ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

B. After completing system installation and testing, adjusting, and balancing RTU and air-distribution systems, clean filter housings and install new filters.

3.5 DEMONSTRATION

A. As directed Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain RTUs.

END OF SECTION 237416.11

SECTION 237416.13 - PACKAGED, LARGE-CAPACITY, ROOFTOP AIR-CONDITIONING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes packaged, large-capacity, rooftop air conditioning units (RTUs) with the following components and accessories:

1. Casings.
2. Fans.
3. Motors.
4. Coils.
5. Refrigerant circuit components.
6. Air filtration.
7. Supported bag filters.
8. Gas furnaces.
9. Dampers.
10. Electrical power connections.
11. Controls.
12. Accessories
13. Roof curbs.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

C. Shop Drawings:

1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.

D. Delegated-Design Submittal: For RTU supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
2. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.

3. Wind- and Seismic-Restraint Details: Detail fabrication and attachment of wind and seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans and other details, drawn to scale and coordinated with each other, using input from installers of the items involved.

B. Product Certificates: Submit certification that specified equipment will withstand wind forces identified in "Performance Requirements" Article and in Section 230548 "Vibration and Seismic Controls for HVAC."

C. Seismic Qualification Data: Certificates, for RTUs, accessories, and components, from manufacturer.

D. Field quality-control reports.

E. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of RTUs that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: As directed, Manufacturer's standard, but not less than five or 10 years from date of Substantial Completion.
2. Warranty Period for Gas Furnace Heat Exchangers: Manufacturer's standard, but not less than five, 10, 15 or 20 years from date of Substantial Completion As directed.
3. Warranty Period for Solid-State Ignition Modules: Manufacturer's standard, but not less than three years from date of Substantial Completion.
4. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. AHRI Compliance:

1. Comply with AHRI 340/360 for testing and rating energy efficiencies for RTUs.
2. Comply with AHRI 270 for testing and rating sound performance for RTUs.
3. Comply with AHRI 1060 for testing and rating performance for air-to-air exchanger.

4. Comply with AHRI 210/240 for testing and rating energy efficiencies for RTUs.

B. AMCA Compliance:

1. Comply with AMCA 11 and bear the AMCA-Certified Ratings Seal for air and sound performance according to AMCA 211 and AMCA 311.
2. Damper leakage tested in accordance with AMCA 500-D.
3. Operating Limits: Classify according to AMCA 99.

C. ASHRAE Compliance:

1. Comply with ASHRAE 15 for refrigeration system safety.
2. Comply with ASHRAE 33 for methods of testing cooling and heating coils.
3. Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. NFPA Compliance: Comply with NFPA 90A or NFPA 90B.

F. UL Compliance: Comply with UL 1995.

G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 MANUFACTURERS

2.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design mounting and restraints for RTUs, including comprehensive engineering analysis.

1. Design RTU supports to comply with wind and seismic performance requirements.

B. Wind-Restraint Performance:

1. Basic Wind Speed: As directed.
2. Building Classification Category: As directed, I, II, III or IV.
3. Minimum 10 lb/sq. ft. (48.8 kg/sq. m) multiplied by the maximum area of the mechanical component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

C. Seismic Performance: RTUs shall withstand the effects of earthquake motions determined according to ASCE 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified" and the unit will be fully operational after the seismic event.

2.4 CAPACITIES AND CHARACTERISTICS

A. Exterior Casing Thickness: As directed, 0.052 inch (1.3 mm), 0.0626 inch (1.6 mm) or 0.079 inch (2.0 mm) thick.

B. Supply-Air Fan:

1. Fan Type: As directed, Belt-driven, double width, forward curved or backward inclined, centrifugal.
2. Fan Type: Double width, forward curved, centrifugal.
3. Airflow: As directed.
4. External Static Pressure: As directed.
5. Fan Speed: Variable.
6. Motor Horsepower: As directed.

C. Relief (Exhaust)-Air Fan:

1. Airflow: As directed.
2. External Static Pressure: As directed.
3. Fan Speed: As directed.
4. Motor Horsepower: As directed.
5. Motor Speed: As directed.

D. Outdoor-Air-Intake Relief-Air Fan:

1. Airflow: As directed.
2. Static Pressure: As directed.
3. Fan Speed: As directed.
4. Motor Horsepower: As directed.
5. Motor Speed: As directed.

E. Motors:

1. Service Factor: 1.15.
2. Motor Bearings: As directed.
3. Unusual Service Conditions:

    a. Ambient Temperature: As directed.
    b. Altitude: Feet (m) above sea level As directed.
    c. Humidity: High As directed.
    d. Other: As directed.

4. Efficiency: Premium efficient. As directed.
5. NEMA Design: As directed.

F. Supply-Air Refrigerant Coil:

1. Total Cooling Capacity: As directed.
2. Sensible Cooling Capacity: As directed.
3. Entering-Air Dry-Bulb Temperature: As directed.
4. Entering-Air Wet-Bulb Temperature: As directed.

G. Outdoor-Air Refrigerant Coil:

1. Ambient-Air Temperature: As directed.
2. Fan Motor: As directed.
3. Number of Fans: As directed.

H. Electric-Resistance Heating Coil:

1. Capacity: As directed.
2. Number of Steps: As directed.

I. Compressors:

1. Suction Temperature: As directed.
2. Power Input: As directed.
3. Seasonal Energy Efficiency Ratio (SEER): As directed.

J. Gas Furnace:

1. Airflow: As directed.
2. Minimum AFUE: Percent As directed.
3. Minimum Thermal Efficiency: Percent As directed.
4. Minimum Combustion Efficiency: Percent As directed.
5. Input: As directed.
6. Output: As directed.
7. Entering-Air Temperature: As directed.
8. Air-Temperature Rise: As directed.

K. Recirculating-Air Filters:

1. Minimum Face Area: As directed.
2. Thickness: As directed, 1 inch (25 mm) or 2 inches (50 mm).
3. Initial Resistance: As directed.
4. Final Resistance: As directed.

L. Outdoor-Air Filters:

1. Minimum Face Area: As directed.
2. Thickness: As directed, 1 inch (25 mm) or 2 inches (50 mm).
3. Initial Resistance: As directed.
4. Final Resistance: As directed.

M. Electrical Characteristics for Single-Point Connection:

1. Voltage: As directed.
2. Phase: As directed.

3. Hertz: As directed.
4. Full-Load Amperes: As directed.
5. Minimum Circuit Ampacity: As directed.
6. Maximum Overcurrent Protection: As directed.

N. Attenuator Insertion Loss Rating (ILR):

1. 1st Octave: dB as directed.
2. 2nd Octave: dB as directed.
3. 3rd Octave: dB as directed.
4. 4th Octave: dB as directed.
5. 5th Octave: dB as directed.
6. 6th Octave: dB as directed.
7. 7th Octave: dB as directed.
8. 8th Octave: dB as directed.

2.5 CASINGS

A. General Fabrication Requirements for Casings: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.

B. Double-Wall Construction: As directed, Fill space between walls with 1 inch (25 mm) or 2 inch (50 mm) foam insulation and seal moisture tight for R-7 or R-13 performance.

C. Exterior Casing Material: Galvanized steel with factory-painted finish, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.

D. Inner Casing Fabrication Requirements:

1. Inside Casing: As directed, G-90-coated galvanized steel, 0.034 inch (0.86 mm) or 0.028 inch (0.7 mm) thick, perforated 40 percent free area.

E. Casing Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.

1. Materials: ASTM C1071, Type I.
2. Thickness: As directed, 1/2 inch (13 mm) or 1 inch (25 mm).
3. Liner materials shall have air-stream surface coated with an erosion- and temperature-resistant coating or faced with a plain or coated fibrous mat or fabric.
4. Liner Adhesive: Comply with ASTM C916, Type I.

F. Plastic Condensate Drain Pans: Fabricated using rigid heavy plastic polymer complying with ASTM G21, a minimum of 2 inches (50 mm) deep, and complying with ASHRAE 62.1 for design and construction of drain pans.

G. Condensate Drain Pans: As directed, Fabricated using G-90-coated galvanized 0.028 inch (0.70 mm) thick or stainless 0.025 inch (0.715 mm) thick steel sheet, a minimum of 2 inches (50 mm) deep, and complying with ASHRAE 62.1 for design and construction of drain pans.

1. Double-Wall Construction: Fill space between walls with foam insulation and seal moisture tight.
2. Drain Connections: Threaded nipple.

H. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

2.6 FANS

A. Supply-Air Fans: Aluminum or painted-steel wheels, and galvanized- or painted-steel fan scrolls.

1. Direct-Driven Supply-Air Fans: Motor shall be resiliently mounted in the fan inlet.
2. Belt-Driven Supply-Air Fans: Motors shall be installed on an adjustable fan base resiliently mounted in the casing.

B. Condenser-Coil Fan: Variable-speed propeller, mounted on shaft of permanently lubricated multispeed or ECM motors.

C. Relief-Air Fan: As directed, Propeller, forward curved or Backward inclined, shaft mounted on permanently lubricated motor.

D. Seismic Fabrication Requirements: Fabricate fan section, internal mounting frame and attachment to fans, fan housings, motors, casings, accessories, and other fan section components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC" when fan-mounted frame and RTU-mounted frame are anchored to building structure.

2.7 MOTORS

A. Comply with Section 230513 "Common Motor Requirements for HVAC Equipment" and the requirements of this Article.

B. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

C. Service Factor: 1.15.

D. Motor Bearings: As directed.

E. Unusual Service Conditions:

1. Ambient Temperature: As directed.
2. Altitude: Feet (m) above sea level as directed.
3. High humidity.

F. Efficiency: Premium efficient.

G. NEMA Design: As directed.

2.8 COILS

A. Supply-Air Refrigerant Coil:

1. As directed, Aluminum or Copper-plate fin and seamless internally grooved copper tube in steel casing with equalizing-type vertical distributor.
2. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.
3. Coil Split: Interlaced.
4. Condensate Drain Pan: As directed, Galvanized steel with corrosion-resistant coating or Stainless steel formed with pitch and drain connections complying with ASHRAE 62.1.

B. Supply-Air Hydronic Heating Coil:

1. As directed, One- or Two-row aluminum or copper-plate fin and seamless internally grooved copper tube in steel casing with equalizing-type vertical distributor and with air vent and drain.

C. Outdoor-Air Refrigerant Coil:

1. As directed, Aluminum or Copper-plate fin and seamless internally grooved copper tube in steel casing with equalizing-type vertical distributor.
2. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.

D. Electric-Resistance Heating:

1. Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium, supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.
2. Overtemperature Protection: Disk-type, automatically reset, thermal-cutout, safety device; serviceable through terminal box.
3. Overcurrent Protection: Manual-reset thermal cutouts, factory wired in each heater stage.
4. Control Panel: Unit mounted with disconnecting means and overcurrent protection. Include the following controls:

    a. As directed, Magnetic or Mercury contactors.
    b. Step Controller: Pilot lights and override toggle switch for each step.
    c. SCR Controller: Pilot lights operate on load ratio, a minimum of five steps.
    d. Time-delay relay.
    e. Airflow proving switch.

2.9 REFRIGERANT CIRCUIT COMPONENTS

A. Number of Refrigerant Circuits: As directed, One or Two.

B. Compressor: Hermetic, variable speed scroll, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief, and crankcase heater.

C. Refrigeration Specialties:

1. Refrigerant: R-410A.
2. Expansion valve with replaceable thermostatic element.
3. Refrigerant filter/dryer.
4. Manual-reset high-pressure safety switch.
5. Automatic-reset low-pressure safety switch.
6. Minimum off-time relay.
7. Automatic-reset compressor motor thermal overload.
8. Brass service valves installed in compressor suction and liquid lines.

2.10 AIR FILTRATION

A. Minimum arrestance and a minimum efficiency reporting value according to ASHRAE 52.2.

B. Flat Panel Filters:

1. Description: Factory-fabricated, self-supported, flat, nonpleated, panel-type, disposable air filters with holding frames.
2. Filter Unit Class: UL 900, Class 1 or Class 2.
3. Media: As directed, Interlaced glass or synthetic fibers or Cotton and synthetic fibers coated with nonflammable adhesive.

    a. Adhesive: As recommended by air-filter manufacturer and with a VOC content of 80 g/L or less.
    b. Adhesive: As recommended by air-filter manufacturer and that complies with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
    c. Media shall be coated with an antimicrobial agent.
    d. Metal Retainer: Upstream side and downstream side.

C. Pleated Panel Filters:

1. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters with holding frames.
2. Filter Unit Class: As directed, UL 900, Class 1 or Class 2.
3. Media: As directed, Interlaced glass or synthetic fibers or Cotton and synthetic fibers coated with nonflammable adhesive.

    a. Adhesive: As recommended by air-filter manufacturer and with a VOC content of 80 g/L or less.
    b. Adhesive: As recommended by air-filter manufacturer and that complies with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
    c. Media shall be coated with an antimicrobial agent.
    d. Separators shall be bonded to the media to maintain pleat configuration.
    e. Welded-wire grid shall be on downstream side to maintain pleat.
    f. Media shall be bonded to frame to prevent air bypass.

g. Support members on upstream and downstream sides to maintain pleat spacing.

2.11 SUPPORTED BAG FILTERS

A. Description: Factory-fabricated, dry, extended-surface, self-supported filters with holding frames in steel, basket-type retainers.

B. Filter Unit Class: As directed, UL 900, Class 1 or Class 2.

C. Media: Fibrous material constructed so individual pleats are maintained in tapered form under rated-airflow conditions by flexible internal supports.

1. Media shall be coated with an antimicrobial agent.

D. Rigid Cell Box Filters:

1. Description: Factory-fabricated, adhesive-coated, disposable, packaged air filters with media perpendicular to airflow, and with holding frames.
2. Filter Unit Class: As directed, UL 900, Class 1 or Class 2.
3. Media: Fibrous material constructed so individual pleats are maintained in tapered form under rated-airflow conditions by flexible internal supports.

a. Adhesive: As recommended by air-filter manufacturer and with a VOC content of 80 g/L or less.
b. Adhesive: As recommended by air-filter manufacturer and that complies with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
c. Media shall be coated with an antimicrobial agent.

2.12 GAS FURNACES

A. Description: Factory assembled, piped, and wired; complying with ANSI Z21.47/CSA 2.3 and NFPA 54.

1. CSA Approval: Designed and certified by and bearing label of CSA.

B. Burners: Stainless steel.

1. Fuel: As directed, Natural or Propane gas.
2. Ignition: Electronically controlled electric spark or hot-surface igniter with flame sensor.
3. High-Altitude Model or Kit as airected: For Project elevations more than 2000 feet (610 m) above sea level.

C. Heat-Exchanger and Drain Pan: Stainless steel.

D. Venting: Gravity vented with vertical extension.

E. Power Vent: Integral, motorized centrifugal fan interlocked with gas valve with vertical extension.

F. Safety Controls:

1. Gas Control Valve: As directed, Single stage, Two stage or Modulating.
2. Gas Train: Single-body, regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff.

2.13 DAMPERS

A. Outdoor-Air Damper: Linked damper blades, for 0 to 25 or 30 percent outdoor air, with manual or motorized damper filter as directed.

B. Outdoor- and Return-Air Mixing Dampers: As directed, Parallel- or Opposed-blade galvanized-steel dampers mechanically fastened to cadmium plated for galvanized-steel operating rod in reinforced cabinet. Connect operating rods with common linkage or gears and interconnect so dampers operate simultaneously.

1. Leakage Rate: As required by ASHRAE/IES 90.1.
2. Damper Motor: Modulating with adjustable minimum position.
3. Relief-Air Damper: Gravity actuated or motorized, as required by ASHRAE/IES 90.1, with bird screen and hood.

C. Barometric relief dampers.

2.14 ELECTRICAL POWER CONNECTIONS

A. RTU shall have a single connection of power to unit with unit-mounted disconnect switch accessible from outside unit and control-circuit transformer with built-in overcurrent protection.

2.15 CONTROLS

A. Basic Unit Controls:

1. Control-voltage transformer.
2. Wall-mounted thermostat or sensor with the following features:

a. Heat-cool-off switch.
b. Fan on-auto switch.
c. Fan-speed switch.
d. As directed, Manual or Automatic changeover.
e. Adjustable deadband.
f. As directed, Concealed or Exposed set point.
g. As directed, Concealed or Exposed indication.
h. As directed, Degree F or Degree C indication.
i. Unoccupied-period-override push button.

j. Data entry and access port to input temperature and humidity set points, occupied and unoccupied periods, and output room temperature and humidity, supply-air temperature, operating mode, and status.

3. As directed, Remote Wall or Unit-Mounted Annunciator Panel for Each Unit:

a. Lights to indicate power on, cooling, heating, fan running, filter dirty, and unit alarm or failure.
b. DDC controller or programmable timer and interface with HVAC instrumentation and control system.
c. Digital display of outdoor-air temperature, supply-air temperature, return-air temperature, economizer damper position, indoor-air quality, and control parameters.

B. As directed, Electronic or DDC Controller:

1. Controller shall have non-volatile-memory backup.
2. Safety Control Operation:

a. Smoke Detectors: Stop fan and close outdoor-air damper if smoke is detected. Provide additional contacts for alarm interface to fire alarm control panel.
b. Firestats: Stop fan and close outdoor-air damper if air greater than 130 deg F (54 deg C) enters unit. Provide additional contacts for alarm interface to fire alarm control panel.
c. Fire Alarm Control Panel Interface: Provide control interface to coordinate with operating sequence described in Section 284621.11 "Addressable Fire-Alarm Systems" or Section 284621.13 "Conventional Fire-Alarm Systems" As directed

3. Scheduled Operation: As directed, Occupied and unoccupied periods on seven or 365-day clock with a minimum of two or four programmable periods per day.
4. Unoccupied Period:

a. Heating Setback: Plus 10 deg F (Minus 11 deg C).
b. Cooling Setback: System off.
c. Override Operation: Two hours.

5. Supply Fan Operation:

a. Occupied Periods: Run fan continuously.
b. Unoccupied Periods: Cycle fan to maintain setback temperature.

6. Refrigerant Circuit Operation:

a. Occupied Periods: As directed, Cycle or stage compressors to match compressor output to cooling load to maintain room or discharge temperature and humidity. Cycle condenser fans to maintain maximum hot-gas pressure.
b. Unoccupied Periods: Compressors off.

7. Gas Furnace Operation:

a. Occupied Periods: As directed, Cycle, Stage or Modulate burner to maintain room or discharge temperature.
b. Unoccupied Periods: Cycle burner to maintain setback temperature.

8. Electric-Heating-Coil Operation:

a. Occupied Periods: As directed, Cycle, Stage or Modulate coil to maintain room or discharge temperature.
b. Unoccupied Periods: Energize coil to maintain setback temperature.

9. Fixed Minimum Outdoor-Air Damper Operation:

a. Occupied Periods: Open to 25 percent.
b. Unoccupied Periods: Close the outdoor-air damper.

10. Economizer Outdoor-Air Damper Operation:

a. Morning warm up, cool down or building outdoor air flush cycles.
b. Occupied Periods: Open to 10 or 25 percent fixed minimum intake, and maximum 100 percent of the fan capacity. Controller shall permit air-side economizer operation when outdoor air is less than 60 deg F (15 deg C). As directed, use outdoor-air temperature, mixed-air and outdoor-air temperature, outdoor-air enthalpy or mixed-air temperature and select between outdoor-air and return-air enthalpy to adjust mixing dampers. Start relief-air fan with end switch on outdoor-air damper. During economizer cycle operation, lock out cooling.
c. Unoccupied Periods: Close outdoor-air damper and open return-air damper.

11. Terminal-Unit Relays:

a. Provide heating- and cooling-mode changeover relays compatible with terminal control system required in Section 233600 "Air Terminal Units" and Section 230923 "Direct Digital Control (DDC) System for HVAC."

C. Interface Requirements for HVAC Instrumentation and Control System:

1. Interface relay for scheduled operation.
2. Interface relay to provide indication of fault at the central workstation and diagnostic code storage.
3. Provide BACnet or LonWorks compatible interface for central HVAC control workstation for the following:

a. Adjusting set points.
b. Monitoring supply fan start, stop, and operation.
c. Inquiring data to include outdoor-air damper position, supply- and room-air temperature and humidity.
d. Monitoring occupied and unoccupied operations.
e. Monitoring constant and variable motor loads.
f. Monitoring variable-frequency drive operation.
g. Monitoring cooling load.
h. Monitoring economizer cycles.
i. Monitoring air-distribution static pressure and ventilation air volume.

2.16 ACCESSORIES

A. Electric heater with integral thermostat maintains minimum 50 deg F (10 deg C) temperature in gas burner compartment.

B. Duplex, 115-V, ground-fault-interrupter outlet with 15-A overcurrent protection. Include transformer if required. Outlet shall be energized even if the unit main disconnect is open.

C. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.

D. Remote potentiometer to adjust minimum economizer damper position.

E. Return-air bypass damper.

F. Factory- or field-installed demand-controlled ventilation.

G. Safeties:

1. Smoke detector.
2. Condensate overflow switch.
3. Phase-loss reversal protection.
4. High and low pressure control.
5. As directed, Gas furnace or Electric coil airflow-proving switch.

H. Coil guards of painted, galvanized-steel wire.

I. Hail guards of galvanized steel, painted to match casing.

J. Concentric diffuser with white louvers and polished aluminum return grilles, insulated diffuser box with mounting flanges, and interior transition.

K. Vertical vent extensions to increase the separation between the outdoor-air intake and the flue-gas outlet.

L. Door switches to disable heating or reset set point when open.

M. Outdoor air intake weather hood with moisture eliminator.

N. Service Lights and Switch: As directed, factory installed in fan section, fan and coil sections or each accessible section with weatherproof cover. Factory wire lights to a single-point field connection.

2.17 ROOF CURBS

A. Roof curbs with vibration isolators and wind or seismic restraints are specified in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match RTU, used to anchor unit to the curb, and designed for loads at Project site. Comply with

requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for wind-load requirements.

C. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.

1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.

a. Materials: ASTM C1071, Type I or II.
b. Thickness: As directed, 1 inch (25 mm), 1-1/2 inches (38 mm) or 2 inches (50 mm).

2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.

a. Liner Adhesive: Comply with ASTM C916, Type I.
b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
c. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
d. Liner Adhesive: Comply with ASTM C916, Type I.

D. Curb Dimensions: As directed, Height of 14 inches (355 mm), 24 inches (610 mm) or 36 inches (910 mm) Adaptable horizontal dimensions as required for existing roof openings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Roof Curb: Install on roof structure, level and secure, according to NRCA's "NRCA Roofing Manual: Membrane Roof Systems" or AHRI Guideline B As directed. Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 077200 "Roof Accessories." Secure RTUs to upper curb rail, and secure curb base to roof framing.

B. Unit Support: As directed, Install unit level on structural curbs or steel supports. Coordinate wall penetrations and flashing with wall construction. Secure RTUs to structural support with anchor bolts.

C. Equipment Mounting:

1. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

3.2 CONNECTIONS

A. Install condensate drain, minimum connection size, with trap and indirect connection to nearest roof drain or area drain.

B. Install piping adjacent to RTUs to allow service and maintenance.

1. Gas Piping: Comply with applicable requirements in Section 231123 "Facility Natural-Gas Piping" or Section 231126 "Facility Liquefied-Petroleum Gas Piping" As directed. Connect gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.

C. Duct installation requirements are specified in other HVAC Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:

1. Install ducts to termination at top of roof curb.
2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
3. Connect supply ducts to RTUs with flexible duct connectors specified in Section 233300 "Air Duct Accessories."
4. Install return-air duct continuously through roof structure.
5. Install normal-weight, 3000-psi (20.7-MPa), compressive strength (28-day) concrete mix inside roof curb, 4 inches (100 mm) thick. Concrete, formwork, and reinforcement are specified with concrete.

D. Connect electrical wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

E. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

F. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs as layers of black with engraved white letters at least 1/2-inch (13-mm) high.
3. Locate nameplate where easily visible.

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.

2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. RTU will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.4 DEMONSTRATION

A. As directed, Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain RTUs.

END OF SECTION 237416.13

SECTION 237423.13 - PACKAGED, DIRECT-FIRED, OUTDOOR, HEATING-ONLY MAKEUP-AIR UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes direct-fired heating and ventilating units.

1.2 ACTION SUBMITTALS

A. Product Data: For each type and configuration of outdoor, direct-fired heating and ventilating unit.

B. Sustainable Design Submittals:

C. Shop Drawings: For each type and configuration of outdoor, direct-fired heating and ventilating unit.

1. As directed, include plans, elevations, sections, and mounting or attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

1.3 INFORMATIONAL SUBMITTALS

A. Sample Warranty: For manufacturer's special warranty.

B. Seismic Qualification Certificates: For outdoor, direct-fired heating and ventilating units, accessories, and components, from manufacturer.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Comply with NFPA 70.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of direct-fired heating and ventilating units that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Heat Exchangers: As directed, manufacturer's standard, but not less than five or 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 SYSTEM DESCRIPTION

A. Factory-assembled, prewired, self-contained unit consisting of cabinet, supply fan, controls, filters, and direct-fired gas burner to be installed exterior to the building.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 UNIT CASINGS

A. General Fabrication Requirements for Casings:

1. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
2. Casing Joints: Sheet metal screws or pop rivets, factory sealed with water-resistant sealant.
3. Factory Finish for Steel and Galvanized-Steel Casings: Apply manufacturer's standard primer immediately after cleaning and pretreating.
4. Air-Handling-Unit Mounting Frame: Formed galvanized-steel channel or structural channel supports, designed for low deflection, welded with integral lifting lugs.

    a. Seismic Fabrication Requirements: Fabricate mounting base and attachment to air-handling-unit sections, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC" when air-handling-unit frame is anchored to building structure.

5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. Configuration: As directed, horizontal unit with top, horizontal or bottom discharge for roof-mounting or concrete-base installation.

C. Cabinet: As directed, galvanized-steel, Aluminized- or galvanized-steel or Aluminized-steel panels, formed to ensure rigidity and supported by galvanized-steel channels or structural channel supports with lifting lugs. Duct flanges at inlet and outlet. Pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.

D. Outer Casing: As directed, 0.0598-inch (1.519-mm), 0.0478-inch (1.214-mm) or 0.0359-inch (0.912-mm) thick steel with heat-resistant, baked-enamel, enamel-painted, baked-on, polyester-powder or unpainted over-corrosion-resistant-treated surface in color to match fan section.

E. Outer Casing: As directed, 0.0598-inch (1.519-mm), 0.0478-inch (1.214-mm) or 0.0359-inch (0.912-mm) thick steel with unpainted finish.

F. Outer Casing: 0.0359-inch (0.912-mm) thick steel with heat-resistant, baked-enamel over-corrosion-resistant-treated surface in color to match fan section.

G. Inner Casing:

1. Burner Section Inner Casing: 0.0299-inch- (0.759-mm-) thick steel.Retain first subparagraph below if double-wall casing is required.
2. As double-wall casing with inner wall of perforated or solid steel, for the following sections:

    a. Blower section.
    b. Filter section.
    c. Mixing box.
    d. Inlet plenum.
    e. Discharge plenum.
    f. As directed, access Doors or Panels: As directed, Lift out, Piano hinged with cam-lock fasteners or Hinged with handles for burner and fan motor assemblies on both sides of unit.

3. Internal Insulation: As directed, fibrous-glass duct lining, neoprene coated, comply with ASTM C1071, Type II, applied on complete unit or burner and fan sections only.

    a. Thickness: As directed, 1 inch (25 mm) or 2 inches (50 mm).
    b. Insulation Adhesive: Comply with ASTM C916, Type I.
    c. Density: As directed, 1.5 lb/cu. ft. (24.0 kg/cu. m), 2.0 lb/cu. ft. (32.0 kg/cu. m) or 3.0 lb/cu. ft. (48.0 kg/cu. m).
    d. Mechanical Fasteners: Galvanized steel suitable for adhesive, mechanical, or welding attachment to casing without damaging liner when applied as recommended by manufacturer and without causing air leakage.

H. Discharge Section: As directed, Galvanized or Aluminized-steel assembly with gravity, individually adjustable, vaned, two-position, motorized, parallel-blade dampers with nylon bushings.

1. Pattern: As directed, Single or Double deflection.
2. Leakage: As directed, Standard or Low leakage.

I. Discharge Section: Trapezoidal cowls with horizontal louvers.

J. Discharge Section: As directed, Plenum with two or four sides louvered.

K. Discharge Section: Down-discharge plenum insulated with 1-inch (25-mm), 1.5-lb/cu. ft. (24.0-kg/cu. m) fibrous glass.

L. Casing Insulation and Adhesive:

1. Materials: As directed, ASTM C1071, Type I or Type II.
2. Location and Application: Factory applied with adhesive and mechanical fasteners to the internal surface of section panels downstream from, and including, the heating-coil section.

M. Inspection and Access Panels and Access Doors: Formed and reinforced, single- or double-wall and insulated panels of same materials and thicknesses as casing.

2.4 ACCESSORIES

A. Service Platform: As directed, Steel, Galvanized steel, Aluminum, 42 inches (1070 mm) wide running entire length of unit and located on service access side, with angle side rails, 4-inch (100-mm) kick plates, and expanded metal floor. Provide platform with a fixed ladder that extends from the top of the side rail to the floor.

B. Electric heater with integral thermostat maintains minimum 50 deg F (10 deg C) temperature in gas burner compartment.

C. Coil guards of painted, galvanized-steel wire.

D. Hail guards of galvanized steel, painted to match casing.

2.5 OUTDOOR-AIR INTAKE HOOD

A. Type: Manufacturer's standard hood or louver.

B. Materials: Match cabinet.

C. Bird Screen: Comply with requirements in ASHRAE 62.1.

D. Filter: As directed, Aluminum, 1 inch (25 mm) or 2 inches (50 mm) cleanable.

E. Configuration: Designed to inhibit wind-driven rain and snow from entering unit.

2.6 ROOF CURBS

A. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.

1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
2. Thickness: As directed, 1 inch (25 mm), 1-1/2 inches (38 mm) or 2 inches (50 mm).

3. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.

    a. Liner Adhesive: Comply with ASTM C916, Type I.
    b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
    c. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
    d. Liner Adhesive: Comply with ASTM C916, Type I.

B. Curb Height: As directed, 14 inches (355 mm), 24 inches (610 mm) or 36 inches (910 mm).

2.7 SUPPLY-AIR FAN

A. Fan Type: As directed, Centrifugal, rated according to AMCA 210; statically and dynamically balanced, galvanized steel; mounted on solid-steel shaft with heavy-duty, self-aligning, permanently lubricated ball bearings, pillow-block bearings. Bearing rating: As directed, L10 of 60,000 hours, L10 of 120,000 hours or L10 of 150,000 hours.

B. Drive: V-belt drive with matching fan pulley and adjustable motor sheaves and belt assembly.

C. Mounting: As directed, Fan wheel, motor, and drives shall be mounted in fan casing with restrained, elastomeric or spring isolators.

D. Fan-Shaft Lubrication Lines: Extended to a location outside the casing.

2.8 AIR FILTERS

A. Comply with as directed, NFPA 90A or NFPA 90B.

B. Cleanable Filters: Cleanable metal mesh.

1. Thickness: As directed, 1 inch (25 mm) or 2 inches (50 mm).

C. Disposable Panel Filters: Factory-fabricated, flat-panel-type, disposable air filters with holding frames, with a MERV 6 according to ASHRAE 52.2.

2.9 DAMPERS

A. Outdoor-Air and Return-Air Damper: Galvanized-steel, opposed-blade dampers with vinyl blade seals and stainless-steel jamb seals, having a maximum leakage of 10 cfm/sq. ft. (51 L/s per sq. m) of damper area, at a differential pressure of 2-inch wg (448 Pa).

B. Damper Operator: Direct coupled, electronic with spring return or fully modulating as required by the control sequence.

2.10 DIRECT-FIRED GAS BURNER

A. Description: Factory assembled, piped, and wired; and complying with ANSI Z21.47, "Gas-Fired Central Furnaces," and with NFPA 54, "National Fuel Gas Code."

1. CSA Approval: Designed and certified by and bearing label of CSA.
2. Burners: As directed, Aluminized steel with stainless-steel inserts or Stainless steel.

    a. Gas Control Valve: As directed, Single stage, Two stage or Modulating.
    b. Fuel: As directed, Natural or Propane gas.
    c. Minimum Combustion Efficiency: 95 percent.
    d. Ignition: Electronically controlled electric spark with flame sensor.
    e. High-Altitude Model or Kit As directed: For Project elevation above sea level.

B. Safety Controls:

1. Vent Flow Verification: As directed, Differential pressure switch to verify open vent or Flame rollout switch.
2. Control Transformer: 24-V ac.
3. High Limit: Thermal switch or fuse to stop burner.
4. Gas Train: As directed, Regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, hydraulic or electronic-modulating temperature control valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.
5. Purge-period timer shall automatically delay burner ignition and bypass low-limit control.
6. Gas Manifold: Safety switches and controls complying with ANSI standards, FM Global or XL Insurance As directed.
7. Airflow Proving Switch: Differential pressure switch senses correct airflow before energizing pilot.
8. Automatic-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
9. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.

2.11 CONTROLS

A. Comply with requirements in Section 230900 "Instrumentation and Control for HVAC" and Section 230993 "Sequence of Operations for HVAC Controls" for control equipment and sequence of operation.

B. Control Devices:

1. Remote Thermostat: Adjustable room thermostat with temperature readout.
2. Remote Setback Thermostat: Adjustable room thermostat without temperature readout.
3. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
4. Fire-Protection Thermostats: Fixed or adjustable settings to operate at not less than 75 deg F (24 deg C) above normal maximum operating temperature.
5. Timers: Seven-day, programming-switch timer with synchronous-timing motor and seven-day dial; continuously charged, nickel-cadmium-battery-driven, eight-hour, power-

failure carryover; multiple-switch trippers; minimum of two and maximum of eight signals per day with two normally open and two normally closed output contacts.

6. Ionization-Type Smoke Detectors: 24-V dc, nominal; self-restoring; plug-in arrangement; integral visual-indicating light; sensitivity that can be tested and adjusted in place after installation; integral addressable module; remote controllability; responsive to both visible and invisible products of combustion; self-compensating for changes in environmental conditions.

C. Fan Control: Interlock fan to start with exhaust fan(s) to which this heating and ventilating unit is associated for makeup air.

D. Outdoor-Air Damper Control, 100 Percent Outdoor-Air Units: Outdoor-air damper shall open when supply fan starts, and close when fan stops.

E. Mixed Outdoor- and Return-Air Damper Control: When fan is running, outdoor- and return-air dampers shall modulate to supply minimum outdoor air as follows:

F. Temperature Control: Operates gas valve to maintain supply-air temperature.

1. Operates gas valve to maintain discharge-air temperature with factory-mounted sensor in blower outlet.
2. Timer shall select remote setback thermostat to maintain space temperature at 50 deg F (10 deg C).
3. Burner Control: Two or four steps of control using one or two burner sections in series.

2.12 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Enclosure: As directed, Open, dripproof, Totally enclosed, fan cooled, Totally enclosed, air over, Open, externally ventilated, Totally enclosed, nonventilated, Severe duty, Explosion proof or Dust-ignition-proof machine.
2. Enclosure Materials: As directed, Cast iron, Cast aluminum or Rolled steel.
3. Motor Bearings: As directed.
4. Unusual Service Conditions:

    a. Ambient Temperature: As directed.
    b. Altitude: Feet (m) above sea level as directed.
    c. High humidity.

    Efficiency: As directed, Premium efficient or EPAct compliant.
5. NEMA Design: As directed.
6. Service Factor: As directed.

2.13 CAPACITIES AND CHARACTERISTICS

A. Fan:

1. Discharge Configuration: As directed, Horizontal or Vertical.
2. Airflow in CFM (L/s): As directed.
3. External Static Pressure: As directed.
4. Maximum RPM: As directed.
5. Minimum Size: As directed.
6. Altitude: As directed.

B. Fan Motor:

1. Horsepower: As directed.
2. RPM: As directed.
3. Service Factor: As directed.
4. Speed: As directed, Single or Two.

C. Single-Point Electrical Connection:

1. Volts: As directed, 120, 240, 277 or 480.
2. Phase: As directed, Single or Three.
3. Hertz: 60.
4. Full-Load Amperes: As directed.
5. Minimum Circuit Ampacity: As directed.
6. Maximum Overcurrent Protection: As directed.

D. Direct-Fired Gas Burner:

1. Minimum Combustion Efficiency: As directed.
2. Entering-Air Temperature: As directed.
3. Leaving-Air Temperature: As directed.
4. Airflow: As directed.
5. Gas Input: As directed.
6. Burner Output: As directed.
7. Number of Stages: As directed.
8. Minimum Inlet Pressure: As directed.
9. Maximum Inlet Pressure: As directed.
10. Gas Piping Connection Size: As directed.
11. Vent Diameter: As directed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment Mounting:

1. Install heating and ventilating unit on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000

"Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" As directed.

2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

B. Unit Support: Install heating and ventilating unit level on structural curbs or pilings As directed. Coordinate wall penetrations and flashing with wall construction. Secure units to structural support with anchor bolts.

C. Install gas-fired units according to NFPA 54, "National Fuel Gas Code."

D. Install controls and equipment shipped by manufacturer for field installation with direct-fired heating and ventilating units.

E. Roof Curb: As directed, install on roof structure or concrete base, level and secure, according to NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts" or AHRI Guideline B. Install units on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 077200 "Roof Accessories." Secure units to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts.

F. Unit Support: As directed, Install unit level on structural curbs or pilings. Coordinate wall penetrations and flashing with wall construction. Secure units to structural support with anchor bolts.

3.2 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

1. Gas Piping: As directed, comply with requirements in Section 231123 "Facility Natural-Gas Piping" or Section 231126 "Facility Liquefied-Petroleum Gas Piping". Connect gas piping with shutoff valve and union, and with sufficient clearance for burner removal and service. Make final connections of gas piping to unit with corrugated, stainless-steel tubing flexible connectors complying with ANSI LC 1/CSA 6.26 equipment connections.

B. Drain: Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for traps and accessories on piping connections to condensate drain pans under condensing heat exchangers. Where installing piping adjacent to heating and ventilating units, allow space for service and maintenance.

C. Duct Connections: Connect supply and return ducts to direct-fired heating and ventilating units with flexible duct connectors. Comply with requirements in Section 233300 "Air Duct Accessories" for flexible duct connectors.

D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. Units will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.4 ADJUSTING

A. Adjust initial temperature set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

3.5 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain heating and ventilating units.

END OF SECTION 237423.13

SECTION 237423.16 - PACKAGED, INDIRECT-FIRED, OUTDOOR, HEATING-ONLY MAKEUP-AIR UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes indirect-fired makeup-air units.

1.2 ACTION SUBMITTALS

A. Product Data: For each type and configuration of outdoor, indirect-fired makeup-air unit.

B. Sustainable Design Submittals:

C. Shop Drawings: For each type and configuration of outdoor, indirect-fired heating and ventilating unit.

1. Include plans, elevations, sections, and mounting or attachment details As directed.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

1.3 INFORMATIONAL SUBMITTALS

A. Sample Warranty: For manufacturer's special warranty.

B. Seismic Qualification Certificates: For outdoor, indirect-fired makeup-air units, accessories, and components, from manufacturer.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Comply with NFPA 70.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of indirect-fired heating and ventilating units that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Heat Exchangers: As directed, Manufacturer's standard, but not less than five or 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 SYSTEM DESCRIPTION

A. Factory-assembled, prewired, self-contained unit consisting of cabinet, supply fan, controls, filters, and indirect-fired gas burner to be installed exterior to the building.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 UNIT CASINGS

A. General Fabrication Requirements for Casings:

1. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
2. Casing Joints: Sheet metal screws or pop rivets, factory sealed with water-resistant sealant.
3. Factory Finish for Steel and Galvanized-Steel Casings: Apply manufacturer's standard primer immediately after cleaning and pretreating.
4. Air-Handling-Unit Mounting Frame: Formed galvanized-steel channel or structural channel supports, designed for low deflection, welded with integral lifting lugs.

a. Seismic Fabrication Requirements: Fabricate mounting base and attachment to air-handling-unit sections, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC" when air-handling-unit frame is anchored to building structure.

5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. Configuration: As directed, Horizontal unit with top, horizontal or bottom discharge for roof-mounting or concrete-base installation.

C. Cabinet: As directed, Galvanized-steel, Aluminized- or galvanized-steel or Aluminized-steel panels, formed to ensure rigidity and supported by galvanized-steel channels or structural

channel supports with lifting lugs. Duct flanges at inlet and outlet. Pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.

D. Outer Casing: As directed, 0.0598-inch (1.519-mm), 0.0478-inch (1.214-mm) or 0.0359-inch (0.912-mm) thick steel with heat-resistant, baked-enamel, enamel-painted, baked-on, polyester-powder or unpainted over-corrosion-resistant-treated surface in color to match fan section.

E. Outer Casing: As directed, 0.0598-inch (1.519-mm), 0.0478-inch (1.214-mm) or 0.0359-inch (0.912-mm) thick steel with unpainted finish.

F. Outer Casing: 0.0359-inch (0.912-mm) thick steel with heat-resistant, baked-enamel over-corrosion-resistant-treated surface in color to match fan section.

G. Inner Casing:

1. Burner Section Inner Casing: 0.0299-inch- (0.759-mm-) thick steel.
2. Double-wall casing with inner wall of perforated or solid steel, for the following sections:

    a. Blower section.
    b. Filter section.
    c. Mixing box.
    d. Inlet plenum.
    e. Discharge plenum.
    f. As directed, access Doors or Panels: Lift out, Piano hinged with cam-lock fasteners or Hinged with handles for burner and fan motor assemblies on both sides of unit.

3. Internal Insulation: Fibrous-glass duct lining, neoprene coated, comply with ASTM C1071, Type II, applied on complete unit or burner and fan sections only.

    a. Thickness: As directed, 1 inch (25 mm) or 2 inches (50 mm).
    b. Insulation Adhesive: Comply with ASTM C916, Type I.
    c. Density: As directed, 1.5 lb/cu. ft. (24.0 kg/cu. m), 2.0 lb/cu. ft. (32.0 kg/cu. m) or 3.0 lb/cu. ft. (48.0 kg/cu. m).
    d. Mechanical Fasteners: Galvanized steel suitable for adhesive, mechanical, or welding attachment to casing without damaging liner when applied as recommended by manufacturer and without causing air leakage.

H. Discharge Section: As directed, Galvanized or Aluminized-steel assembly with gravity or individually adjustable, vaned, two-position, motorized, parallel-blade dampers with nylon bushings.

1. Pattern: As directed, Single or Double deflection.
2. Leakage: As directed, Standard or Low leakage.

I. Discharge Section: Trapezoidal cowls with horizontal louvers.

J. Discharge Section: As directed, Plenum with two or four sides louvered.

K. Discharge Section: Down-discharge plenum insulated with 1-inch (25-mm), 1.5-lb/cu. ft. (24.0-kg/cu. m) fibrous glass.

L. Casing Insulation and Adhesive:

1. Materials: As directed, ASTM C1071, Type I or Type II.
2. Location and Application: Factory applied with adhesive and mechanical fasteners to the internal surface of section panels downstream from, and including, the heating-coil section.

M. Inspection and Access Panels and Access Doors: As directed, fabricated with one or two percent slope in at least two planes to collect condensate from condensate-producing heat exchangers and from humidifiers, and to direct water toward drain connection; and complying with ASHRAE 62.1.

2.4 ACCESSORIES

A. Service Platform: As directed, Steel, Galvanized steel, Aluminum, 42 inches (1070 mm) wide running entire length of unit and located on service access side, with angle side rails, 4-inch (100-mm) kick plates, and expanded metal floor. Provide platform with a fixed ladder that extends from the top of the side rail to the floor.

2.5 OUTDOOR-AIR INTAKE HOOD

A. Type: Manufacturer's standard hood or louver.

B. Materials: Match cabinet.

C. Bird Screen: Comply with requirements in ASHRAE 62.1.

D. Filter: Aluminum, 1 inch (25 mm), cleanable.

E. Configuration: Designed to inhibit wind-driven rain and snow from entering unit.

2.6 ROOF CURBS

A. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.

1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
2. Thickness: As directed, 1 inch (25 mm), 1-1/2 inches (38 mm) or 2 inches (50 mm).
3. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.

B. Curb Height: As directed, 14 inches (355 mm), 24 inches (610 mm) or 36 inches (910 mm).

2.7 SUPPLY-AIR FAN

A. Fan Type: Centrifugal, rated according to AMCA 210; statically and dynamically balanced, galvanized steel; mounted on solid-steel shaft with heavy-duty, self-aligning, permanently

lubricated ball bearings, pillow-block bearings. Bearing rating: As directed, L10 of 60,000 hours, L10 of 120,000 hours or L10 of 150,000 hours.

B. Drive: V-belt drive with matching fan pulley and adjustable motor sheaves and belt assembly.

C. Mounting: Fan wheel, motor, and drives shall be mounted in fan casing with restrained, elastomeric or spring isolators.

D. Fan-Shaft Lubrication Lines: Extended to a location outside the casing.

2.8 AIR FILTERS

A. Comply with NFPA 90A or NFPA 90B as directed.

B. Cleanable Filters: Cleanable metal mesh.

1. Thickness: As directed, 1 inch (25 mm) or 2 inches (50 mm).

C. Disposable Panel Filters: Factory-fabricated, flat-panel-type, disposable air filters with holding frames, with a MERV 6 according to ASHRAE 52.2.

2.9 DAMPERS

A. Outdoor-Air and Return-Air Damper: Galvanized-steel, opposed-blade dampers with vinyl blade seals and stainless-steel jamb seals, having a maximum leakage of 10 cfm/sq. ft. (51 L/s per sq. m) of damper area, at a differential pressure of 2-inch wg (448 Pa).

B. Damper Operator: Direct coupled, electronic with spring return or fully modulating as required by the control sequence.

2.10 INDIRECT-FIRED GAS BURNER

A. Description: Factory assembled, piped, and wired; and complying with ANSI Z21.47, "Gas-Fired Central Furnaces," and with NFPA 54, "National Fuel Gas Code."

1. CSA Approval: Designed and certified by and bearing label of CSA.
2. Burners: Aluminized steel with stainless-steel inserts or Stainless steel.

a. Gas Control Valve: As directed, Single stage, Two stage or Modulating.
b. Fuel: As directed, Natural or Propane gas.
c. Minimum Combustion Efficiency: 80 percent.
d. Ignition: Electronically controlled electric spark with flame sensor.
e. High-Altitude As directed, Model or Kit: For Project elevation above sea level.

B. Venting: Gravity vented.

C. Venting: Power vented, with integral, motorized centrifugal fan interlocked with gas valve.

D. Combustion-Air Intake: Separate combustion-air intake and vent terminal assembly.

E. Heat Exchanger: As directed, Aluminized or Stainless steel.

F. Heat-Exchanger Drain Pan: Stainless steel.

G. Safety Controls:

1. Vent Flow Verification: As directed, Differential pressure switch to verify open vent or Flame rollout switch.
2. Control Transformer: 24-V ac.
3. High Limit: Thermal switch or fuse to stop burner.
4. Gas Train: As directed, Regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, hydraulic or electronic-modulating temperature control valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.
5. Purge-period timer shall automatically delay burner ignition and bypass low-limit control.
6. Gas Manifold: As directed, Safety switches and controls complying with ANSI standards and FM Global or XL Insurance.
7. Airflow Proving Switch: Differential pressure switch senses correct airflow before energizing pilot.
8. Automatic-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
9. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.

2.11 UNIT CONTROL PANEL

A. Factory-wired, fuse-protected control transformer, connection for power supply and field-wired unit to remote control panel.

B. Control Panel: As directed, Surface-mounted or Recessed, with trim ring, remote panel, with engraved plastic cover and the following lights and switches:

1. As directed, On-off or On-off-auto fan switch.
2. Heat-vent-off switch.
3. Supply-fan operation indicating light.
4. Heating operation indicating light.
5. Thermostat.
6. Damper position potentiometer.
7. Dirty-filter indicating light operated by unit-mounted differential pressure switch.
8. Safety-lockout indicating light.
9. Enclosure: As directed, NEMA 250, Type 1, Type 3R, Type 4 or Explosion proof.

2.12 CONTROLS

A. Control Devices:

1. Remote Thermostat: Adjustable room thermostat with temperature readout.
2. Remote Setback Thermostat: Adjustable room thermostat without temperature readout.

3. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
4. Fire-Protection Thermostats: Fixed or adjustable settings to operate at not less than 75 deg F (24 deg C) above normal maximum operating temperature.
5. Timers: Seven-day, programming-switch timer with synchronous-timing motor and seven-day dial; continuously charged, nickel-cadmium-battery-driven, eight-hour, power-failure carryover; multiple-switch trippers; minimum of two and maximum of eight signals per day with two normally open and two normally closed output contacts.
6. Ionization-Type Smoke Detectors: 24-V dc, nominal; self-restoring; plug-in arrangement; integral visual-indicating light; sensitivity that can be tested and adjusted in place after installation; integral addressable module; remote controllability; responsive to both visible and invisible products of combustion; self-compensating for changes in environmental conditions.

B. Fan Control: Interlock fan to start with exhaust fan(s) to which this heating and ventilating unit is associated for makeup air.

1. Smoke detectors, located in supply and return air, shall stop fans when the presence of smoke is detected.

C. Outdoor-Air Damper Control, 100 Percent Outdoor-Air Units: Outdoor-air damper shall open when supply fan starts, and close when fan stops.

D. Mixed Outdoor- and Return-Air Damper Control: When fan is running, outdoor- and return-air dampers shall modulate to supply minimum outdoor air as follows:

E. Temperature Control: Operates gas valve to maintain supply-air temperature.

1. Operates gas valve to maintain discharge-air temperature with factory-mounted sensor in blower outlet.
2. Timer shall select remote setback thermostat to maintain space temperature at 50 deg F (10 deg C).
3. Burner Control: Two or four steps of control using one or two burner sections in series.
4. Burner Control: 20 to 100 percent modulation of the firing rate. 10 to 100 percent with dual burner units.

2.13 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Enclosure: As directed Open, dripproof, Totally enclosed, fan cooled, Totally enclosed, air over, Open, externally ventilated, Totally enclosed, nonventilated, Severe duty, Explosion proof or Dust-ignition-proof machine.
2. Enclosure Materials: As directed Cast iron, Cast aluminum or Rolled steel.
3. Motor Bearings: As directed.
4. Unusual Service Conditions:

a. Ambient Temperature: As directed.

b. Altitude: Feet (m) above sea level as directed.
c. High humidity.

5. Efficiency: As directed Premium efficient or EPAct compliant.
6. NEMA Design: As directed.
7. Service Factor: As directed.

2.14 CAPACITIES AND CHARACTERISTICS

A. Fan:

1. Discharge Configuration: As directed Horizontal or Vertical.
2. Airflow in CFM (L/s): As directed.
3. External Static Pressure: As directed.
4. Maximum RPM: As directed.
5. Minimum Size: As directed.
6. Altitude: As directed.

B. Fan Motor:

1. Horsepower: As directed.
2. RPM: As directed.
3. Service Factor: As directed.
4. Speed: As directed Single or Two.

C. Single-Point Electrical Connection:

1. Volts: As directed 120, 240, 277 or 480.
2. Phase: As directed Single or Three.
3. Hertz: 60.
4. Full-Load Amperes: As directed.
5. Minimum Circuit Ampacity: As directed.
6. Maximum Overcurrent Protection: As directed.

D. Indirect-Fired Gas Burner:

1. Minimum Combustion Efficiency: Percent As directed.
2. Entering-Air Temperature: As directed.
3. Leaving-Air Temperature: As directed.
4. Airflow: As directed.
5. Gas Input: As directed.
6. Burner Output: As directed.
7. Number of Stages: As directed.
8. Minimum Inlet Pressure: As directed.
9. Maximum Inlet Pressure: As directed.
10. Gas Piping Connection Size: As directed.
11. Vent Diameter: As directed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment Mounting:

1. Install heating and ventilating units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" As directed
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

B. Unit Support: As directed Install heating and ventilating unit level on structural curbs or pilings. Coordinate wall penetrations and flashing with wall construction. Secure units to structural support with anchor bolts.

C. Install gas-fired units according to NFPA 54, "National Fuel Gas Code."

D. Install controls and equipment shipped by manufacturer for field installation with indirect-fired heating and ventilating units.

E. Roof Curb: As directed Install on roof structure or concrete base, level and secure, according to NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts" or ARI Guideline B. Install units on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 077200 "Roof Accessories." Secure units to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts.

F. Unit Support: As directed Install unit level on structural curbs or pilings. Coordinate wall penetrations and flashing with wall construction. Secure units to structural support with anchor bolts.

3.2 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

1. Gas Piping: As directed Comply with requirements in Section 231123 "Facility Natural-Gas Piping" or Section 231126 "Facility Liquefied-Petroleum Gas Piping." Connect gas piping with shutoff valve and union, and with sufficient clearance for burner removal and service. Make final connections of gas piping to unit with corrugated, stainless-steel tubing flexible connectors complying with ANSI LC 1/CSA 6.26 equipment connections.

B. Drain: Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for traps and accessories on piping connections to condensate drain pans under condensing heat exchangers. Where installing piping adjacent to heating and ventilating units, allow space for service and maintenance.

C. Duct Connections: Connect supply and return ducts to indirect-fired heating and ventilating units with flexible duct connectors. Comply with requirements in Section 233300 "Air Duct Accessories" for flexible duct connectors.

D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections with the assistance of a factory-authorized service representative.

C. Units will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.4 ADJUSTING

A. Adjust initial temperature set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

3.5 DEMONSTRATION

A. As directed Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain heating and ventilating units.

END OF SECTION 237423.16

SECTION 237433 - DEDICATED OUTDOOR-AIR UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes factory-packaged units capable of supplying up to 100 percent outdoor air and providing cooling only and heating.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

C. Shop Drawings: Include plans, elevations, sections, and attachment details.

D. Delegated-Design Submittal: For design of vibration isolation, seismic restraints and, wind restraints, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Roof-curb mounting details, drawn to scale, and coordinated with each other, using input from installers of the items involved:

B. Seismic Qualification Certificates: For dedicated outdoor-air units, accessories, and components, from manufacturer.

C. Startup service reports.

D. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to replace components of units that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: Five years from date of Substantial Completion.
2. Warranty Period for Heat Exchangers: As directed, Five or 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. General Fabrication Requirements: Comply with requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Start-up."

B. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation, seismic restraints, and, wind restraints As directed.

C. Seismic Performance: Units shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

D. Wind-Restraint Performance:

1. Basic Wind Speed: As directed.
2. Building Classification Category: As directed, I, II, III or IV.
3. Minimum 10 lb/sq. ft (48.8 kg/sq. m) multiplied by the maximum area of unit projected on a vertical plane that is normal to the wind direction and 45 degrees either side of normal.

E. Cabinet Thermal Performance:

1. Maximum Overall U-Value: Comply with requirements in ASHRAE/IESNA 90.1.
2. Maximum Overall U-Value: 0.10 Btu/h x sq. ft. x deg F (0.57 W/sq. m x deg K).
3. Include effects of metal-to-metal contact and thermal bridges in the calculations.

F. Cabinet Surface Condensation:

1. Cabinet shall have additional insulation and vapor seals if required to prevent condensation on the interior and exterior of the cabinet.
2. Portions of cabinet located downstream from the cooling coil shall have a thermal break at each thermal bridge between the exterior and interior casing to prevent condensation from occurring on the interior and exterior surfaces. The thermal break shall not compromise the structural integrity of the cabinet.

G. Maximum Cabinet Leakage: As directed, 0.5, 1 or 2 percent of the total supply-air flow at a pressure rating equal to the fan shut-off pressure.

H. Cabinet Deflection Performance:

1. As directed, Walls and roof deflection shall be within 1/200 or 1/240 of the span at the design working pressure equal to the fan shut-off pressure. Deflection limits shall be measured at any point on the surface.
2. As directed, Floor deflections shall be within 1/240, 1/300 or 1/360 of the span considering the worst-case condition caused by the following:

    a. Service personnel.
    b. Internal components.
    c. Design working pressure defined for the walls and roof.

I. Electrical components, devices, and accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

J. Capacities and Characteristics:

1. Supply Airflow: As directed.
2. External Static Pressure: As directed.
3. Supply Fan:

    a. Size: As directed.
    b. Speed: As directed.
    c. Brake Horsepower: As directed.

4. Supply Fan Motor:

    a. Size: As directed.
    b. Speed: As directed.
    c. Volts: As directed, 120, 208, 230 or 460.
    d. Phase: As directed, Single or Three.
    e. Hertz: 60.

5. Refrigerant Cooling:

    a. Capacity: As directed.
    b. Full-Load Efficiency (EER or COP): As directed.
    c. Condenser Ambient-Air Temperature: As directed.
    d. Evaporator Coil:

        1) Sensible Heat-Transfer Rate: As directed.
        2) Total Heat-Transfer Rate: As directed.
        3) Entering-Air, Dry-Bulb Temperature: As directed.
        4) Entering-Air, Wet-Bulb Temperature: As directed.
        5) Leaving-Air, Dry-Bulb Temperature: As directed.
        6) Leaving-Air, Wet-Bulb Temperature: As directed.
        7) Face Area: As directed.
        8) Maximum Face Velocity: As directed.
        9) Maximum Air-Side, Static-Pressure Drop: As directed.
        10) Fin Spacing: As directed.
        11) Fin Thickness: As directed.
        12) Number of Rows: As directed.

6. Electric-Resistance Heating Coils:

    a. Heat-Transfer Rate: As directed.
    b. Entering-Air Temperature: As directed.
    c. Leaving-Air Temperature: As directed.
    d. Power Input: As directed.
    e. Volts: As directed, 120, 208, 230 or 480.
    f. Phase: As directed, Single or Three.
    g. Hertz: 60.
    h. Full-Load Amperes: As directed.
    i. Maximum Overcurrent Protection: As directed.
    j. Capacity Control Number of Steps: As directed.

7. Gas-Fired Furnace Heating:

    a. Heat-Transfer Rate: As directed.
    b. Entering-Air Temperature: As directed.
    c. Leaving-Air Temperature: As directed.
    d. Efficiency: 80 percent.
    e. Fuel: As directed, Natural or Propane gas.
    f. Gas Heating Value: As directed.
    g. Gas Input: As directed.
    h. Gas Burner Electrical Characteristics:

        1) Power Input: As directed.
        2) Volts: As directed, 120, 208, 230 or 460.
        3) Phase: As directed, Single or Three.
        4) Hertz: 60.
        5) Full-Load Amperes: As directed.
        6) Minimum Circuit Ampacity: As directed.
        7) Maximum Overcurrent Protection: As directed.

8. Hot-Water Heating Coils:

    a. Heat-Transfer Rate: As directed.
    b. Entering-Air Temperature: As directed.
    c. Leaving-Air Temperature: As directed.
    d. Face Area: As directed.
    e. Maximum Face Velocity: As directed.
    f. Maximum Air-Side, Static-Pressure Drop: As directed.
    g. Coil Type: As directed, Continuous circuit, Self-draining or Cleanable.
    h. Piping Connections: As directed, Threaded, Flanged; same end or opposite ends of coil.
    i. Tube Thickness: As directed.
    j. Fin Spacing: As directed.
    k. Fin Thickness: As directed.
    l. Number of Rows: As directed.
    m. Coil Working-Pressure Ratings: 200 psig (1380 kPa), 325 deg F (163 deg C).
    n. Fluid Flow: As directed.
    o. Maximum Fluid-Pressure Drop: As directed.
    p. Entering-Fluid Temperature: As directed.

q. Leaving-Fluid Temperature: As directed.
r. Fluid Velocity: As directed.

9. Overall Unit Electrical Characteristics:

a. Volts: As directed, 120, 208, 230 or 460.
b. Phase: As directed, Single or Three.
c. Hertz: 60.
d. Full-Load Amperes: As directed.
e. Minimum Circuit Ampacity: As directed.
f. Maximum Overcurrent Protection: As directed.

2.3 CABINET

A. Construction: Single or double wall.

B. Exterior Casing Material: Galvanized steel with paint finish or stainless steel.

C. Interior Casing Material: As directed, Galvanized or stainless steel.

D. Lifting and Handling Provisions: Factory-installed shipping skids and lifting lugs.

E. Base Rails: As directed, Galvanized or Stainless-steel rails for mounting on roof curb or pad as indicated.

F. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.

1. Service Doors: Hinged access doors with gaskets. Material and construction of doors shall match material and construction of cabinet in which doors are installed.

G. Roof: Standing seam or membrane; sloped to drain water.

H. Floor: Reinforced, metal surface; reinforced to limit deflection when walked on by service personnel. Insulation shall be below metal walking surface.

I. Cabinet Insulation:

1. Type: Fibrous-glass duct lining complying with ASTM C1071, Type II or flexible elastomeric insulation complying with ASTM C534, Type II, sheet materials.
2. Thickness: As directed, 1 inch (25 mm) or 2 inches (50 mm).
3. Insulation Adhesive: Comply with ASTM C916, Type I.
4. Mechanical Fasteners: Suitable for adhesive, mechanical, or welding attachment to casing without damaging liner and without causing air leakage when applied as recommended by manufacturer.

J. Condensate Drain Pans:

1. Shape: As directed, Rectangular, with 1 or 2 percent slope in at least two planes to direct water toward drain connection.

2. Size: Large enough to collect condensate from cooling coils including coil piping connections, coil headers, and return bends.

    a. Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
    b. Depth: A minimum of 2 inches (50 mm) deep.

3. Configuration: Single wall.
4. Configuration: Double wall, with space between walls filled with foam insulation and moisture-tight seal.
5. Material: Galvanized-steel sheet with asphaltic waterproofing compound coating on pan top surface.
6. Material: Stainless-steel sheet.
7. Drain Connection:

    a. As directed, located on one end or both ends of pan, at lowest point of pan.
    b. Terminated with threaded nipple.
    c. Minimum Connection Size: As directed, NPS 1 (DN 25) or NPS 2 (DN 50).

8. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

K. Surfaces in Contact with Airstream: Comply with requirements in ASHRAE 62.1 for resistance to mold and erosion.

L. Roof Curb: As directed, Full-perimeter curb of sheet metal, minimum 8 inches (200 mm), 12 inches (300 mm) or 16 inches (400 mm) high, with wood nailer, neoprene sealing strip, and welded Z-bar flashing.

1. Comply with requirements in "The NRCA Roofing Manual."

2.4 SUPPLY FAN

A. Forward-Curved Fan Type: Centrifugal; statically and dynamically balanced.

1. Fan Wheel Material: As directed, Galvanized, Painted or Coated steel, mounted on solid-steel shaft.
2. Bearings: As directed, Self-aligning, permanently lubricated ball bearings or Pillow-block bearings rated L_{50} for 200,000 hours and having external grease fittings.

B. Plenum Fan Type: Single width, non-overloading, with backward-inclined or airfoil blades.

1. Fan Wheel Material: Aluminum; attached directly to motor shaft.
2. Fan Wheel Drive and Arrangement: Direct drive, AMCA Arrangement 4.
3. Fan panel and frame Material: Powder-coated steel, stainless steel, or aluminum.
4. Fan Enclosure: Easily removable enclosure around rotating parts.
5. Fan Balance: Precision balance fan below 0.08 inch/s (2.0 mm/s) at design speed with filter in.

C. Service Factor for Belt Drive Applications: Multiple V-belt drive with matching fan pulley and adjustable motor sheaves and belt assembly with minimum 1.4, 1.5 or 2.0 service factor As directed.

D. Motors:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Enclosure: As directed, Open dripproof or Totally enclosed.
3. Enclosure Materials: As directed, Cast iron, Cast aluminum or Rolled steel.
4. Motor Bearings: As directed.
5. Unusual Service Conditions:

    a. Ambient Temperature: As directed.
    b. Altitude: Feet (m) above sea level As directed.
    c. High humidity.

6. Efficiency: Premium efficient.
7. NEMA Design: As directed.
8. Service Factor: As directed, 1.0 or 1.15.

E. Mounting: As directed, Fan wheel, motor, and drives shall be mounted to fan casing with restrained, elastomeric or spring isolators.

2.5 COOLING COILS

A. Capacity Ratings: Comply with ASHRAE 33 and ARI 410 and coil bearing the ARI label.

B. Coil Casing Material: As directed, Manufacturer's standard material, Aluminum, Galvanized steel or Stainless steel.

C. Tube Material: Copper.

D. Tube Header Material: As directed, Manufacturer's standard material, Copper, Carbon steel or Red brass.

E. Fin Material: As directed, Aluminum or Copper.

F. Fin and Tube Joints: Mechanical bond.

G. Leak Test: Coils shall be leak tested with air underwater.

H. Refrigerant Coil Capacity Reduction: As directed, Circuit coils for face, row or interleaved control.

I. Refrigerant Coil Suction and Distributor Header Materials: Seamless copper tube with brazed joints.

J. Coating: Corrosion-resistant coating after assembly.

2.6 REFRIGERATION SYSTEM

A. Comply with requirements in ASHRAE 15, "Safety Standard for Refrigeration Systems."

B. Refrigerant Charge: Factory charged with refrigerant and filled with oil.

C. Compressors: As directed, Scroll or Reciprocating or scroll compressors with integral vibration isolators, internal overcurrent and overtemperature protection, internal pressure relief, and crankcase heater.

D. Refrigerant: As directed, R-134a, R-407C, R-410A or HFC refrigerant.

1. Classified as Safety Group A1 according to ASHRAE 34.
2. Provide unit with operating charge of refrigerant.

E. Refrigeration System Specialties:

1. Expansion valve with replaceable thermostatic element.
2. Refrigerant dryer.
3. High-pressure switch.
4. Low-pressure switch.
5. Thermostat for coil freeze-up protection during low ambient temperature operation or loss of air.
6. Brass service valves installed in discharge and liquid lines.

F. Capacity Control:

1. Hot-gas bypass refrigerant control for capacity control with continuous dehumidification on a single compressor.
2. Patented, Rawal APR control with zero to 100 percent modulating capacity control using hot-gas bypass. Evaporator coil shall be continuously active for dehumidification.
3. Single compressor with evaporator and condenser coil within the refrigerant section to provide initial pre-cooling and to reheat for humidity control.
4. Heat-pipe heat exchanger wrapped around the evaporator coil to pre-cool the air entering the evaporator coil and reheat the air leaving the evaporator coil to control humidity.

G. Refrigerant condenser and reheat condenser coils:

1. Capacity Ratings: Complying with ASHRAE 33 and ARI 410 and coil bearing the ARI label.
2. Tube Material: Copper.
3. Fin Material: As directed, Aluminum or Copper.
4. Fin and Tube Joint: Mechanical bond.
5. Leak Test: Coils shall be leak tested with air underwater.
6. Coating: Corrosion-resistant coating after assembly.

H. Condenser Fan Assembly:

1. Fans: Direct-drive propeller type with statically and dynamically balanced fan blades.
2. Fan Motors:

a. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
b. Motor Enclosure: Totally enclosed non-ventilating (TENV) or totally enclosed air over (TEAO) enclosure.
c. Enclosure Materials: As directed, Cast iron, Cast aluminum or Rolled steel.
d. Motor Bearings: Permanently lubricated bearings.
e. Unusual Service Conditions:

1) Ambient Temperature: As directed.
2) Altitude: Feet (m) above sea level as directed.
3) High humidity.

f. Built-in overcurrent and thermal-overload protection.
g. Efficiency: Premium efficient.
h. NEMA Design: As directed.
i. Service Factor: As directed.

3. Fan Safety Guards: Steel with corrosion-resistant coating.

I. Safety Controls:

1. Compressor motor and condenser coil fan motor low ambient lockout.
2. Overcurrent protection for compressor motor.

2.7 ELECTRIC-RESISTANCE HEATING COIL

A. UL Compliance: Comply with requirements in UL 1995, "Heating and Cooling Equipment."

B. Electric-Resistance Heating Elements:

1. Coiled Resistance Wire: 80 percent nickel and 20 percent chromium.
2. Tubular-Steel Sheath: Compacted magnesium oxide powder.
3. Fins: Spiral-wound, copper-plated, steel fins continuously brazed to sheath.
4. Heating Capacity: Low density 35 W per sq. in. (54 kW per sq. m), factory wired for single-point wiring connection; with time delay for element staging and overcurrent- and overheat-protection devices.
5. Safety Controls:

a. Blower-motor interlock, air-pressure switch.
b. Quiet mercury contactors.
c. Time delay between steps.
d. Integral, nonfused power disconnect switch.

C. Electric-Resistance Heating Elements:

1. Open-Coil Resistance Wire: 80 percent nickel and 20 percent chromium.
2. Supports and Insulation: Floating ceramic bushings recessed into casing openings; fastened to supporting brackets and mounted in galvanized-steel frame.

3. Heating Capacity: Low density 35 W per sq. in. (54 kW per sq. m), factory wired for single-point wiring connection; with time delay for element staging and overcurrent- and overheat-protection devices.
4. Safety Controls:

    a. Blower-motor interlock, air-pressure switch.
    b. Quiet mercury contactors.
    c. Time delay between steps.
    d. Integral, nonfused power disconnect switch.

2.8 INDIRECT-FIRED GAS FURNACE HEATING

A. Furnace Assembly:

1. Factory assembled, piped, and wired.
2. Comply with requirements in NFPA 54, "National Fuel Gas Code," and ANSI Z21.47, "Gas-Fired Central Furnaces."
3. AGA Approval: Designed and certified by and bearing label of AGA.

B. Burners:

1. Heat-Exchanger Material: As directed, Aluminized steel with stainless-steel inserts or Stainless steel with a minimum thermal efficiency of 80 percent.
2. Fuel: As directed, Natural or Propane gas.
3. Ignition: Electronically controlled electric spark with flame sensor.
4. High-Altitude As directed, Model or Kit: For Project elevations more than 2000 feet (610 m) above sea level.

C. Heat-Exchanger Drain Pan Material: Stainless steel.

D. Venting: Gravity vented.

E. Venting: Power vent with integral, motorized centrifugal fan interlocked with gas valve.

F. Safety Controls:

1. Gas Control Valve: As directed, Single stage, Two stage or Electronic modulating.
2. Gas Train: Single-body, regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff.

2.9 HOT-WATER HEATING COIL

A. Capacity Ratings: Comply with ASHRAE 33 and ARI 410 and coil bearing the ARI label.

B. Coil Casing Material: As directed, Manufacturer's standard material, Aluminum, Galvanized steel or Stainless steel.

C. Tube Material: Copper.

D. Tube Header Material: As directed, Manufacturer's standard material, Copper, Carbon steel or Red brass.

E. Fin Material: As directed, Aluminum or Copper.

F. Fin and Tube Joints: Mechanical bond.

G. Leak Test: Coils shall be leak tested with air underwater.

H. Coating: Corrosion-resistant coating after assembly.

2.10 CORROSION-RESISTANT COATINGS

A. Corrosion-Resistant Coating: Coat coils and fan guards with a corrosion-resistant coating capable of withstanding a 3,000-hour salt-spray test according to ASTM B117.

1. Standards:

   a. ASTM B117 for salt spray.
   b. ASTM D2794 for minimum impact resistance of 100 in-lb (11.3 N-m)
   c. ASTM D3359 for cross hatch adhesion of 5B.

2. Application: As directed, Immersion or Spray.
3. Thickness: 1 mil.
4. Gloss: Minimum gloss of 50 gloss units on a single angle 60-degree meter.
5. UV Protection: Spray applied topcoat.

2.11 OUTDOOR-AIR INTAKE HOOD

A. Type: Manufacturer's standard hood or louver.

B. Materials: Match cabinet.

C. Bird Screen: Comply with requirements in ASHRAE 62.1.

D. Configuration: Designed to inhibit wind-driven rain and snow from entering unit.

2.12 FILTERS

A. Cleanable Filters: 2-inch- (50-mm-) thick, cleanable metal mesh.

B. Disposable Panel Filters:

1. Comply with NFPA 90A.
2. Factory-fabricated, viscous-coated, flat-panel type.
3. Thickness: As directed, 1 inch (25 mm) or 2 inches (50 mm).
4. Initial Resistance: As directed.
5. Recommended Final Resistance: As directed.
6. Minimum Arrestance: 80, according to ASHRAE 52.1.

7. Minimum MERV: 6, according to ASHRAE 52.2.
8. Media: Interlaced glass fibers sprayed with nonflammable adhesive and antimicrobial agent.

C. Extended-Surface, Disposable Panel Filters:

1. Comply with NFPA 90A.
2. Factory-fabricated, dry, extended-surface type.
3. Thickness: As directed, 1 inch (25 mm), 2 inches (50 mm) or 4 inches (100 mm).
4. Initial Resistance: As directed.
5. Recommended Final Resistance: As directed.
6. Minimum Arrestance: 90, according to ASHRAE 52.1.
7. Minimum MERV: 7, according to ASHRAE 52.2.
8. Media: Fibrous material formed into deep-V-shaped pleats with antimicrobial agent and held by self-supporting wire grid.

D. Extended-Surface, Nonsupported-Media Filters:

1. Comply with NFPA 90A.
2. Factory-fabricated, dry, extended-surface, self-supporting type.
3. Initial Resistance: As directed.
4. Recommended Final Resistance: As directed.
5. Minimum Arrestance: 95, according to ASHRAE 52.1.
6. Minimum MERV: 13, according to ASHRAE 52.2.
7. Media: Fibrous material coated with an antimicrobial agent and constructed so individual pleats are maintained in tapered form by flexible internal supports under rated-airflow conditions.

E. Mounting Frames:

1. Panel filters arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or from access plenum.
2. Extended surface filters arranged for flat orientation, removable from access plenum.
3. Galvanized or stainless steel with gaskets and fasteners, suitable for bolting together into built-up filter banks with space for prefilter.

2.13 ELECTRICAL POWER CONNECTIONS

A. General Electrical Power Connection Requirements: Factory-installed and -wired switches, motor controllers, transformers, and other necessary electrical devices shall provide a single-point field power connection to unit.

B. Enclosure: NEMA 250, As directed, Type 3R, Type 4 or Type 4X, mounted in unit with hinged access door in unit cabinet having a lock and key or padlock and key,

C. Wiring: Numbered and color-coded to match wiring diagram.

D. Wiring Location: Install factory wiring outside an enclosure in a raceway.

E. Power Interface: As directed, Field power interface shall be to wire lugs or NEMA KS 1, heavy-duty, nonfused disconnect switch.

F. Factory Wiring: Branch power circuit to each motor and to controls with one of the following disconnecting means:

1. NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
2. NEMA KS 1, heavy-duty, nonfusible switch.
3. UL 489, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

G. Factory-Mounted, Overcurrent-Protection Service: For each motor.

H. Transformer: Factory mounted with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.

I. Controls: Factory wire unit-mounted controls where indicated.

J. Lights: Factory wire unit-mounted lights.

K. Receptacle: Factory wire unit-mounted, ground fault interrupt (GFI) duplex receptacle.

L. Control Relays: Auxiliary and adjustable time-delay relays.

2.14 CONTROLS

A. Control equipment and sequence of operation are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."

B. Control Valves: Comply with requirements in Section 230923.11 "Control Valves."

C. Control Wiring: Factory wire connection for controls' power supply.

D. Control Devices: Sensors, transmitters, relays, switches, detectors, operators, actuators, and valves shall be manufacturer's standard items to accomplish indicated control functions.

E. As directed, Remote or Unit-Mounted Status Panel:

1. Cooling/Off/Heating Controls: Control operational mode.
2. Damper Position: Indicate position of outdoor-air dampers in terms of percentage of outdoor air.
3. Status Lights:

    a. Filter dirty.
    b. Fan operating.
    c. Cooling operating.
    d. Heating operating.
    e. Smoke alarm.
    f. General alarm.

4. Digital Numeric Display:

    a. Outdoor airflow.
    b. Supply airflow.
    c. Outdoor dry-bulb temperature.
    d. Outdoor dew point temperature.
    e. Space temperature.
    f. Supply temperature.
    g. Space relative humidity.
    h. Space carbon dioxide level

F. Control Dampers:

1. Damper Location: Factory installed inside unit for ease of blade axle and bushing service. Arrange dampers located in a mixing box to achieve convergent airflow to minimize stratification.
2. Damper Leakage: Comply with requirements in AMCA 500-D. Leakage shall not exceed 6.5 cfm per sq. ft. (33 L/s per sq. m) at a static-pressure differential of 4.0 inches water column (1000 Pa) when a torque of 5 inch pounds per sq. ft. (30.1 Newton meters per sq. m) is applied to the damper jackshaft.
3. Damper Rating: Rated for close-off pressure equal to the fan shutoff pressure.
4. Damper Label: Bear the AMCA seal for both air leakage and performance.
5. Blade Configuration: Unless otherwise indicated, use parallel blade configuration for two-position control and equipment isolation service and use modulating control when mixing two airstreams. For other applications, use an opposed-blade configuration.
6. Damper Frame Material: As directed, Extruded aluminum, galvanized steel or stainless steel.
7. Blade Type: Single-thickness metal reinforced with multiple V-grooves or hollow-shaped airfoil.
8. Blade Material: As directed, Extruded aluminum, galvanized steel or stainless steel.
9. Maximum Blade Width: 6 inches (150 mm).
10. Maximum Blade Length: 48 inches (1200 mm).
11. Blade Seals: Replaceable, continuous perimeter vinyl seals and jambs with stainless-steel compression-type seals.
12. Bearings: Thrust bearings for vertical blade axles.
13. Airflow Measurement:

    a. Monitoring System: Complete and functioning system of airflow monitoring as an integral part of the damper assembly where indicated.
    b. Remote Monitoring Signal: 0-10 volt or 4-20 mA scaled signal.
    c. Accuracy of flow measurement: As directed, Within 5 or 10 percent of the actual flow rate between the range of the scheduled minimum and maximum airflow. For units with a large range between minimum and maximum airflow, configure the damper sections and flow measurement assembly as necessary to comply with accuracy.
    d. Straightening Device: Integral to the flow measurement assembly if required to achieve the specified accuracy as installed.
    e. Flow measuring device: Suitable for operation in untreated and unfiltered outdoor air. If necessary, include temperature and altitude compensation and correction to maintain the accuracy.

G. Damper Operators:

1. Factory-installed electric operator for each damper assembly with one operator for each damper assembly mounted to the damper frame.
2. Operator capable of shutoff against fan pressure and able to operate the damper with sufficient reserve power to achieve smooth modulating action and proper speed of response at the velocity and pressure conditions to which the damper is subjected.
3. Maximum Operating Time: As directed, Open or close damper 90 degrees in 60 or 90 seconds.
4. Adjustable Stops: For both maximum and minimum positions.
5. Position Indicator and Graduated Scale: Factory installed on each actuator with words "OPEN" and "CLOSED," or similar identification, at travel limits.
6. Spring-return operator to fail-safe; either closed or open as required by application.
7. Operator Type: Direct coupled, designed for minimum 60,000 full-stroke cycles at rated torque.
8. Position feedback Signal: For remote monitoring of damper position.
9. Coupling: V-bolt and V-shaped, toothed cradle.
10. Circuitry: Electronic overload or digital rotation-sensing circuitry.

H. Refrigeration System Controls:

1. Unit-mounted enthalpy controller shall lock out refrigerant system when outdoor-air enthalpy is less than 28 Btu/lb (65 kJ/kg) of dry air or outdoor-air temperature is less than 60 deg F (15 deg C).
2. Outdoor-air sensor de-energizes dehumidifier operation when outdoor-air temperature is less than 60 deg F (15 deg C).
3. Relative-humidity sensor energizes dehumidifier operation when relative humidity is more than 50 percent.

I. Furnace Controls:

1. As directed, Factory-mounted sensor in supply outlet or Remote sensor for field installation in supply-air duct with sensor adjustment located in control panel to modulate gas furnace burner to maintain space temperature.
2. As directed, Wall-mounted, space-temperature sensor with temperature adjustment, unit-mounted temperature adjustment or adjustment on remote-control panel to modulate gas furnace burner to maintain space temperature.
3. Remote Setback: Adjustable room thermostat selected by timer, set at 50 deg F (10 deg C); cycles supply fan and gas furnace burner to maintain space temperature.
4. Staged Burner Control: As directed, Two or Four steps of control.
5. Electromechanical or Electronic Burner Control: 20 to 100 percent modulation of the firing rate; 10 to 100 percent with dual-furnace units.

J. Electric-Resistance Heat Controls:

1. As directed, Factory-mounted sensor in unit discharge or Remote sensor for field installation in supply-air duct with sensor adjustment located in control panel to control electric coil to maintain temperature.
2. As directed, Wall-mounted, space-temperature sensor with temperature adjustment, unit-mounted temperature adjustment or adjustment on remote-control panel to control electric coil to maintain temperature.

3. Capacity Controls: As directed, On/off, Multiple steps or Modulating SCR.

K. Hot-Water Coil Controls: As directed, Factory-mounted sensor in unit discharge or Remote sensor for field installation in supply-air duct with sensor adjustment located in control panel to modulate factory-mounted or furnished coil control valve to maintain temperature.

L. Hot-Water Coil Controls: Space-temperature sensor with temperature adjustment, unit-mounted temperature adjustment or adjustment on remote-control panel to modulate factory-mounted or furnished coil control valve to maintain temperature.

M. Damper Controls: Space pressure sensor modulates outdoor- and return-air dampers to maintain a positive pressure in space at a minimum of 0.05 inch wg (12.4 Pa) with respect to outdoor reference.

N. Integral Smoke Alarm: Smoke detector installed in supply and return air.

O. DDC Temperature Control: Standalone control module for link between unit controls and DDC temperature-control system. Control module shall be compatible with control system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC." Links shall include the following:

1. Start/stop interface relay, and relay to notify DDC temperature-control system alarm condition.
2. Hardware interface or additional sensors for the following:

    a. Room temperature.
    b. Discharge-air temperature.
    c. Refrigeration system operating.
    d. Furnace operating.
    e. Constant and variable motor loads.
    f. Variable-frequency-controller operation.
    g. Cooling load.
    h. Economizer cycles.
    i. Air-distribution static pressure and ventilation-air volumes.

P. Interface with DDC System for HVAC: Factory-installed hardware and software to enable the DDC system for HVAC to monitor, control, and display unit status and alarms.

1. Hardwired Points:

    a. Monitoring: On-off status, common trouble alarm.
    b. Control: As directed, On-off operation, space temperature set-point adjustment, supply temperature set-point adjustment, space humidity set-point adjustment or space pressure set-point adjustment.

2. As directed, ASHRAE 135 (BACnet), LonTalk, Modbus or Industry-accepted, open-protocol communication interface with the DDC system for HVAC shall enable the DDC system for HVAC operator to remotely control and monitor the unit from an operator workstation. Control features and monitoring points displayed locally at unit control panel shall be available through the DDC system for HVAC.

2.15 ACCESSORIES

A. Service Lights and Switch: As directed, Factory installed in fan section, fan and coil sections or each accessible section with weatherproof cover. Factory wire lights to a single-point field connection.

B. Duplex Receptacle: Factory mounted in unit supply-fan section and refrigeration section, with 20 amp 120 V GFI duplex receptacle and weatherproof cover.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with manufacturer's rigging and installation instructions for unloading units and moving to final locations.

B. Curb Support: Install roof curb on roof structure according to "The NRCA Roofing Manual."

1. Install and secure units on curbs and coordinate roof penetrations and flashing with roof construction.
2. Coordinate size, installation, and structural capacity of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."
3. Coordinate size, location, and installation of unit manufacturer's roof curbs and equipment supports with roof Installer.

C. Restrained Curb Support: Install restrained vibration isolation roof-curb rails on roof structure according to "The NRCA Roofing Manual."

D. Equipment Mounting:

1. Install air units on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" As directed
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

E. Suspended Units: Suspend and brace units from structural-steel support frame using threaded steel rods and spring hangers. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC" or Section 230548.13 "Vibration Controls for HVAC" As directed.

F. Install wall- and duct-mounted sensors furnished by manufacturer for field installation. Install control wiring and make final connections to control devices and unit control panel.

G. Install 3000-psi (20.7-MPa), compressive-strength (28-day) concrete base inside roof curb, 4 inches (100 mm) thick. Concrete and reinforcement are specified with concrete.

H. Comply with requirements for gas-fired furnace installation in NFPA 54, "National Fuel Gas Code."

I. Install separate devices furnished by manufacturer and not factory installed.

J. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

K. Install drain pipes from unit drain pans to sanitary drain.

1. Drain Piping: Drawn-temper copper water tubing complying with ASTM B88, Type L (ASTM B88M, Type B), with soldered joints.
2. Drain Piping: Schedule 40 PVC pipe complying with ASTM D1785, with solvent-welded fittings.
3. Pipe Size: Same size as condensate drain pan connection.

3.2 CONNECTIONS

A. Where installing piping adjacent to units, allow space for service and maintenance.

B. Gas Piping Connections:

1. Comply with requirements in Section 231123 "Facility Natural-Gas Piping" or Section 231126 "Facility Liquefied-Petroleum Gas Piping" As directed.
2. Connect gas piping to furnace, full size of gas train inlet, and connect with union, pressure regulator, and shutoff valve with sufficient clearance for burner removal and service.
3. Install AGA-approved flexible connectors.

C. Hydronic Piping Connections:

1. Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
2. Install shutoff valve and union or flange on each supply connection and install balancing valve and union or flange on each return connection.

D. Duct Connections:

1. Comply with requirements in Section 233113 "Metal Ducts."
2. Drawings indicate the general arrangement of ducts.
3. Connect ducts to units with flexible duct connectors. Comply with requirements for flexible duct connectors in Section 233300 "Air Duct Accessories."

E. Electrical Connections: Comply with requirements for power wiring, switches, and motor controls in electrical Sections.

1. Install electrical devices furnished by unit manufacturer but not factory mounted.

3.3 STARTUP SERVICE

A. As directed, Engage a factory-authorized service representative to perform or Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Inspect units for visible damage to furnace combustion chamber.
3. Perform the following operations for both minimum and maximum firing and adjust burner for peak efficiency:

    a. Measure gas pressure at manifold.
    b. Measure combustion-air temperature at inlet to combustion chamber.
    c. Measure flue-gas temperature at furnace discharge.
    d. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
    e. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.

4. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:

    a. High-limit heat exchanger.
    b. Alarms.

5. Inspect units for visible damage to refrigerant compressor, condenser and evaporator coils, and fans.
6. Start refrigeration system when outdoor-air temperature is within normal operating limits and measure and record the following:

    a. Cooling coil leaving-air, dry- and wet-bulb temperatures.
    b. Cooling coil entering-air, dry- and wet-bulb temperatures.
    c. Condenser coil entering-air dry-bulb temperature.
    d. Condenser coil leaving-air dry-bulb temperature.

7. Simulate maximum cooling demand and inspect the following:

    a. Compressor refrigerant suction and hot-gas pressures.
    b. Short-circuiting of air through outside coil or from outside coil to outdoor-air intake.

8. Inspect casing insulation for integrity, moisture content, and adhesion.
9. Verify that clearances have been provided for servicing.
10. Verify that controls are connected and operable.
11. Verify that filters are installed.
12. Clean coils and inspect for construction debris.
13. Clean furnace flue and inspect for construction debris.
14. Inspect operation of power vents.
15. Purge gas line.
16. Inspect and adjust vibration isolators and seismic restraints.
17. Verify bearing lubrication.

18. Clean fans and inspect fan-wheel rotation for movement in correct direction without vibration and binding.
19. Adjust fan belts to proper alignment and tension.
20. Start unit.
21. Inspect and record performance of interlocks and protective devices including response to smoke detectors by fan controls and fire alarm.
22. Operate unit for run-in period.
23. Calibrate controls.
24. Adjust and inspect high-temperature limits.
25. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
26. Verify operational sequence of controls.
27. Measure and record the following airflows. Plot fan volumes on fan curve.

    a. Supply-air volume.
    b. Return-air flow.
    c. Outdoor-air flow.

B. After startup, change filters, verify bearing lubrication, and adjust belt tension.

C. Remove and replace components that do not properly operate and repeat startup procedures as specified above.

D. Prepare written report of the results of startup services.

3.4 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

END OF SECTION 237433

SECTION 238113.11 - PACKAGED TERMINAL AIR-CONDITIONERS, THROUGH-WALL UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes packaged, terminal, through-the-wall air conditioners.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: For packaged, terminal air conditioners.

1. Include plans, elevations, sections, details for wall penetrations, seismic bracing, and attachments to other work.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Color Samples: For unit cabinet, discharge grille, and exterior louver, and for each color and texture specified.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of packaged, terminal air conditioners that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Sealed Refrigeration System: Manufacturer's standard, but not less than five years from date of Substantial Completion, including components and labor.
2. Warranty Period for Nonsealed System Parts: Manufacturer's standard, but not less than five years from date of Substantial Completion, including only components and excluding labor.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 MANUFACTURED UNITS

A. Description: Factory-assembled and -tested, self-contained, packaged, terminal air conditioner with room cabinet, electric refrigeration system, heating, and temperature controls; fully charged with refrigerant and filled with oil; with cord-connected or hardwired chassis As directed.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."

D. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

2.3 CHASSIS

A. Cabinet: As directed, 0.052-inch- (1.3-mm-) thick galvanized or powder-coated steel with removable front panel with concealed latches.

1. Mounting: As directed, Wall with wall sleeve or Floor with subbase.
2. Top: As directed, Angled or Flat.
3. Discharge Grille: As directed, Punched-louver discharge grille allowing four-way discharge-air pattern, Extruded-aluminum discharge grille or Reversible-polycarbonate discharge grille allowing upward and horizontal airflow, tamperproof, and carrying a flame test rating in accordance with UL standard 494.
4. Louvers: As directed, Extruded aluminum with enamel finish, Stamped aluminum with clear-anodized finish, Stamped steel with enamel finish; white, bronze, brown or beige color.
5. Finish: As directed, Epoxy coating or Baked enamel.
6. Access Door: Hinged door in top of cabinet for access to controls.
7. Cabinet Extension: Matching cabinet in construction and finish, allowing diversion of airflow to adjoining room; with grille.
8. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
9. Subbase: Enameled steel with adjustable leveling feet and adjustable end plates, with factory-installed and -wired, fused disconnect switch and receptacle sized for unit.
10. Wall Sleeves: Galvanized steel with polyester finish, Galvanized steel with powder-coated paint, Molded polymer or Molded fiberglass-reinforced polyester.

B. Refrigeration System: Direct-expansion indoor coil with capillary restrictor and hermetically sealed scroll compressor with vibration isolation and overload protection.

1. Indoor and Outdoor Coils: Seamless copper tubes mechanically expanded into aluminum fins with capillary tube distributor on indoor coil.
2. Accumulator.
3. Constant-pressure expansion valve.
4. Reversing valve.
5. Charge: As directed, R-407C or R-410A.

C. Indoor Fan: Forward curved, centrifugal; with motor and positive-pressure ventilation damper with concealed manual or electric operator as directed.

D. Filters: Washable polyurethane in molded plastic frame.

E. Condensate Drain: Drain pan to direct condensate to outdoor coil for re-evaporation and piping to direct condensate to building waste and vent piping.

1. Comply with ASHRAE 62.1 for drain pan construction and connections.

F. Outdoor Fan: As directed, forward curved, centrifugal, Propeller or Forward curved, centrifugal or propeller type with separate or driven by indoor fan motor.

1. Indoor and Outdoor Fan Motors: Two speed; comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

a. Fan Motors: Permanently lubricated split capacitor.
b. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
c. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

2.4 HEATING

A. Electric-Resistance Heating Coil: Nickel-chromium-wire, electric-resistance heating elements with contactor and high-temperature-limit switch.

2.5 CONTROLS

A. Control Module: Unit-mounted digital panel with touchpad temperature control and with touchpad for heating, cooling, and fan operation. Include the following features:

1. Low-Ambient Lockout Control: Prevents cooling-cycle operation below 40 deg F (5 deg C) outdoor air temperature.
2. Heat-Pump Ambient Control: Field-adjustable switch changes to heat-pump heating operation above 40 deg F (5 deg C) and to supplemental heating below plus 25 deg F (minus 4 deg C).
3. Temperature-Limit Control: Prevents occupant from exceeding preset setback or setup temperature.
4. Reverse-Cycle Defrost: Solid-state sensor monitors frost buildup on indoor or outdoor coil and reverses unit to melt frost as directed.

B. Remote Control: Standard unit-mounted controls with remote-mounted, low-voltage, adjustable thermostat with heat anticipator; heat-off-cool-auto or heat-off-cool switch as directed; and on-auto fan switch.

C. Outdoor Air: Motorized intake damper. Open intake when unit indoor-air fan runs.

D. Outdoor Air: Manual intake damper.

2.6 CAPACITIES AND CHARACTERISTICS

A. Airflow: As directed.

B. Outdoor-Air Intake Rate: As directed.

C. Cooling Capacity:

1. Total: As directed.
2. Sensible: As directed.
3. Energy-Efficiency Ratio: As directed.
4. Indoor Coil Entering-Air Dry Bulb Temperature: As directed.
5. Indoor Coil Entering-Air Wet Bulb Temperature: As directed.
6. Indoor Coil Leaving-Air Dry Bulb Temperature: As directed.
7. Indoor Coil Leaving-Air Wet Bulb Temperature: As directed.
8. Outdoor Coil Entering-Air Temperature: As directed.

D. Heat-Pump Capacity:

1. Total: As directed.
2. Outdoor Temperature: As directed.

E. Electric Heat Capacity: As directed.

F. Sound:

1. Indoor: As directed.
2. Outdoor: As directed.

G. Electrical Characteristics:

1. Volts: As directed.
2. Phase: As directed, Single or Three.
3. Hertz: 60.
4. Full-Load Amperes: As directed.
5. Minimum Circuit Ampacity: As directed.
6. Maximum Overcurrent Protection: As directed.

2.7 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Factory test to comply with AHRI 300, "Sound Rating and Sound Transmission Loss of Packaged Terminal Equipment."

B. Unit Performance Ratings: Factory test to comply with AHRI 310/380/CSA C744, "Packaged Terminal Air-Conditioners and Heat Pumps."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb, maintaining manufacturer's recommended clearances and tolerances.

B. Install wall sleeves in finished wall assembly; seal and weatherproof. Joint-sealant materials and applications are specified in Section 079200 "Joint Sealants."

C. Install and anchor wall sleeves to withstand, without damage to equipment and structure, seismic forces required by building code.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
2. After installing packaged, terminal air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Packaged, terminal air conditioners will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 238113.11

SECTION 238113.12 - PACKAGED TERMINAL AIR-CONDITIONERS, FREESTANDING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes packaged, terminal, freestanding air conditioners.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Sustainable Design Submittals:
1.

C. Shop Drawings: For packaged, terminal air conditioners.

1. Include plans, elevations, sections, details for wall penetrations, seismic bracing, and attachments to other work.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

D. Color Samples: For unit cabinet, discharge grille, and exterior louver, and for each color and texture specified.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of packaged, terminal air conditioners that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Sealed Refrigeration System: Manufacturer's standard, but not less than five years from date of Substantial Completion, including components and labor.

2. Warranty Period for Nonsealed System Parts: Manufacturer's standard, but not less than five years from date of Substantial Completion, including only components and excluding labor.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 MANUFACTURED UNITS

A. Description: Factory-assembled and -tested, self-contained, packaged, terminal air conditioner with room cabinet, electric refrigeration system, heating, and temperature controls; fully charged with refrigerant and filled with oil; with cord-connected or hardwired chassis as directed.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."

D. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

2.3 CHASSIS

A. Cabinet: As directed, 0.052-inch- (1.32-mm-) thick galvanized or powder-coated steel with removable front panel with concealed latches.

1. Mounting: As directed, Floor with subbase, Horizontal or Vertical.
2. Top: As directed, Angled or Flat.
3. Discharge Grille: As directed, Punched-louver discharge grille allowing four-way discharge-air pattern, Extruded-aluminum discharge grille or Reversible-polycarbonate discharge grille allowing upward and horizontal airflow, tamperproof, and carrying a flame test rating in accordance with UL standard 494.
4. Louvers: As directed, Extruded aluminum with enamel finish, Stamped aluminum with clear-anodized finish, Stamped steel with enamel finish; white, bronze, brown or beige color.
5. Finish: As directed, Epoxy coating or Baked enamel.
6. Access Door: Hinged door in top of cabinet for access to controls.
7. Cabinet Extension: Matching cabinet in construction and finish, allowing diversion of airflow to adjoining room; with grille.
8. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
9. Subbase: Enameled steel with four adjustable leveling feet and adjustable end plates, with factory-installed and -wired, fused disconnect switch and receptacle sized for unit.

10. Wall Sleeves: As directed, Galvanized steel with polyester finish, Galvanized steel with powder coated paint, Molded polymer or Molded fiberglass-reinforced polyester.

B. Refrigeration System: Direct-expansion indoor coil with capillary restrictor and hermetically sealed scroll compressor with vibration isolation and overload protection.

1. Indoor and Outdoor Coils: Seamless copper tubes mechanically expanded into aluminum fins with capillary tube distributor on indoor coil.
2. Accumulator.
3. Constant-pressure expansion valve.
4. Reversing valve.
5. Charge: As directed, R-407C or R-410A.

C. Indoor Fan: Forward curved, centrifugal; with motor and positive-pressure ventilation damper with concealed manual or electric operator as directed.

D. Filters: Washable polyurethane in molded plastic frame.

E. Condensate Drain: Drain pan to direct condensate to outdoor coil for re-evaporation and piping to direct condensate to building waste and vent piping.

1. Comply with ASHRAE 62.1 for drain pan construction and connections.

F. Outdoor Fan: As directed, forward curved, centrifugal, Propeller, forward curved, centrifugal or propeller type with separate or driven by indoor fan motor.

1. Indoor and Outdoor Fan Motors: Two speed; comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

a. Fan Motors: Permanently lubricated split capacitor.
b. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
c. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

2.4 HEATING

A. Electric-Resistance Heating Coil: Nickel-chromium-wire, electric-resistance heating elements with contactor and high-temperature-limit switch.

2.5 CONTROLS

A. Control Module: Unit-mounted digital panel with touchpad temperature control and with touchpad for heating, cooling, and fan operation. Include the following features:

1. Low-Ambient Lockout Control: Prevents cooling-cycle operation below 40 deg F (5 deg C) outdoor air temperature.

2. Heat-Pump Ambient Control: Field-adjustable switch changes to heat-pump heating operation above 40 deg F (5 deg C) and to supplemental heating below plus 25 deg F (minus 4 deg C).
3. Temperature-Limit Control: Prevents occupant from exceeding preset setback or setup temperature.
4. Reverse-Cycle Defrost: As directed, Solid-state sensor monitors frost buildup on indoor or outdoor coil and reverses unit to melt frost.

B. Remote Control: Standard unit-mounted controls with remote-mounted, low-voltage, adjustable thermostat with heat anticipator; As directed, heat-off-cool-auto or heat-off-cool switch; and on-auto fan switch.

C. Outdoor Air: Motorized intake damper. Open intake when unit indoor-air fan runs.

D. Outdoor Air: Manual intake damper.

2.6 CAPACITIES AND CHARACTERISTICS

A. Airflow: As directed.

B. Outdoor-Air Intake Rate: As directed.

C. Cooling Capacity:

1. Total: As directed.
2. Sensible: As directed.
3. Energy-Efficiency Ratio: As directed.
4. Indoor Coil Entering-Air Dry Bulb Temperature: As directed.
5. Indoor Coil Entering-Air Wet Bulb Temperature: As directed.
6. Indoor Coil Leaving-Air Dry Bulb Temperature: As directed.
7. Indoor Coil Leaving-Air Wet Bulb Temperature: As directed.
8. Outdoor Coil Entering-Air Temperature: As directed.

D. Heat-Pump Capacity:

1. Total: As directed.
2. Outdoor Temperature: As directed.

E. Electric Heat Capacity: As directed.

F. Sound:

1. Indoor: As directed.
2. Outdoor: As directed.

G. Electrical Characteristics:

1. Volts: As directed.
2. Phase: As directed, Single or Three.
3. Hertz: 60.
4. Full-Load Amperes: As directed.

5. Minimum Circuit Ampacity: As directed.
6. Maximum Overcurrent Protection: As directed.

2.7 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Factory test to comply with AHRI 300, "Sound Rating and Sound Transmission Loss of Packaged Terminal Equipment."

B. Unit Performance Ratings: Factory test to comply with AHRI 310/380/CSA C744, "Packaged Terminal Air-Conditioners and Heat Pumps."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb, maintaining manufacturer's recommended clearances and tolerances.

B. Install exterior louver in finished wall assembly; seal and weatherproof. Joint-sealant materials and applications are specified in Section 079200 "Joint Sealants."

C. Install and anchor exterior louver to withstand, without damage to equipment and structure, seismic forces required by building code.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
2. After installing packaged, terminal air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Packaged, terminal air conditioners will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 238113.12

SECTION 238113.13 - PACKAGED TERMINAL AIR-CONDITIONERS, OUTDOOR, WALL-MOUNTED UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes packaged, terminal, outdoor, wall-mounted air conditioners.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: For packaged, terminal air conditioners.

1. Include plans, elevations, sections, details for wall penetrations, seismic bracing, and attachments to other work.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Color Samples: For unit cabinet, discharge grille, and exterior louver, and for each color and texture specified.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of packaged, terminal air conditioners that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Sealed Refrigeration System: Manufacturer's standard, but not less than five years from date of Substantial Completion, including components and labor.
2. Warranty Period for Nonsealed System Parts: Manufacturer's standard, but not less than five years from date of Substantial Completion, including only components and excluding labor.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 MANUFACTURED UNITS

A. Description: Factory-assembled and -tested, self-contained, packaged, terminal air conditioner with room cabinet, electric refrigeration system, heating, and temperature controls; fully charged with refrigerant and filled with oil; with hardwired chassis and circuit breaker.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."

D. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

2.3 CHASSIS

A. Cabinet: Sloped top, 0.052-inch- (1.32-mm-) thick steel or aluminum with removable front panel with concealed latches as directed.

1. Mounting: On exterior wall.
2. Discharge Grille: As directed, Extruded-aluminum discharge grille or Supply-air acoustical plenum.
3. Return Grille: As directed, Extruded-aluminum grille or Return-air acoustical plenum.
4. Louvers: As directed, Extruded aluminum with enamel finish or Stamped aluminum with clear-anodized finish; medium bronze or dark bronze color.
5. Finish: As directed, Epoxy coating or Baked enamel.
6. Access Door: Hinged door in top of cabinet for access to controls.
7. Cabinet Extension: Matching cabinet in construction and finish, allowing diversion of airflow to adjoining room; with grille.
8. Insulation: Cooling and heating sections fully insulated with 1-inch (25-mm)-thick fiberglass insulation.
9. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
10. Wall Sleeves: As directed, Galvanized steel with polyester finish, Molded polymer or Molded fiberglass-reinforced polyester.

B. Refrigeration System: Direct-expansion indoor coil with capillary restrictor and hermetically sealed scroll compressor with vibration isolation, and overload protection.

1. Indoor and Outdoor Coils: Seamless copper tubes mechanically expanded into aluminum fins with capillary tube distributor on indoor coil.
2. Accumulator.
3. Constant-pressure expansion valve.

4. Reversing valve.
5. Charge: As directed, R-407C or R-410A.

C. Indoor Fan: Forward curved, centrifugal; with motor and positive-pressure ventilation damper with concealed manual or electric operator as directed.

D. Filters: Washable polyurethane in molded plastic frame.

E. Condensate Drain: Coated galvanized-steel drain pan to direct condensate to outdoor coil for re-evaporation and piping to direct condensate to building waste and vent piping.

1. Comply with ASHRAE 62.1 for drain pan construction and connections.

F. Outdoor Fan: Forward curved, centrifugal, Propeller, forward curved, centrifugal, or propeller type with separate, driven by indoor fan motor As directed.

1. Indoor and Outdoor Fan Motors: Two speed; comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

a. Fan Motors: Permanently lubricated split capacitor.
b. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
c. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

2.4 HEATING

A. Electric-Resistance Heating Coil: Nickel-chromium-wire, electric-resistance heating elements with contactor and high-temperature-limit switch.

2.5 CONTROLS

A. Control Module: Unit-mounted digital panel with touchpad temperature control and with touchpad for heating, cooling, and fan operation. Include the following features:

1. Low-Ambient Lockout Control: Prevents cooling-cycle operation below 40 deg F (5 deg C) outdoor air temperature.
2. Heat-Pump Ambient Control: Field-adjustable switch changes to heat-pump heating operation above 40 deg F (5 deg C) and to supplemental heating below plus 25 deg F (minus 4 deg C).
3. Temperature-Limit Control: Prevents occupant from exceeding preset setback or setup temperature.
4. Reverse-Cycle Defrost: Solid-state sensor monitors frost buildup on indoor or outdoor coil and reverses unit to melt frost.

B. Remote Control: Standard unit-mounted controls with remote-mounted, low-voltage, adjustable thermostat with heat anticipator; heat-off-cool-auto or heat-off-cool switch; and on-auto fan switch.

C. Outdoor Air: Motorized intake damper. Open intake when unit indoor-air fan runs.

D. Outdoor Air: Manual intake damper.

2.6 CAPACITIES AND CHARACTERISTICS

A. Airflow: As directed.

B. Outdoor-Air Intake Rate: As directed.

C. Cooling Capacity:

1. Total: As directed.
2. Sensible: As directed.
3. Energy-Efficiency Ratio: As directed.
4. Indoor Coil Entering-Air Dry Bulb Temperature: As directed.
5. Indoor Coil Entering-Air Wet Bulb Temperature: As directed.
6. Indoor Coil Leaving-Air Dry Bulb Temperature: As directed.
7. Indoor Coil Leaving-Air Wet Bulb Temperature: As directed.
8. Outdoor Coil Entering-Air Temperature: As directed.

D. Heat-Pump Capacity:

1. Total: As directed.
2. Outdoor Temperature: As directed.

E. Electric Heat Capacity: As directed.

F. Sound:

1. Indoor: As directed.
2. Outdoor: As directed.

G. Electrical Characteristics:

1. Volts: As directed.
2. Phase: As directed, Single or Three.
3. Hertz: 60.
4. Full-Load Amperes: As directed.
5. Minimum Circuit Ampacity: As directed.
6. Maximum Overcurrent Protection: As directed.

2.7 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Factory test to comply with AHRI 300, "Sound Rating and Sound Transmission Loss of Packaged Terminal Equipment."

B. Unit Performance Ratings: Factory test to comply with AHRI 310/380/CSA C744, "Packaged Terminal Air-Conditioners and Heat Pumps."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb, maintaining manufacturer's recommended clearances and tolerances.

B. Install wall sleeves in finished wall assembly; seal and weatherproof. Joint-sealant materials and applications are specified in Section 079200 "Joint Sealants."

C. Install and anchor wall sleeves to withstand, without damage to equipment and structure, seismic forces required by building code.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
2. After installing packaged, terminal air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Packaged, terminal air conditioners will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 238113.13

SECTION 238119 - SELF-CONTAINED AIR-CONDITIONERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes packaged, air-cooled air-conditioning units with refrigerant compressors and controls intended for indoor installations.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

C. Shop Drawings:

1. Include plans, elevations, sections, and mounting or attachment details As directed.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
4. Include diagrams for power, signal, and control wiring.

D. Samples: For units with factory-applied color finishes.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Detail self-contained air-conditioners and adjacent equipment. Show support locations, type of support, weight on each support, required clearances, and other details, drawn to scale and coordinated with each other, using input from installers of the items involved.

B. Seismic Qualification Data: Certificates, for self-contained air-conditioners, accessories, and components, from manufacturer.

C. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An NRTL.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of self-contained air-conditioners that fail in materials or workmanship within specified warranty period.

1. Warranty Period:

a. For Compressor: As directed, One or Five year(s) from date of Substantial Completion.
b. For Parts: As directed, One or Five year(s) from date of Substantial Completion.
c. For Labor: As directed, One or Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."

C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

D. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation and seismic restraints, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

E. Seismic Performance: Self-contained air-conditioners shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: As directed, 1.5 or 1.0.

2.2 CAPACITIES AND CHARACTERISTICS

A. Cooling Capacity:

1. Total: As directed.
2. Sensible: As directed.
3. Seasonal Energy-Efficiency Ratio: As directed, 10.0, 12.0, 13.0, 14.0 or 16.0.
4. Energy-Efficiency Ratio: As directed, 10.0, 12.0, 13.0, 14.0 or 16.0.
5. Entering-Air Temperature:

    a. Dry Bulb: As directed.
    b. Wet Bulb: As directed.

6. Leaving-Air Temperature:

    a. Dry Bulb: As directed.
    b. Wet Bulb: As directed.

B. Heating Capacity:

1. Total: As directed.
2. Air-Temperature Rise: As directed.
3. Airflow:

    a. High: As directed.
    b. Low: As directed.

4. Electric Heat:

    a. Total Capacity: As directed, Btu/h (kW).
    b. Air-Temperature Rise: As directed, deg F (deg C).
    c. Control Steps: As directed, One, Two or Three.

C. Supply-Air Fan:

1. Size: As directed.
2. Total Airflow:

    a. High: As directed.
    b. Low: As directed.

3. Outdoor Airflow: As directed.

D. Air-Cooled Condenser:

1. Number of Fans: As directed, Two or Four.
2. Motor Speed: As directed, rpm.
3. Motor Horsepower (Watts): hp (W).
4. Ambient Temperature: As directed, deg F (deg C).

E. Filters:

1. Type: As directed.
2. Face Dimensions, each: inches by inches (mm by mm).
3. Depth: As directed, inches (mm).
4. Numbers of Filters, Wide by High: As directed.
5. Maximum or Rated Face Velocity: As directed, fpm (m/s).
6. Initial Resistance: As directed, inches wg (Pa).
7. Recommended Final Resistance: As directed, inches wg (Pa).
8. Minimum Efficiency Reporting Value and Average Arrestance:

    a. MERV Rating: MERV 4, and corresponding average arrestance according to ASHRAE 52.2.

9. Minimum Efficiency Reporting Value:

    a. MERV Rating: As directed, MERV 6 or MERV 13, according to ASHRAE 52.2.

F. Accessories:

1. Manual outdoor-air damper.
2. Motorized outdoor-air damper.
3. Air-side economizer.
4. Hot-gas bypass.
5. Air Pressure Switch: Indicates when differential pressure exceeds set point representing dirty filters.

G. Single-Point Electrical Characteristics:

1. Volts: As directed, 120, 208, 230 or 460 V.
2. Phase: As directed, Single or Three.
3. Hertz: 60 Hz.
4. Full-Load Amperes: As directed.
5. Minimum Circuit Ampacity: As directed.
6. Maximum Overcurrent Protection: As directed.

2.3 MANUFACTURERS

2.4 PACKAGED UNITS

A. Description: Factory assembled, wired, and tested; and fully charged with refrigerant and oil.

B. Configuration: Horizontal, ceiling-plenum mounted.

C. Configuration: Vertical, floor mounted; vertical and horizontal discharge.

D. Configuration: Horizontal, ceiling mounted and vertical, floor mounted; vertical and horizontal discharge.

E. Disconnect Switch: Factory mounted in control panel or on cabinet.

2.5 CABINET

A. Frame and Panels: Structural-steel frame with galvanized-steel panels and access doors or panels.

1. Exterior-Surface Finish: Factory painted in color selected by Architect.
2. Interior-Surface Finish: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. Insulation: 1-inch- (25-mm-) thick, glass-fiber duct liner complying with ASTM C1091 and having a microbial coating on cabinet interior and control panel..

C. Return-Air Opening: Rear, open or flange for duct connection.

D. Corrosion-Resistant Treatment: As directed, None or Phenolic coating on unit interior and exterior.

2.6 Supply-air Fan

A. Fan Material: Galvanized steel.

B. Configuration: As directed, Double-width, double-inlet, forward-curved or airfoil centrifugal fan; statically and dynamically balanced. Vertical or Horizontal discharge with flexible discharge collar.

C. Drive: As directed, Belt, with permanently lubricated bearings, with greaseable bearings Direct, with fan and motor resiliently mounted.

D. Motor Type: As directed, Multispeed, permanent split case, Open-dripproof, Totally enclosed fan-cooled or Electronically commutated variable speed type.

E. Motor Sheave: As directed, Fixed or Variable and adjustable pitch, dynamically balanced, and selected to achieve specified rpm when set at midposition.

F. Fan Sheaves: As directed, Variable or Fixed pitch, dynamically balanced, bored to fit shafts, and keyed for initial startup.

G. Belt Rating: As recommended by manufacturer or a minimum of one and one-half times nameplate rating of motor.

H. Bearings: Grease lubricated with grease lines extended to exterior of unit with L-50 life at 200,000 hours.

I. Variable-Frequency Motor Controller: Comply with Section 262923 "Variable-Frequency Motor Controllers."

J. Variable-Frequency Motor Controller: Serving each fan.

1. Manufactured Units: Pulse-width modulated; constant torque and variable torque for Design A and Design B or inverter-duty motors As directed.

2. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range or 66 Hz, with torque constant as speed changes; maximum voltage equals input voltage.
3. Unit Operating Requirements:

    a. Internal Adjustability:

        1) Minimum Speed: 5 to 25 percent of maximum rpm.
        2) Maximum Speed: 80 to 100 percent of maximum rpm.
        3) Acceleration: 0.1 to 999.9 seconds.
        4) Deceleration: 0.1 to 999.9 seconds.
        5) Current Limit: 30 to minimum of 150 percent of maximum rating.

    b. Self-Protection and Reliability Features:

        1) Surge suppression.
        2) Loss of input signal protections.
        3) Under- and overvoltage trips.
        4) Variable-frequency motor controller and motor-overload/overtemperature protection.
        5) Critical frequency rejection.
        6) Loss-of-phase protection.
        7) Reverse-phase protection.
        8) Motor-overtemperature fault.

    c. Bidirectional autospeed search.
    d. Torque boost.
    e. Motor temperature compensation at slow speeds.

        1) Panel-mounted operator station.
        2) Historical logging information and displays.
        3) Digital indicating devices.

    f. Control Signal Interface: Electric.
    g. Proportional Integral Derivative control interface.
    h. DDC system for HVAC Protocols for Network Communications: ASHRAE 135.

4. Line Conditioning:

    a. Input line conditioning.
    b. Output filtering.
    c. EMI/RFI filtering.

5. Bypass Systems:

    a. Bypass Mode: As directed, Manual operation only or Field-selectable automatic or manual.
    b. Bypass Controller: Two-contactor style, with bypass and output isolating contactors and isolating switch.
    c. Bypass Controller: Three-contactor style, with bypass and input and output isolating contactors and isolating switch.

d. Bypass Contactor Configuration: As directed, Full-voltage (across the line) or Reduced-voltage (autotransformer) type.

K. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Special Motor Features: Premium efficiency, as defined in Section 230513 "Common Motor Requirements for HVAC Equipment."

L. Isolation: Mount fan and motor on common subbase and mount assembly on spring isolators with minimum static deflection of 1 inch (25 mm).

M. Outdoor-Air-Intake Accessories:

1. Barometric Outdoor-Air Damper: Adjustable-blade damper allowing induction of up to 25 percent outdoor air when evaporator fan is running.
2. Motorized Outdoor-Air Damper: Motorized, two-position blade damper allowing induction of up to 25 percent outdoor air; with spring-return, low-voltage damper motor.
3. Energy-Recovery Ventilator: Assembly of desiccant-coated, heat-recovery wheels and centrifugal exhaust fans to transfer approximately 67 percent of the difference between the sensible and latent heat of outdoor and exhaust air; with type and depth filter as directed, on outside-air inlet side to keep ventilator clean.
4. Air-Side Economizer: Damper assembly allowing induction of up to 100 percent outdoor air to maintain a selected mixed-air temperature; and exhaust damper and spring-return, low-voltage, modulating damper motor with minimum position adjustment.

2.7 REFRIGERATION SYSTEM

A. Compressor: Scroll type, hermetically sealed, 3600 rpm maximum, and resiliently mounted with positive lubrication and internal motor protection.

B. Refrigerant Coils Indoor and Outdoor for Air-Cooled Units: Seamless copper tubes expanded into aluminum fins.

1. Corrosion-Resistant Treatment: Phenolic coating applied with multiple coating dips and baked.
2. Refrigerant Circuits: A separate circuit for each compressor, with externally equalized thermal-expansion valve with adjustable superheat, filter dryer, sight glass, high-pressure relief valve, and charging valves.
3. Mount coil assembly over sloped, stainless-steel drain pan complying with ASHRAE 62.1 and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir.
4. Refrigerant: R-407C or R-410A.
5. Refrigerant dryer.
6. High-pressure switch.
7. Low-pressure switch.
8. Thermostat for coil freeze-up protection during low ambient temperature operation or loss of air.

9. Low ambient temperature switch.
10. Brass service valves installed in discharge and liquid lines.

2.8 Heating Coil

A. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements with refractory ceramic support bushings; automatic-reset thermal cutout; built-in magnetic contactors; manual-reset thermal cutout; airflow-proving device; and one-time fuses in terminal box for overcurrent protection.

2.9 CONTROLS

A. Control equipment and sequence of operation are specified in Section 230923 "Direct-Digital Control System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."

B. Control Package: Factory wired, including contactor, high- and low-pressure cutouts, internal-winding thermostat for compressor, control-circuit transformer, and noncycling reset relay.

1. System Selector Switch: As directed, Heat-off-cool or Off-heat-auto-cool.
2. Adjustable Thermostat: As directed, Unit mounted or Remote to control the following:

    a. Supply fan.
    b. Compressor.
    c. Condenser.
    d. Electric heater.

3. Time-Delay Relay: Delay in starting lag compressor to prevent power demand surges.
4. Antirecycle Timer: Locks out the compressor for an interval of time to prevent rapid starting and stopping.

C. Control Package:

1. Microprocessor Control Panel: Controls unit functions as standalone, full BAS communication via BACnet MS/TP, full BAS communication via BACnet/IP, full BAS communication via LON or full BAS communication via MODBUS As directed, including refrigeration and safety controls, with unit-mounted display, and the following:

    a. Supply fan.
    b. Supply-fan motor speed.
    c. Compressors.
    d. Air-cooled condenser.
    e. Cooling tower pump.
    f. Multistep, electric heater.
    g. Time-of-day control to cycle unit on and off.
    h. Night-heat, morning warm-up cycle.
    i. Economizer control.
    j. Panel-mounted control switch to operate unit in remote or local control mode or to stop or reset.
    k. Panel-mounted indication of the following:

1) Operating status.
2) System diagnostics and safety alarms.
3) Supply-air temperature set point.
4) Zone heating-temperature set point.
5) Supply-air pressure set point.
6) Economizer minimum position set point.
7) Supply-air-pressure, high-limit set point.

2.10 SOURCE QUALITY CONTROL

A. AHRI Compliance:

1. AHRI 210/240 Certification: Units and their components shall be factory tested according to AHRI 210/240 and shall be listed and labeled by AHRI.
2. AHRI 340/360 Certification: Units and their components shall be factory tested according to AHRI 340/360 and shall be listed and labeled by AHRI.
3. AHRI 390 Certification: Units and their components shall be factory tested according to AHRI 390 and shall be listed and labeled by AHRI.

B. ETL listed.

C. Refrigerant Coils: Factory tested to minimum 450-psig (3100-kPa) internal pressure and to minimum 300-psig (2070-kPa) internal pressure while underwater, according to AHRI 410 and ASHRAE 33.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment Mounting:

1. Install air-handling units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" As directed
2. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."
3. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
4. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548.13 "Vibration Controls for HVAC."

B. Suspended Units: Suspend and brace units from structural-steel support frame using threaded steel rods and spring hangers. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC" or Section 230548.13 "Vibration Controls for HVAC" As directed.

C. Arrange installation of units to provide access space around units for service and maintenance.

D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.

E. Connect duct to units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."

F. Duct Connections: Duct installation requirements are specified in Section 233113 "Metal Ducts." Drawings indicate the general arrangement of ducts. Connect supply and return ducts to self-contained air-conditioners with flexible duct connectors. Flexible duct connectors are specified in Section 233300 "Air Duct Accessories."

3.2 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect condensate drain pans using NPS 1-1/4 (DN 32), ASTM B88, Type M (ASTM B88M, Type C) copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

C. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.

D. Where installing piping adjacent to equipment, allow space for service and maintenance.

E. Connect piping to units mounted on vibration isolators with flexible connectors.

3.3 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Charge refrigerant coils with refrigerant and test for leaks.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Units will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing unit.

3.7 CLEANING

A. After completing system installation and testing, adjusting, and balancing unit and after completing startup service, clean units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings; install new, clean filters.

END OF SECTION 238119

SECTION 238123.11 – SMALL CAPACITY (6 TONS (21 KW) AND SMALLER), COMPUTER-ROOM AIR-CONDITIONERS, FLOOR-MOUNTED UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes floor-mounted, computer-room air conditioners of 6 tons (21 kW) and smaller.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: For computer-room air conditioners.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

D. Color Samples: For unit cabinet, discharge grille, and exterior louver and for each color and texture specified.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, elevations, and other details, drawn to scale, using input from installers of the items involved.

B. Seismic Qualification Data: Certificates, for computer-room air conditioners, accessories, and components, from manufacturer.

C. Field quality-control reports.

D. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of computer-room air conditioners that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: Manufacturer's standard, but not less than five or 10 years from date of Substantial Completion As directed.
2. Warranty Period for Humidifiers: Manufacturer's standard, but not less than three years from date of Substantial Completion.
3. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Computer-room air conditioners shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."

D. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

E. ASME Compliance: Fabricate and label water-cooled condenser shell to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

2.3 MANUFACTURED UNITS

A. Description: Self-contained, factory assembled, prewired, and prepiped; consisting of cabinet, fan, filters, and controls; for vertical floor mounting in upflow or downflow configuration.

B. Cabinet and Frame: Welded tubular-steel frame with removable steel panels with baked-enamel finish, insulated with 1-inch- (25-mm-) thick duct liner.

1. Floor Stand: Welded tubular steel, required height high as directed, with adjustable legs and vibration isolation pads with turning vanes mounted within the stand.
2. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
3. As directed, Unit with two, three or four-way, powder-coated insulated air distribution plenum.

C. Supply-Air Fan: Forward curved, centrifugal, and with adjustable V-belt drive.

D. Refrigeration System:

1. Compressor: Digital Scroll, variable capacity, with oil strainer, internal motor overload protection, resilient suspension system, and crankcase heater.
2. Refrigeration Circuit:

    a. Low-pressure switch.
    b. Manually reset, high-pressure switch.
    c. Thermal-expansion valve with external equalizer.
    d. Sight glass with moisture indicator.
    e. Service shutoff valves.
    f. Charging valves.
    g. Hot-gas bypass.
    h. Refrigerant charge.

3. Refrigerant: As directed, R-407C or R-410A.
4. Refrigerant Evaporator Coil: Direct-expansion coil of seamless copper tubes expanded into aluminum fins, with two circuits, each with solenoid valve.
5. Refrigerant line sets.
6. Refrigerant line-sweat-adapter kit to permit field brazing of refrigerant lines.

    a. Mount stainless-steel drain pan complying with ASHRAE 62.1 and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir under coil assembly.

7. Remote Air-Cooled Refrigerant Condenser:

    a. Integral, copper-tube aluminum-fin coil.
    b. Condenser with surge protection device (SPD) and locking disconnect in the enclosed electrical panel section.

8. Fan: As directed, Direct-drive, single or variable-speed propeller type.
9. Fan: Belt-drive, single propeller type.
10. Fan: As directed, Direct-drive, single or variable-speed centrifugal type.
11. Fan: Belt-drive, single-speed centrifugal type.
12. Split system shall have suction- and liquid-line compatible fittings and refrigerant piping for field interconnection.

E. Electric-Resistance Reheat Coil:

1. Finned-tube electric elements with contactor and high-temperature-limit switches.
2. SCR to proportionally control the reheat elements providing precise temperature control.

F. Pre-Filter: As directed, 2-inch- (50-mm-) or 4-inch- (100-mm-)] thick, disposable, pleated, glass-fiber media.

G. Filter: As directed, 2-inch- (50-mm-) or 4-inch- (100-mm-) thick, disposable, pleated, glass-fiber media.

1. Initial Resistance: Inches wg (Pa) As directed.
2. Recommended Final Resistance: Inches wg (Pa) As directed.
3. Pre-Filter Minimum Efficiency Reporting Value and Average Arrestance:

    a. MERV Rating: As directed, MERV 1, MERV 2, MERV 3 or MERV 4 and corresponding average arrestance according to ASHRAE 52.2.

4. Pre-Filter Minimum Efficiency Reporting Value:

    a. MERV 6 according to ASHRAE 52.2.

5. Filter Minimum Efficiency Reporting Value:

    a. MERV Rating: As directed, MERV 6 or MERV 13 according to ASHRAE 52.2.

H. Electrode Steam Humidifier: Self-contained, microprocessor-controlled unit with disposable, polypropylene-plastic cylinders and having field-adjustable steel electrodes and stainless-steel steam dispersion tube.

1. Plumbing Components and Valve Bodies: Plastic, linked by flexible rubber hosing, with water fill with air gap and solenoid valve incorporating built-in strainer, pressure-reducing and flow-regulating orifice, and drain with integral air gap.
2. Control: Fully modulating to provide gradual modulation from zero to 100 percent capacity with field-adjustable maximum capacity; with high-water probe.
3. Drain Cycle: Field-adjustable drain duration and drain interval.

I. Disconnect Switch: As directed, Locking or Non-locking disconnect with handle accessible with the door closed.

J. Disconnect Switch: Non-locking, non-automatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.

K. Control System:

1. As directed, Microprocessor unit or remote-mounted panel.
2. Fan contactor.
3. Compressor contactor.
4. Compressor start capacitor.
5. Control transformer with circuit breaker.
6. Solid-state temperature- and humidity-control modules.
7. Humidity contactor.
8. Time-delay relay.
9. Heating contactor.
10. Smoke sensor.
11. High-temperature thermostat.

12. As directed, Solid-state, wall-mounted control panel with start-stop switch, adjustable humidity set point, remote temperature sensors or remote humidity sensors and adjustable temperature set point.
13. Remote panel to monitor and change temperature and humidity set points and sensitivities of the unit and unit alarms.

L. Fan Motors:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load does not require motor to operate in service factor range above 1.0.
3. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

2.4 CAPACITIES AND CHARACTERISTICS

A. Unit Configuration: As directed, Draw or Blow through.

B. Supply-Air Fan:

1. Number of Fans: As directed, One or Two.
2. Airflow: As directed.
3. Minimum Static Pressure: As directed.
4. Motor Size: As directed, hp.

C. Refrigeration System:

1. Unit Energy Efficiency: As directed, COP or EER.
2. Refrigerant Compressor:

    a. Total Unit Cooling Capacity: As directed.
    b. Sensible Unit Cooling Capacity: As directed.
    c. Number of Compressors: As directed, One or Two.
    d. Motor Size: As directed, hp.

3. Refrigerant Evaporator Coil:

    a. Cooling Capacity: As directed.
    b. Entering-Air Dry-Bulb Temperature: As directed.
    c. Entering-Air Wet-Bulb Temperature: As directed.
    d. Leaving-Air Dry-Bulb Temperature: As directed.
    e. Leaving-Air Wet-Bulb Temperature: As directed.

4. Air-Cooled Refrigerant Condenser:

    a. Cooling Capacity: As directed.
    b. Entering-Air Temperature: As directed.

c. Number of Condenser Fan Motors: As directed.
d. Condenser Fan Motors: As directed, hp.

D. Electric-Resistance Reheating Coil:

1. Total Capacity: As directed.
2. Stages of Heating: As directed, 1 or 2.

E. Humidifier:

1. Total: As directed.
2. Input: As directed.

F. Electrical Characteristics:

1. Volts: As directed, 120, 208, 240, 277 or 480.
2. Phase: As directed, Single or Three.
3. Hertz: 60.
4. Full-Load Amperes: As directed.
5. Minimum Circuit Ampacity: As directed.
6. Maximum Overcurrent Protection: As directed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Layout and install computer-room air conditioners and suspension system coordinated with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

B. Install computer-room air conditioners coordinated with computer-room access flooring Installer.

C. Install computer-room air conditioners level and plumb, maintaining manufacturer's recommended clearances. Install according to AHRI Guideline B.

D. Computer-Room Air-Conditioner Mounting: As directed, Install using elastomeric pads, elastomeric mounts or restrained spring isolators. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC" or Section 230548.13 "Vibration Controls for HVAC" As directed

1. Minimum Deflection: As directed, 1/4 inch (6 mm) or 1 inch (25 mm).

E. Suspended Computer-Room Air Conditioners: As directed, Install using continuous-thread hanger rods and elastomeric hangers, spring hangers or spring hangers with vertical-limit stop of size required to support weight of computer-room air conditioner.

1. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC" or Section 230548.13 "Vibration Controls for HVAC" As directed. Fabricate brackets or supports as required.

2. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

F. Air-Cooled Refrigerant Condenser Mounting: Install using elastomeric pads, elastomeric mounts or restrained spring isolators on concrete base. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC" or Section 230548.13 "Vibration Controls for HVAC" As directed

1. Minimum Deflection: As directed, 1/4 inch (6 mm) or 1 inch (25 mm).

3.2 CONNECTIONS

A. Piping installation requirements are specified in other heating, ventilating, and air-conditioning Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to computer-room air conditioners, allow space for service and maintenance.

C. Drainage Connections: Comply with applicable requirements in Section 221116 "Domestic Water Piping." Provide adequate connections for water-cooled units, condensate drain, and humidifier flushing system.

D. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Provide shutoff valves and piping.

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
2. After installing computer-room air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Computer-room air conditioners will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

D. After startup service and performance test, change filters and flush humidifier.

3.4 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain computer-room air conditioners.

END OF SECTION 238123.11

SECTION 238123.12 – LARGE CAPACITY (7 TONS (25 KW) AND LARGER), COMPUTER-ROOM AIR-CONDITIONERS, FLOOR-MOUNTED UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes floor-mounted, computer-room air conditioners of 7 tons (25 kW) and larger.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

C. Shop Drawings: For computer-room air conditioners.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

D. Color Samples: For unit cabinet, discharge grille, and exterior louver and for each color and texture specified.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, elevations, and other details, drawn to scale, using input from installers of the items involved.

B. Seismic Qualification Data: Certificates, for computer-room air conditioners, accessories, and components, from manufacturer.

C. Field quality-control reports.

D. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of computer-room air conditioners that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: As directed, Manufacturer's standard, but not less than five or 10 years from date of Substantial Completion.
2. Warranty Period for Humidifiers: Manufacturer's standard, but not less than three years from date of Substantial Completion.
3. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Computer-room air conditioners shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."

D. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

E. ASME Compliance: Fabricate and label water-cooled condenser shell to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

2.3 MANUFACTURED UNITS

A. Description: Self-contained, factory assembled, prewired, and prepiped; consisting of cabinet, fan, filters, and controls; for vertical floor mounting in upflow or downflow configuration.

B. Cabinet and Frame: As directed, Welded tubular-steel frame with removable single or double-thick steel panels and insulated with 1-inch- (25-mm-) or 1-1/2-inch- (38-mm-) thick duct liner.

1. Floor Stand: As directed, Welded tubular steel, 4 inches (100 mm) or 6 inches (150 mm) high, with adjustable legs and vibration isolation pads with turning vanes mounted within the stand.
2. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
3. As directed, Unit with two, three or four-way, powder-coated insulated air distribution plenum.

C. Supply-Air Fan:

1. Forward curved, double width, double inlet, centrifugal, with adjustable V-belt drive.
2. Plug/plenum, single inlet, direct drive, electronically commutated, and variable speed.

D. Refrigeration System:

1. Compressor: As directed, Semihermetic, Scroll or Digital scroll, variable capacity with oil strainer, internal motor overload protection, resilient suspension system, and crankcase heater.
2. Refrigeration Circuit:

    a. Two independent circuits with hot-gas mufflers.
    b. Low-pressure switch.
    c. Manually reset, high-pressure switch.
    d. Thermal-expansion valve with external equalizer.
    e. Sight glass with moisture indicator.
    f. Service shutoff valves.
    g. Charging valves.
    h. Hot-gas bypass.
    i. Refrigerant charge.

3. Refrigerant: R-407C or R-410A
4. Refrigerant Evaporator Coil: Direct-expansion coil of seamless copper tubes expanded into aluminum fins, with two circuits, each with solenoid valve.

    a. Mount stainless-steel drain pan complying with ASHRAE 62.1 and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir under coil assembly.

5. Remote Air-Cooled Refrigerant Condenser:

    a. Integral, copper-tube aluminum-fin coil.
    b. Condenser with surge protection device (SPD) and locking disconnect in the enclosed electrical panel section.

6. Fan: As directed, Direct-drive, single or variable-speed propeller type.
7. Fan: Belt-drive, single-speed propeller type.
8. Fan: As directed, Direct-drive, single or variable-speed centrifugal type.
9. Fan: Belt-drive, single-speed centrifugal type.
10. Split system shall have suction- and liquid-line compatible fittings and refrigerant piping for field interconnection.

E. Hot-Gas Reheat: Copper-tube, aluminum-fin coil with three-way solenoid valve and refrigerant check valve.

F. Electric-Resistance Reheat Coil:

1. Finned-tube electric elements with contactor and high-temperature-limit switches.
2. SCR to proportionally control the reheat elements providing precise temperature control.

G. Pre-Filter: As directed, 2-inch- (50-mm-) or 4-inch- (100-mm-) thick, disposable, pleated, glass-fiber media.

H. Final Filter: As directed, 2-inch- (50-mm-) or 4-inch- (100-mm-) thick, disposable, pleated, glass-fiber media.

1. Initial Resistance: Inches wg (Pa) As directed.
2. Recommended Final Resistance: Inches wg (Pa) As directed.
3. Pre-Filter Minimum Efficiency Reporting Value and Average Arrestance:

    a. MERV Rating: As directed, MERV 1, MERV 2, MERV 3 or MERV 4 and corresponding average arrestance according to ASHRAE 52.2.

4. Pre-Filter Minimum Efficiency Reporting Value:

    a. MERV 6 according to ASHRAE 52.2.

5. Filter Minimum Efficiency Reporting Value:

    a. MERV Rating: As directed, MERV 6 or MERV 13 according to ASHRAE 52.2.

I. Electrode Steam Humidifier: Self-contained, microprocessor-controlled unit with disposable, polypropylene-plastic cylinders and having field-adjustable steel electrodes and stainless-steel steam dispersion tube.

1. Plumbing Components and Valve Bodies: Plastic, linked by flexible rubber hosing, with water fill with air gap and solenoid valve incorporating built-in strainer, pressure-reducing and flow-regulating orifice, and drain with integral air gap.
2. Control: Fully modulating to provide gradual modulation from zero to 100 percent capacity with field-adjustable maximum capacity; with high-water probe.
3. Drain Cycle: Field-adjustable drain duration and drain interval.

J. Disconnect Switch: As directed, Locking or Non-locking disconnect with handle accessible with the door closed.

K. Disconnect Switch: Non-locking, non-automatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.

L. Control System:

1. As directed, Microprocessor unit or remote-mounted panel.
2. Fan contactor.
3. Compressor contactor.
4. Compressor start capacitor.

5. Control transformer with circuit breaker.
6. Solid-state temperature- and humidity-control modules.
7. Humidity contactor.
8. Time-delay relay.
9. Heating contactor.
10. Smoke sensor.
11. High-temperature thermostat.
12. As directed, Solid-state, wall-mounted control panel with start-stop switch, adjustable humidity set point, remote temperature sensors or remote humidity sensors and adjustable temperature set point.
13. Remote panel to monitor and change temperature and humidity set points and sensitivities of the unit and unit alarms.
14. Sequential load activation and self-diagnostics.

M. Fan Motors:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load does not require motor to operate in service factor range above 1.0.
3. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
4. Type: As directed, Open dripproof or Totally enclosed fan cooled.

2.4 CAPACITIES AND CHARACTERISTICS

A. Unit Configuration: As directed, Draw or Blow through.

B. Supply-Air Fan:

1. Number of Fans: As directed, One or Two.
2. Airflow: As directed.
3. Minimum Static Pressure: As directed.
4. Motor Size: hp as directed.

C. Refrigeration System:

1. Unit Energy Efficiency: As directed, COP or EER.
2. Refrigerant Compressor:

    a. Total Unit Cooling Capacity: As directed.
    b. Sensible Unit Cooling Capacity: As directed.
    c. Number of Compressors: As directed, One or Two.
    d. Motor Size: hp as directed.

3. Refrigerant Evaporator Coil:

a. Cooling Capacity: As directed.
b. Entering-Air Dry-Bulb Temperature: As directed.
c. Entering-Air Wet-Bulb Temperature: As directed.
d. Leaving-Air Dry-Bulb Temperature: As directed.
e. Leaving-Air Wet-Bulb Temperature: As directed.

4. Air-Cooled Refrigerant Condenser:

a. Cooling Capacity: As directed.
b. Entering-Air Temperature: As directed.
c. Number of Condenser Fan Motors: As directed.
d. Condenser Fan Motors: hp as directed.

D. Electric-Resistance Reheating Coil:

1. Total Capacity: As directed.
2. Stages of Heating: As directed, 1 or 2.

E. Humidifier:

1. Total: As directed.
2. Input: As directed.

F. Electrical Characteristics:

1. Volts: As directed, 120, 208, 240, 277 or 480.
2. Phase: As directed, Single or Three.
3. Hertz: 60.
4. Full-Load Amperes: As directed.
5. Minimum Circuit Ampacity: As directed.
6. Maximum Overcurrent Protection: As directed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Layout and install computer-room air conditioners and suspension system coordinated with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

B. Install computer-room air conditioners coordinated with computer-room access flooring Installer.

C. Install computer-room air conditioners level and plumb, maintaining manufacturer's recommended clearances. Install according to AHRI Guideline B.

D. Computer-Room Air-Conditioner Mounting: Install using elastomeric pads, elastomeric mounts or restrained spring isolators. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC" or Section 230548.13 "Vibration Controls for HVAC" As directed

1. Minimum Deflection: As directed, 1/4 inch (6 mm) or 1 inch (25 mm).

E. Suspended Computer-Room Air Conditioners: As directed, Install using continuous-thread hanger rods and elastomeric hangers, spring hangers or spring hangers with vertical-limit stop of size required to support weight of computer-room air conditioner.

1. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC" or Section 230548.13 "Vibration Controls for HVAC" As directed, fabricate brackets or supports as required.
2. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

F. Air-Cooled Refrigerant Condenser Mounting: Install using elastomeric pads, elastomeric mounts or restrained spring isolators on concrete base. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC" or Section 230548.13 "Vibration Controls for HVAC" As directed

1. Minimum Deflection: 1/4 inch (6 mm) or 1 inch (25 mm) As directed.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other heating, ventilating, and air-conditioning Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to computer-room air conditioners, allow space for service and maintenance.

C. Drainage Connections: Comply with applicable requirements in Section 221116 "Domestic Water Piping." Provide adequate connections for water-cooled units, condensate drain, and humidifier flushing system.

D. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Provide shutoff valves and piping.

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
2. After installing computer-room air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Computer-room air conditioners will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

D. After startup service and performance test, change filters and flush humidifier.

3.4 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain computer-room air conditioners.

END OF SECTION 238123.12

SECTION 238123.13 - COMPUTER-ROOM AIR-CONDITIONERS, CEILING-MOUNTED UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes ceiling-mounted, computer-room air conditioners.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: For computer-room air conditioners.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

D. Color Samples: For unit cabinet, discharge grille, and exterior louver and for each color and texture specified.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, elevations, and other details, drawn to scale, using input from installers of the items involved.

B. Seismic Qualification Certificates: For computer-room air conditioners, accessories, and components, from manufacturer.

C. Field quality-control reports.

D. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of computer-room air conditioners that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: As directed, Manufacturer's standard, but not less than five or 10 years from date of Substantial Completion.
2. Warranty Period for Humidifiers: Manufacturer's standard, but not less than three years from date of Substantial Completion.
3. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Computer-room air-conditioners, ceiling-mounted units shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."

D. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

E. ASME Compliance: Fabricate and label water-cooled condenser shell to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

2.3 MANUFACTURED UNITS

A. Description: Self-contained, factory assembled, prewired, and prepiped; consisting of cabinet, fan, filters, and controls.

1. Mounting Configuration: Exposed in the space.

2. Mounting Configuration: Fit T-bar in lay-in ceiling opening.
3. Mounting Configuration: Concealed above a hard ceiling.

B. Cabinet: Galvanized steel serviceable from one side, with baked-enamel finish, insulated with 1/2-inch- (13-mm-) thick duct liner, and mounting bracket attached to the unit.

1. Integral factory-supplied supply and return grille to fit ceiling grid kit of 24 by 48 inches (610 by 1220 mm), with filter.
2. Unit with supply and return collars for ducting in the field.
3. Unit with 24-by-48-inch (610-by-1220-mm) air distribution plenum, with integral MERV 8 filter and three-way air distribution.
4. Unit with two-speed, centrifugal direct-drive fan.
5. Unit with single-speed, centrifugal belt-driven fan.
6. Unit with high static blower assembly consisting of field-attached blower box with double-inlet, centrifugal belt-driven fan; with single-speed motor mounted on an adjustable base, and providing up to 2 inches wc (500 Pa) of external pressure.
7. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Supply-Air Fan:

1. Forward curved, double width, double inlet, centrifugal, with adjustable V-belt drive.
2. Plug/plenum, single inlet, direct drive, electronically commutated, and variable speed.

D. Refrigeration System:

1. Compressor: Scroll, with oil strainer, internal motor overload protection, resilient suspension system, and crankcase heater.
2. Refrigeration Circuit Components:

    a. Low-pressure switch.
    b. Manually reset, high-pressure switch.
    c. Thermal-expansion valve with external equalizer.
    d. Sight glass with moisture indicator.
    e. Service shutoff valves.
    f. Charging valves.
    g. Hot-gas bypass.
    h. Refrigerant charge.

3. Refrigerant: R-407C or R-410A.
4. Refrigerant Evaporator Coil: Direct-expansion coil of seamless copper tubes expanded into aluminum fins.
5. As directed, Refrigerant line sets precharged in lengths of 15 feet (4.6 m) or 30 feet (9.0 m) and of sufficient length to serve the unit from its condensing unit.
6. Refrigerant line-sweat-adapter kit to permit field brazing of refrigerant lines.

    a. Mount stainless-steel drain pan complying with ASHRAE 62.1 and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir under coil assembly.

7. Remote, Air-Cooled Refrigerant Condenser: Integral, copper-tube aluminum-fin coil with direct-drive, propeller or centrifugal fan As directed.
8. Split system shall have suction- and liquid-line compatible fittings and refrigerant piping for field interconnection.
9. Mount stainless-steel drain pan complying with ASHRAE 62.1 and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir under coil assembly.

E. Electric-Resistance Reheat Coil:

1. Finned-tube electric elements with contactor.
2. Dehumidification relay.
3. High-temperature-limit switches.
4. SCR to proportionally control the reheat elements providing precise temperature control.

F. Filter: 1-inch- (25-mm-) thick, disposable, glass-fiber media.

1. Initial Resistance: Inches wg (Pa) as directed.
2. Recommended Final Resistance: Inches wg (Pa) As directed.
3. Pre-Filter Minimum Efficiency Reporting Value and Average Arrestance:

    a. MERV Rating: As directed, MERV 1, MERV 2, MERV 3 or MERV 4 and corresponding average arrestance according to ASHRAE 52.2.

4. Pre-Filter Minimum Efficiency Reporting Value:

    a. MERV 6 according to ASHRAE 52.2.

5. Filter Minimum Efficiency Reporting Value:

    a. MERV Rating: As directed, MERV 6 or MERV 13 according to ASHRAE 52.2.

G. Electrode Steam Humidifier: Self-contained, microprocessor-controlled unit with disposable, polypropylene-plastic cylinders, and having field-adjustable steel electrodes and stainless-steel steam dispersion tube.

1. Plumbing Components and Valve Bodies: Plastic, linked by flexible rubber hosing, with water fill with air gap and solenoid valve incorporating built-in strainer, pressure-reducing and flow-regulating orifice, and drain with integral air gap.
2. Control: Fully modulating to provide gradual modulation from zero to 100 percent capacity with field-adjustable maximum capacity; with high-water probe.
3. Drain Cycle: Field-adjustable drain duration and drain interval.

H. Disconnect Switch: Non-automatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.

I. Single point power kit permitting single electrical feed to the evaporator and condensing unit of a close-coupled system.

J. Epoxy-coated, step-down transformer suitable for mounting on the outdoor condensing unit to provide it with 277-V input power.

K. Control System:

1. As directed, Microprocessor unit or remote-mounted panel.
2. Fan contactor.
3. Compressor contactor.
4. Compressor start capacitor.
5. Control transformer with circuit breaker.
6. Solid-state temperature- and humidity-control modules.
7. Humidity contactor.
8. Time-delay relay.
9. Heating contactor.
10. Smoke sensor.
11. Filter clog switch.
12. Alarm contacts.
13. High-temperature thermostat.
14. As directed, Solid-state, wall-mounted control panel with start-stop switch, adjustable humidity set point, remote temperature sensors or remote humidity sensors and adjustable temperature set point.
15. Remote panel to monitor and change temperature and humidity set points and sensitivities of the unit and unit alarms.

L. Fan Motors:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

    a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load does not require motor to operate in service factor range above 1.0.
    b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

2.4 CAPACITIES AND CHARACTERISTICS

A. Supply-Air Fan:

1. Airflow: As directed.
2. Minimum Static Pressure: As directed.
3. Motor Size: hp as directed.

B. Refrigeration System:

1. Unit Energy Efficiency: As directed, COP or EER.
2. Refrigerant Compressor:

    a. Total Unit Cooling Capacity: As directed.

b. Sensible Unit Cooling Capacity: As directed.
c. Number of Compressors: As directed, One or Two.
d. Motor Size: hp as directed.

3. Refrigerant Evaporator Coil:

a. Cooling Capacity: As directed.
b. Entering-Air Dry-Bulb Temperature: As directed.
c. Entering-Air Wet-Bulb Temperature: As directed.
d. Leaving-Air Dry-Bulb Temperature: As directed.
e. Leaving-Air Wet-Bulb Temperature: As directed.

4. Air-Cooled Refrigerant Condenser:

a. Cooling Capacity: As directed.
b. Entering-Air Temperature: As directed.
c. Number of Condenser Fan Motors: As directed.
d. Condenser Fan Motors: hp As directed.

C. Electric-Resistance Reheating Coil:

1. Total Capacity: As directed.
2. Stages of Heating: As directed, 1 or 2.

D. Humidifier:

1. Total: As directed.
2. Input: As directed.

E. Electrical Characteristics:

1. Volts: As directed, 120, 208, 240, 277 or 480.
2. Phase: As directed, Single or Three.
3. Hertz: 60.
4. Full-Load Amperes: As directed.
5. Minimum Circuit Ampacity: As directed.
6. Maximum Overcurrent Protection: As directed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Layout and install computer-room air conditioners and suspension system coordinated with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

B. Install computer-room air conditioners coordinated with computer-room access flooring Installer.

C. Install computer-room air conditioners level and plumb, maintaining manufacturer's recommended clearances. Install according to AHRI Guideline B.

D. Suspended Computer-Room Air Conditioners: As directed, Install using continuous-thread hanger rods and elastomeric hangers, spring hangers or spring hangers with vertical-limit stop of size required to support weight of computer-room air conditioner.

1. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC" or Section 230548.13 "Vibration Controls for HVAC" as directed, fabricate brackets or supports as required.
2. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

E. Air-Cooled Refrigerant Condenser Mounting: As directed, Install using elastomeric pads, elastomeric mounts or restrained spring isolators on concrete base. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC" or Section 230548.13 "Vibration Controls for HVAC" As directed.

1. Minimum Deflection: As directed, 1/4 inch (6 mm) or 1 inch (25 mm).

3.2 CONNECTIONS

A. Piping installation requirements are specified in other heating, ventilating, and air-conditioning Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to computer-room air conditioners, allow space for service and maintenance.

C. Water and Drainage Connections: Comply with applicable requirements in Section 221116 "Domestic Water Piping." Provide adequate connections for water-cooled units, condensate drain, and humidifier flushing system.

D. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Provide shutoff valves and piping.

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
2. After installing computer-room air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Computer-room air conditioners will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

D. After startup service and performance test, change filters and flush humidifier.

3.4 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain computer-room air conditioners.

END OF SECTION 238123.13

SECTION 238123.14 - COMPUTER-ROOM AIR-CONDITIONERS, CONSOLE UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes console computer-room air conditioners.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

C. Shop Drawings: For computer-room air conditioners.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

D. Color Samples: For unit cabinet, discharge grille, and exterior louver and for each color and texture specified.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, elevations, and other details, drawn to scale, using input from installers of the items involved.

B. Seismic Qualification Certificates: For computer-room air conditioners, accessories, and components, from manufacturer.

C. Field quality-control reports.

D. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of computer-room air conditioners that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: As directed, Manufacturer's standard, but not less than five or 10 years from date of Substantial Completion.
2. Warranty Period for Humidifiers: Manufacturer's standard, but not less than three years from date of Substantial Completion.
3. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Computer-room air-conditioners, console units shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."

D. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

E. ASME Compliance: Fabricate and label water-cooled condenser shell to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

2.3 MANUFACTURED UNITS

A. Description: Split system consisting of evaporator section for floor or wall mounting and remote condensing section.

B. Evaporator Cabinet: Furniture-grade steel with baked-enamel finish; with front access and containing direct-drive centrifugal fans and two-speed motor.

1. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Condenser Cabinet: Steel with baked-enamel finish and containing compressor and condenser.

D. Refrigeration System:

1. Compressor: Scroll, with oil strainer, internal motor overload protection, resilient suspension system, and crankcase heater.
2. Refrigeration Circuit:

    a. Filter/dryer.
    b. Manual-reset high-pressure switch.
    c. Thermal-expansion valve with external equalizer.
    d. Sight glass with moisture indicator.
    e. Service shutoff valves.
    f. Charging valves.
    g. Hot-gas bypass.
    h. Refrigerant charge.

3. Refrigerant: R-407C or R-410A.
4. Refrigerant Evaporator Coil: Direct-expansion coil of seamless copper tubes expanded into aluminum fins.
5. As directed, Refrigerant line sets precharged in lengths of 15 feet (4.5 m) or 30 feet (9.0 m).
6. Refrigerant line sweat adapter kit to permit field brazing of refrigerant lines.

    a. Mount stainless-steel drain pan complying with ASHRAE 62.1 and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir under coil assembly.

7. Remote, Air-Cooled Refrigerant Condenser: As directed, Integral, copper-tube aluminum-fin coil with direct-drive, propeller or centrifugal fan.
8. Split system shall have suction- and liquid-line compatible fittings and refrigerant piping for field interconnection.

E. Electric-Resistance Reheat Coil:

1. Finned-tube electric elements with contactor and high-temperature-limit switches.
2. SCR to proportionally control the reheat elements providing precise temperature control.

F. Filter: Cleanable polypropylene monofilament over expanded aluminum with aluminum frame.

G. Filter: 1-inch- (25-mm-) thick, disposable, glass-fiber media.

1. Initial Resistance: Inches wg (Pa) As directed.
2. Recommended Final Resistance: Inches wg (Pa) As directed.
3. Pre-Filter Minimum Efficiency Reporting Value and Average Arrestance:

    a. MERV Rating: As directed, MERV 1, MERV 2, MERV 3 or MERV 4 and corresponding average arrestance according to ASHRAE 52.2.

4. Pre-Filter Minimum Efficiency Reporting Value:

    a. MERV 6 according to ASHRAE 52.2.

5. Filter Minimum Efficiency Reporting Value:

    a. MERV Rating: As directed, MERV 6 or MERV 13 according to ASHRAE 52.2.

H. Electrode Steam Humidifier: Self-contained, microprocessor-controlled unit with disposable, polypropylene-plastic cylinders and having field-adjustable steel electrodes and stainless-steel steam dispersion tube.

1. Plumbing Components and Valve Bodies: Plastic, linked by flexible rubber hosing, with water fill with air gap and solenoid valve incorporating built-in strainer, pressure-reducing and flow-regulating orifice, and drain with integral air gap.
2. Control: Fully modulating to provide gradual modulation from zero to 100 percent capacity with field-adjustable maximum capacity; with high-water probe.
3. Drain Cycle: Field-adjustable drain duration and drain interval.

I. Disconnect Switch: Non-automatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.

J. Epoxy-coated, step-down transformer suitable for mounting on the outdoor condensing unit to provide it with 277-V ac input power.

K. Control System:

1. Microprocessor, wall-mounted panel interfacing with the unit controls.
2. Contactors.
3. Control transformer with circuit breaker.
4. Solid-state, temperature- and humidity-control modules.
5. Solid-state, unit-mounted control panel with start-stop switch, adjustable humidity set point, and adjustable temperature set point.
6. Remote panel to monitor and change temperature and humidity set points and sensitivities of the unit and unit alarms.

L. Fan Motors:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load does not require motor to operate in service factor range above 1.0.
3. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

2.4 CAPACITIES AND CHARACTERISTICS

A. Unit Configuration: As directed, Draw or Blow through.

B. Supply-Air Fan:

1. Airflow: As directed.

2. Minimum Static Pressure: As directed.
3. Motor Size: hp as directed.

C. Refrigeration System:

1. Unit Energy Efficiency: As directed, COP or EER.
2. Refrigerant Compressor:

    a. Total Unit Cooling Capacity: As directed.
    b. Sensible Unit Cooling Capacity: As directed.
    c. Number of Compressors: As directed, One or Two.
    d. Motor Size: hp as directed.

3. Refrigerant Evaporator Coil:

    a. Cooling Capacity: As directed.
    b. Entering-Air Dry-Bulb Temperature: As directed.
    c. Entering-Air Wet-Bulb Temperature: As directed.
    d. Leaving-Air Dry-Bulb Temperature: As directed.
    e. Leaving-Air Wet-Bulb Temperature: As directed.

4. Air-Cooled Refrigerant Condenser:

    a. Cooling Capacity: As directed.
    b. Entering-Air Temperature: As directed.
    c. Number of Condenser Fan Motors: As directed.
    d. Condenser Fan Motors: hp As directed.

D. Electric-Resistance Reheating Coil:

1. Total Capacity: As directed.
2. Stages of Heating: As directed, 1 or 2.

E. Humidifier:

1. Total: As directed.
2. Input: As directed.

F. Electrical Characteristics:

1. Volts: As directed, 120, 208, 240, 277 or 480.
2. Phase: As directed, Single or Three.
3. Hertz: 60.
4. Full-Load Amperes: As directed.
5. Minimum Circuit Ampacity: As directed.
6. Maximum Overcurrent Protection: As directed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Layout and install computer-room air conditioners and suspension system coordinated with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

B. Install computer-room air conditioners coordinated with computer-room access flooring Installer.

C. Install computer-room air conditioners level and plumb, maintaining manufacturer's recommended clearances. Install according to AHRI Guideline B.

D. Computer-Room Air-Conditioner Mounting: Install using elastomeric pads, elastomeric mounts or restrained spring isolators. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC" or Section 230548.13 "Vibration Controls for HVAC" As directed

1. Minimum Deflection: As directed, 1/4 inch (6 mm) or 1 inch (25 mm).

E. Air-Cooled Refrigerant Condenser Mounting: As directed, Install using elastomeric pads, elastomeric mounts or restrained spring isolators on concrete base. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC" or Section 230548.13 "Vibration Controls for HVAC" As directed

1. Minimum Deflection: As directed, 1/4 inch (6 mm) or 1 inch (25 mm).

3.2 CONNECTIONS

A. Piping installation requirements are specified in other heating, ventilating, and air-conditioning Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to computer-room air conditioners, allow space for service and maintenance.

C. Drainage Connections: Comply with applicable requirements in Section 221116 "Domestic Water Piping." Provide adequate connections for water-cooled units, condensate drain, and humidifier flushing system.

D. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Provide shutoff valves and piping.

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Inspect for and remove shipping bolts, blocks, and tie-down straps.

2. After installing computer-room air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Computer-room air conditioners will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

D. After startup service and performance test, change filters and flush humidifier.

3.4 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain computer-room air conditioners.

END OF SECTION 238123.14

SECTION 238123.18 - COMPUTER-ROOM, RACK-COOLING EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Central refrigeration units.
2. Rear-mounted rack-cooling modules.
3. Top-mounted rack-cooling modules.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: For central refrigeration units and rack-cooling units.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

D. Color Samples: For unit cabinets and discharge grille and for each color and texture specified.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, elevations, and other details, drawn to scale, using input from installers of the items involved.

B. Seismic Qualification Certificates: For computer-room rack-cooling equipment, accessories, and components, from manufacturer.

C. Field quality-control reports.

D. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of computer-room, rack-cooling equipment that fails in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: As directed, Manufacturer's standard, but not less than five or 10 years from date of Substantial Completion.
2. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Computer-room, rack-cooling equipment shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."

D. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

E. ASME Compliance: Fabricate and label water-cooled condenser shell to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

2.3 CENTRAL REFRIGERATION UNIT

A. Description: Packaged, factory assembled, wired, and piped; consisting of cabinet, refrigeration system, heat exchanger, and controls.

B. Cabinet and Frame: Powder-painted cabinet, hinged doors, and welded tubular steel frame.

C. Pumps: As directed, One or Two, factory piped and wired.

D. Heat Exchanger: Brazed plate, Type 316 stainless-steel plates.

E. Chilled-Water Valve: Modulating, two-way valve, responding to room dew point temperature changes to optimize the supply water temperature to avoid condensation.

F. Compressor: Scroll type with a suction gas-cooled motor, vibration isolators, thermal overloads, manual reset high-pressure switch, and pump down low-pressure switch.

G. Control System:

1. Unit-mounted microprocessor panel interfacing with the unit controls consisting of contactors, control transformer with circuit breaker, solid-state temperature- and humidity-control modules and start-stop switch, adjustable humidity set point, and adjustable temperature set point.
2. Remote panel to monitor and change temperature and humidity set points and sensitivities of the unit and unit alarms.

H. Capacities and Characteristics:

1. Refrigeration System:

a. Unit Energy Efficiency: As directed, COP or EER.
b. Refrigerant Compressor:

1) Total Unit Cooling Capacity: As directed.

c. Sensible Unit Cooling Capacity: As directed.
d. Number of Compressors: As directed, One or Two.
e. Motor Size: hp as directed.
f. Refrigerant Heat Exchanger:

1) Cooling Capacity: As directed.
2) Entering-Primary Refrigerant Temperature: As directed.
3) Leaving-Primary Refrigerant Temperature: As directed.
4) Entering-Secondary Refrigerant Temperature: As directed.
5) Leaving-Secondary Refrigerant Temperature: As directed.

g. Water-Cooled Heat Exchanger:

1) Cooling Capacity: As directed.
2) Primary Water Flow: As directed.
3) Cooling Medium: As directed, Water or Glycol solution.
4) Entering-Water Temperature: As directed.
5) Leaving-Water Temperature: As directed.
6) Fluid Pressure Drop: As directed.

2. Electrical Characteristics:

a. Volts: As directed, 120, 208, 240, 277 or 480.
b. Phase: As directed, Single or Three.
c. Hertz: 60.

d. Full-Load Amperes: As directed.
e. Minimum Circuit Ampacity: As directed.
f. Maximum Overcurrent Protection: As directed.

2.4 REAR-MOUNTED RACK-COOLING MODULE

A. Description: Packaged, factory assembled, prewired, consisting of cabinet, refrigeration coils and controls.

B. Cabinet and Frame: Powder-painted cabinet, hinged doors, and welded tubular steel frame with self-locking door latch.

C. Cooling Coils: Two aluminum microchannels with drip pan.

D. Dual power cords with 20-A, 120-V ac receptacle.

E. Refrigerant Piping: ACR copper tubing with brazed joints. Factory-installed piping shall be leak tested and pressure tested prior to shipment from the factory. Factory-supplied pipe connections for field piping.

F. Rack Mounting Kit: Black painted steel.

G. Capacities and Characteristics:

1. Supply-Air Fan:

a. Number of Fans: Six axial fans with finger guards.
b. Airflow: As directed.
c. Minimum Static Pressure: As directed.
d. Refrigerant Heat Exchanger:

1) Cooling Capacity: As directed.
2) Entering-Primary Refrigerant Temperature: As directed.
3) Entering-Secondary Refrigerant Temperature: As directed.
4) Leaving-Primary Refrigerant Temperature: As directed.
5) Leaving-Secondary Refrigerant Temperature: As directed.

2. Electrical Characteristics:

a. Motor Size: hp as directed.
b. Volts: As directed, 120, 208, 240, 277 or 480.
c. Phase: As directed, Single or Three.
d. Hertz: 60.
e. Full-Load Amperes: As directed.
f. Minimum Circuit Ampacity: As directed.
g. Maximum Overcurrent Protection: As directed.

2.5 TOP-MOUNTED RACK-COOLING MODULE

A. Description: Packaged, factory assembled, prewired, and prepiped; consisting of cabinet cooling coil and controls.

B. Cabinet and Frame: Powder-painted cabinet, hinged doors, and welded tubular steel frame.

C. Cooling Coil: Aluminum microchannel with drip pan.

D. Electrical Components:

1. Each module shall be equipped with two sets of two 10-foot (3-m) power cords with automatic switching, primary and secondary, attached with IEC connectors to the rear of the unit.
2. Each cord shall have a NEMA 5-15P (IEC 320-C14) plug at the end.
3. CE-listed version of the unit shall have permanently attached power cords.

E. Refrigerant Piping: ACR copper tubing with brazed joints. Factory-installed piping shall be leak tested and pressure tested prior to shipment from the factory. Factory-supplied pipe connections for field piping.

F. Discharge Diffusers: Mounted on the unit front, discharging to one or both sides.

G. Capacities and Characteristics:

1. Supply-Air Fan:

a. Number of Fans: Six axial fans with finger guards.
b. Airflow: As directed.
c. Minimum Static Pressure: As directed.
d. Refrigerant Heat Exchanger:

1) Cooling Capacity: As directed.
2) Entering-Primary Refrigerant Temperature: As directed.
3) Entering-Secondary Refrigerant Temperature: As directed.
4) Leaving-Primary Refrigerant Temperature: As directed.
5) Leaving-Secondary Refrigerant Temperature: As directed.

2. Electrical Characteristics:

a. Motor Size: hp as directed.
b. Volts: As directed, 120, 208, 240, 277 or 480.
c. Phase: As directed, Single or Three.
d. Hertz: 60.
e. Full-Load Amperes: As directed.
f. Minimum Circuit Ampacity: As directed.
g. Maximum Overcurrent Protection: As directed.

2.6 REFRIGERANT

A. Refrigerant Type: R-134A.

2.7 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load does not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Layout and install computer-room rack-cooling equipment and suspension system coordinated with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

B. Install computer-room, rack-cooling equipment level and plumb, maintaining manufacturer's recommended clearances. Install according to AHRI Guideline B.

C. Suspended Units: As directed, Install using continuous-thread hanger rods and elastomeric hangers, spring hangers or spring hangers with vertical-limit stop of size required to support weight of computer-room, rack-cooling equipment.

1. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC" or Section 230548.13 "Vibration Controls for HVAC" As directed. Fabricate brackets or supports as required.
2. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

3.2 CONNECTIONS

A. Piping installation requirements are specified in other heating, ventilating, and air-conditioning Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to computer-room rack-cooling equipment, allow space for service and maintenance.

C. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Provide shutoff valves and piping.

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
2. After installing computer-room rack-cooling equipment and after electrical circuitry has been energized, test for compliance with requirements.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Computer-room, rack-cooling equipment will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.4 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain computer-room, rack-cooling equipment.

END OF SECTION 238123.18

SECTION 238126 - SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes split-system air-conditioning and heat-pump units consisting of separate evaporator-fan and compressor-condenser components.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Sustainable Design Submittals:

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1.3 INFORMATIONAL SUBMITTALS

A. Warranty: Sample of special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - " Procedures," and Section 7 - "Construction and System Start-up."

C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.

1. Warranty Period:

a. For Compressor: As directed, One or Five year(s) from date of Substantial Completion.
b. For Parts: As directed, One or Five year(s) from date of Substantial Completion.
c. For Labor: As directed, One or Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 INDOOR UNITS (5 TONS (18 kW) OR LESS)

A. Concealed Evaporator-Fan Components:

1. Chassis: Galvanized steel with flanged edges, removable panels for servicing, and insulation on back of panel.
2. Insulation: Faced, glass-fiber duct liner.
3. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
4. Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm); leak tested to 300 psig (2070 kPa) underwater; with a two-position control valve.
5. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements; with refractory ceramic support bushings, automatic-reset thermal cutout, built-in magnetic contactors, manual-reset thermal cutout, airflow proving device, and one-time fuses in terminal box for overcurrent protection.
6. Fan: Forward-curved, double-width wheel of galvanized steel; directly connected to motor.
7. Fan Motors:

a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
c. Wiring Terminations: Connect motor to chassis wiring with plug connection.

8. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
9. Filters: Permanent, cleanable.
10. Condensate Drain Pans:

a. Fabricated with one or two percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection as directed.

1) Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
2) Depth: A minimum of 2 inches (50 mm) deep.

b. As directed, Single-wall, galvanized or stainless-steel sheet.
c. As directed, Double-wall, galvanized or stainless-steel sheet with space between walls filled with foam insulation and moisture-tight seal.
d. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end or both ends of pan as directed..

1) Minimum Connection Size: As directed, NPS 1 (DN 25) or NPS 2 (DN 50).

e. Pan-Top Surface Coating: Asphaltic waterproofing compound.
f. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

B. Floor-Mounted, Evaporator-Fan Components:

1. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect.

a. Discharge Grille: As directed, Steel with surface-mounted frame or Welded steel bars forming a linear grille and welded into supporting panel as directed..
b. Insulation: Faced, glass-fiber duct liner.
c. Drain Pans: Galvanized steel, with connection for drain; insulated.

2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
3. Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm); leak tested to 300 psig (2070 kPa) underwater; with a two-position control valve.
4. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements; with refractory ceramic support bushings, automatic-reset thermal cutout, built-in magnetic contactors, manual-reset thermal cutout, airflow proving device, and one-time fuses in terminal box for overcurrent protection.
5. Fan: Direct drive, centrifugal, with power-induced outside air.
6. Fan Motors:

a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
b. Multitapped, multispeed with internal thermal protection and permanent lubrication.

7. Air Filtration Section:

a. General Requirements for Air Filtration Section:

1) Comply with NFPA 90A.
2) Minimum MERV according to ASHRAE 52.2.
3) Filter-Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lifted out from access plenum.

b. Disposable Panel Filters:

1) Factory-fabricated, viscous-coated, flat-panel type.
2) Thickness: As directed, 1 inch (25 mm) or 2 inches (50 mm).
3) Dust-Holding Capacity: As directed.
4) Initial Resistance: As directed.
5) Recommended Final Resistance: As directed.
6) MERV according to ASHRAE 52.2: 5.
7) Media: Interlaced glass fibers sprayed with nonflammable adhesive and antimicrobial agent.
8) Frame: Galvanized steel, with metal grid on outlet side, steel rod grid on inlet side, and hinged; with pull and retaining handles.

c. Extended-Surface, Disposable Panel Filters:

1) Factory-fabricated, dry, extended-surface type.
2) Thickness: As directed, 1 inch (25 mm), 2 inches (50 mm) or 4 inches (100 mm).
3) Dust-Holding Capacity: As directed.
4) Initial Resistance: As directed.
5) Recommended Final Resistance: As directed.
6) MERV according to ASHRAE 52.2: 7.
7) Media: Fibrous material formed into deep-V-shaped pleats with antimicrobial agent and held by self-supporting wire grid.
8) Media-Grid Frame: As directed, Nonflammable cardboard, Galvanized steel or Fire-retardant, 3/4-inch (20-mm) particleboard with gaskets.
9) Mounting Frames: Welded, galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

C. Wall-Mounted, Evaporator-Fan Components:

1. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.
2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
3. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements; with refractory ceramic support bushings, automatic-reset thermal cutout, built-in magnetic contactors, manual-reset thermal cutout, airflow proving device, and one-time fuses in terminal box for overcurrent protection.
4. Fan: Direct drive, centrifugal.
5. Fan Motors:

a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
c. Enclosure Type: Totally enclosed, fan cooled.
d. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
e. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
f. As directed, Mount unit-mounted disconnect switches on exterior or interior of unit as directed.

6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
7. Condensate Drain Pans:

a. Fabricated with one or two percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection as directed.

1) Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
2) Depth: A minimum of 1 inch (25 mm) deep.

b. Single-wall, galvanized or stainless-steel sheet as directed.
c. Double-wall, galvanized or stainless-steel sheet with space between walls filled with foam insulation and moisture-tight seal As directed.
d. Drain Connection: Located at lowest point of pan and sized to prevent overflow. As directed, Terminate with threaded nipple on one end or both ends of pan.

1) Minimum Connection Size: As directed, NPS 1 (DN 25) or NPS 2 (DN 50).

e. Pan-Top Surface Coating: Asphaltic waterproofing compound.

8. Air Filtration Section:

a. General Requirements for Air Filtration Section:

1) Comply with NFPA 90A.
2) Minimum MERV according to ASHRAE 52.2.
3) Filter-Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lifted out from access plenum.

b. Disposable Panel Filters:

1) Factory-fabricated, viscous-coated, flat-panel type.
2) Thickness: As directed, 1 inch (25 mm) or 2 inches (50 mm).
3) Dust-Holding Capacity: As directed.

4) Initial Resistance: As directed.
5) Recommended Final Resistance: As directed.
6) MERV according to ASHRAE 52.2: 5.
7) Media: Interlaced glass fibers sprayed with nonflammable adhesive and antimicrobial agent.
8) Frame: Galvanized steel, with metal grid on outlet side, steel rod grid on inlet side, and hinged; with pull and retaining handles.

c. Extended-Surface, Disposable Panel Filters:

1) Factory-fabricated, dry, extended-surface type.
2) Thickness: As directed, 1 inch (25 mm), 2 inches (50 mm) or 4 inches (100 mm).
3) Dust-Holding Capacity: As directed.
4) Initial Resistance: As directed.
5) Recommended Final Resistance: As directed.
6) MERV according to ASHRAE 52.2: 7.
7) Media: Fibrous material formed into deep-V-shaped pleats with antimicrobial agent and held by self-supporting wire grid.
8) Media-Grid Frame: As directed, Nonflammable cardboard, Galvanized steel or Fire-retardant, 3/4-inch (20-mm) particleboard with gaskets.
9) Mounting Frames: Welded, galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

2.3 OUTDOOR UNITS (5 TONS (18 kW) OR LESS)

A. Air-Cooled, Compressor-Condenser Components:

1. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.

a. Compressor Type: Scroll.
b. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
c. Refrigerant: As directed, R-22, R-407C or R-410A.
d. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 206/110.

3. Heat-Pump Components: Reversing valve and low-temperature-air cutoff thermostat.
4. Fan: Aluminum-propeller type, directly connected to motor.
5. Motor: Permanently lubricated, with integral thermal-overload protection.
6. Low Ambient Kit: Permits operation down to 45 deg F (7 deg C).
7. Mounting Base: Polyethylene.

2.4 ACCESSORIES

A. Control equipment and sequence of operation are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."

B. Thermostat: Low voltage with subbase to control compressor and evaporator fan.

C. Thermostat: Wireless infrared functioning to remotely control compressor and evaporator fan, with the following features:

1. Compressor time delay.
2. 24-hour time control of system stop and start.
3. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
4. Fan-speed selection including auto setting.

D. Automatic-reset timer to prevent rapid cycling of compressor.

E. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.

F. Drain Hose: For condensate.

G. Monitoring:

1. Monitor constant and variable motor loads.
2. Monitor variable-frequency-drive operation.
3. Monitor economizer cycle.
4. Monitor cooling load.
5. Monitor air distribution static pressure and ventilation air volumes.

2.5 CAPACITIES AND CHARACTERISTICS

A. Cooling Capacity:

1. Total: As directed.
2. Sensible: As directed.
3. SEER: As directed, 10.0, 12.0, 13.0, 14.0 or 16.0.
4. EER: As directed, 10.0, 12.0, 13.0, 14.0 or 16.0.
5. Moisture Removal: As directed.
6. Entering-Air Temperature:

    a. Dry Bulb: As directed.
    b. Wet Bulb: As directed.

7. Leaving-Air Temperature:

    a. Dry Bulb: As directed.
    b. Wet Bulb: As directed.

B. Heating Capacity:

1. Type: As directed, Electric or Natural gas.
2. Total Capacity: As directed.
3. Air-Temperature Rise: As directed.
4. Coefficient of Performance: As directed.
5. Heating Season Performance Factor: As directed, 7.7 or 8.0.
6. Hot Water:

    a. Entering-Water Temperature: As directed.
    b. Leaving-Water Temperature: As directed.
    c. Water Flow: As directed.
    d. Water Pressure Drop: As directed.

7. Electric Heating Coil:

    a. Total Capacity: kW as directed.
    b. Volts: As directed, 120, 208, 230 or 460 V ac.
    c. Phase: As directed, Single or Poly.
    d. Frequency: 60 Hz.
    e. Steps: As directed, One, Two or Three.

8. Gas Heating Section:

    a. Input: As directed.
    b. Output: As directed.

C. Auxiliary Heating Capacity:

1. Type: As directed, Electric, Natural gas or Propane.
2. Total Capacity: As directed.
3. Volts: As directed, 120, 208, 230 or 460 V ac.
4. Phase: As directed, Single or Poly.
5. Frequency: 60 Hz.
6. Steps: As directed, One, Two or Three.
7. Input: As directed.
8. Output: As directed.

D. Indoor Unit:

1. Fan Motor Electrical Characteristics:

    a. Volts: As directed, 120, 208, 230 or 460 V ac.
    b. Phase: As directed, Single or Poly.
    c. Frequency: 60 Hz.

2. Airflow: As directed.

E. Outdoor Unit:

1. Type: As directed, Air cooled or Water cooled.

2. Electrical Characteristics:

    a. Volts: 120, 208, 230 or 460 as directed.
    b. Phase: Single or Poly as directed.
    c. Frequency: 60 Hz.
    d. Minimum Circuit Ampacity: as directed.
    e. Maximum Overcurrent Protection: as directed.
    f. Fan Motor Full-Load Amperes: as directed.
    g. Compressor Full-Load Amperes: as directed.
    h. Compressor Locked-Rotor Amperes: as directed.

3. Sound-Pressure Level: dBa as directed.
4. Water:

    a. Entering-Water Temperature: As directed.
    b. Water Flow: As directed.
    c. Water Pressure Drop: As directed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

C. Install roof-mounted, compressor-condenser components on equipment supports specified in Section 077200 "Roof Accessories." Anchor units to supports with removable, cadmium-plated fasteners.

D. Equipment Mounting:

1. Install ground-mounted, compressor-condenser components on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete"as directed.
2. Install ground-mounted, compressor-condenser components on polyethylene mounting base.
3. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
4. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

E. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

1. Water Coil Connections: Comply with requirements specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Connect hydronic piping to supply and return coil connections with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.
2. Remote, Water-Cooled Condenser Connections: Comply with requirements specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Connect hydronic piping to supply and return connections with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.

B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

C. Duct Connections: Duct installation requirements are specified in Section 233113 "Metal Ducts." Drawings indicate the general arrangement of ducts. Connect supply and return ducts to split-system air-conditioning units with flexible duct connectors. Flexible duct connectors are specified in Section 233300 "Air Duct Accessories."

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

D. Prepare test and inspection reports.

3.4 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 238126

SECTION 238129 – VARIABLE-REFRIGERANT-FLOW HVAC SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes complete VRF HVAC system(s) including, but not limited to, delegated design and the following components to make a complete operating system(s) according to requirements indicated:

1. Indoor, concealed, ceiling-mounted units for ducting.
2. Indoor, concealed, floor-mounted units for ducting.
3. Indoor, exposed, wall-mounted units.
4. Indoor, recessed, ceiling-mounted units.
5. Indoor, suspended, ceiling-mounted units.
6. Outdoor, air-source, heat pump units.
7. Outdoor, air-source heat recovery units.
8. Heat recovery control units.
9. System controls.
10. System refrigerant and oil.
11. System condensate drain piping.
12. System hydronic piping.
13. System refrigerant piping.
14. Metal hangers and supports.
15. Metal framing systems.
16. Fastener systems.
17. Pipe stands.
18. Miscellaneous support materials.
19. Piping and tubing insulation.
20. System control cable and raceways.

1.2 DEFINITIONS

A. Air-Conditioning System Operation: System capable of operation with all zones in cooling only.

B. Heat-Pump System Operation: System capable of operation with all zones in either heating or cooling, but not with simultaneous heating and cooling zones that transfer heat between zones.

C. Heat Recovery System Operation: System capable of operation with simultaneous heating and cooling zones that transfer heat between zones.

D. HRCU: Heat Recovery Control Unit. HRCUs are used in heat recovery VRF HVAC systems to manage and control refrigerant between indoor units to provide simultaneous heating and cooling zones. "Heat Recovery Control Unit" is the term used by ASHRAE for what different manufacturers term as branch circuit controller, branch selector box, changeover box, flow selector unit, mode change unit, and other such terms.

E. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

F. Plenum: A space forming part of the air distribution system to which one or more air ducts are connected. An air duct is a passageway, other than a plenum, for transporting air to or from heating, ventilating, or air-conditioning equipment.

G. Three-Pipe System Design: One high pressure refrigerant vapor line, one low pressure refrigerant vapor line, and one refrigerant liquid line connect a single outdoor unit or multiple manifold outdoor units in a single system to associated system HRCUs. One liquid line and refrigerant vapor line connect HRCUs to associated indoor units.

H. Two-Pipe System Design: One refrigerant vapor line and one refrigerant liquid line connect a single outdoor unit or multiple manifold outdoor units in a single system to associated system HRCUs. One refrigerant liquid line and refrigerant vapor line connect HRCUs to associated indoor units. HRCUs used in two pipe systems act as an intermediate heat exchanger and include diverting valves and gas/liquid separators to move high and low pressure refrigerant between indoor units.

I. VRF: Variable refrigerant flow.

1.3 ACTION SUBMITTALS

A. Product data.

B. Sustainable Design Submittals:

C. Shop Drawings: For VRF HVAC systems.

1. Include plans, elevations, sections, and mounting or attachment details As directed.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
4. Include diagrams and details of refrigerant piping and tubing showing installation requirements for manufacturer-furnished divided flow fittings.
5. Include diagrams for power, signal, and control wiring.

D. Samples for Initial Selection: For fully and partially exposed indoor units with factory finishes viewable by occupants.

E. Delegated-Design Submittals:

1. Include design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
2. Include design calculations with corresponding diagram of refrigerant piping and tubing sizing for each system installed.

3. Include design calculations with corresponding floor plans indicating that refrigerant concentration limits are within allowable limits of ASHRAE 15 and governing codes.
4. Include calculations showing that system travel distance for refrigerant piping and controls cabling are within horizontal and vertical travel distances set by manufacturer. Provide a comparison table for each system installed.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, elevations, sections, and details, drawn to scale, using input from installers of the items involved.

B. Qualification Data:

1. For Installer.
2. For VRF HVAC system manufacturer.
3. For VRF HVAC system provider.

C. Seismic Qualification Data: Certificates, for equipment, accessories, and components, from manufacturer.

D. Product Certificates: For each type of product.

E. Product test reports.

F. Source quality-control reports.

G. Field quality-control reports.

H. Sample warranties.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On CD or DVD, USB media, or approved cloud storage platform, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.6 QUALITY ASSURANCE

A. Factory-Authorized Service Representative Qualifications:

1. Authorized representative of, and trained by, VRF HVAC system manufacturer.
2. In-place facility located within distance of Project As directed.

3. As directed, demonstrated past experience with products being installed for period within three or five consecutive years before time of bid.
4. Demonstrated past experience on five projects of similar complexity, scope, and value.

    a. Each person assigned to Project shall have demonstrated past experience.

5. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
6. Service and maintenance staff assigned to support Project during warranty period.
7. Product parts inventory to support ongoing system operation for a period of not less than five years after Substantial Completion.
8. VRF HVAC system manufacturer's backing to take over execution of Work if necessary to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.

B. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by VRF HVAC system manufacturer.

1. Each employee shall be certified by manufacturer for proper installation of systems, including, but not limited to, equipment, piping, controls, and accessories indicated and furnished for installation.
2. Installer certification shall be valid and current for duration of Project.
3. Retain copies of Installer certificates on-site and make available on request.
4. Each person assigned to Project shall have demonstrated past experience.

    a. As directed, demonstrated past experience with products being installed for period within three or five consecutive years before time of bid.
    b. As directed, Demonstrated past experience on five projects of similar complexity, scope, and value.

5. Installers shall have staffing resources of competent, trained, and experienced full-time employees that are assigned to execute work according to schedule.

C. ISO Compliance: System equipment and components furnished by VRF HVAC system manufacturer shall be manufactured in an ISO 9001 and ISO 14001 facility.

1.7 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace equipment and components that fail(s) in materials or workmanship within specified warranty period.

1. Warranty Period:

    a. For Compressor: As directed, Five, Seven or 10 year(s) from date of Substantial Completion.
    b. For Parts, Including Controls: As directed, Five, Seven or 10 year(s) from date of Substantial Completion.
    c. For Labor: As directed, Five, Seven or 10 year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 SYSTEM DESCRIPTION

A. Direct-expansion (DX) VRF HVAC system(s) with variable capacity in response to varying cooling and heating loads. System shall consist of multiple indoor units, HRCUs, outdoor unit(s), piping, controls, and electrical power to make complete operating system(s) complying with requirements indicated.

1. Two-pipe or three-pipe system design.
2. As directed, System(s) operation, air-conditioning, heat pump or heat recovery as indicated on Drawings.
3. Each system with one refrigerant circuit shared by all indoor units connected to system.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. AHRI Compliance: System and equipment performance certified according to AHRI 1230 and products listed in AHRI directory.

D. ASHRAE Compliance:

1. ASHRAE 15: For safety code for mechanical refrigeration.
2. ASHRAE 62.1: For indoor air quality.
3. ASHRAE 135: For control network protocol with remote communication.
4. ASHRAE/IES 90.1 Compliance: For system and component energy efficiency.

E. UL Compliance: Comply with UL 1995.

2.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: As directed, engage a qualified professional engineer or specialist, as defined in Section 014000 "Quality Requirements," to design complete and operational VRF HVAC system(s) complying with requirements indicated.

1. Provide system refrigerant calculations.

a. Refrigerant concentration limits shall be within allowable limits of ASHRAE 15 and governing codes.
b. Indicate compliance with manufacturer's maximum vertical and horizontal travel distances. Prepare a comparison table for each system showing calculated distances compared to manufacturer's maximum allowed distances.

2. Include a mechanical ventilation system and gas detection system as required to comply with ASHRAE 15 and governing codes.
3. System Refrigerant Piping and Tubing:

a. Arrangement: Arrange piping to interconnect indoor units, HRCUs, and outdoor unit(s) in compliance with manufacturer requirements and requirements indicated.
b. Routing: Conceal piping above ceilings and behind walls to maximum extent possible.
c. Sizing: Size piping system, using a software program acceptable to manufacturer, to provide performance requirements indicated. Consider requirements to accommodate future change requirements.

4. System Controls:

a. Network arrangement.
b. Network interface with other building systems.
c. Product selection.
d. Sizing.

B. Service Access:

1. Provide and document service access requirements.
2. Locate equipment, system isolation valves, and other system components that require service and inspection in easily accessible locations. Avoid locations that are difficult to access if possible.
3. Where serviceable components are installed behind walls and above inaccessible ceilings, provide finished assembly with access doors or panels to gain access. Properly size the openings to allow for service, removal, and replacement.
4. If less than full and unrestricted access is provided, locate components within an 18-inch (450-mm) reach of the finished assembly.
5. Where ladder access is required to service elevated components, provide an installation that provides for sufficient access within ladder manufacturer's written instructions for use.
6. Comply with OSHA regulations.

C. System Design and Installation Requirements:

1. Design and install systems indicated according to manufacturer's recommendations and written instructions.
2. Where manufacturer's requirements differ from requirements indicated, contact Architect for direction. The most stringent requirements should apply unless otherwise directed in writing by Architect.

D. System Adaptability to Future Changes: Arrange and size system refrigerant piping to accommodate future changes to system without having to resize and replace existing refrigerant piping.

1. Future changes to system(s) indicated on Drawings.
2. As directed, each branch circuit shall accommodate addition of one or two indoor unit(s) with unit capacity equal to largest, smallest or average indoor unit connected to the branch circuit.
3. As directed, each branch circuit shall accommodate deletion of one or two indoor unit(s) with unit capacity equal to largest, smallest or average indoor unit connected to the branch circuit.

E. Isolation of Equipment: Provide isolation valves to isolate each HRCU, indoor unit and outdoor unit for service, removal, and replacement without interrupting system operation.

F. System Capacity Ratio: The sum of connected capacity of all indoor units shall be within the following range of outdoor-unit rated capacity:

1. As directed, Not less than 50 or 60 percent.
2. As directed, Not more than 130 or 150 percent.
3. Range acceptable to manufacturer.

G. System Turndown: Stable operation down to 20 percent of outdoor-unit capacity.

H. System Auto Refrigerant Charge: Each system shall have an automatic refrigerant charge function to ensure the proper amount of refrigerant is installed in system.

I. Outdoor Conditions:

1. Suitable for outdoor ambient conditions encountered.

    a. Design equipment and supports to withstand wind loads of governing code and ASCE/SEI 7.
    b. Design equipment and supports to withstand snow and ice loads of governing code and ASCE/SEI 7.
    c. Provide corrosion-resistant coating for components and supports where located in coastal or industrial climates that are known to be harmful to materials and finishes.

2. Maximum System Operating Outdoor Temperature: See Drawings.
3. Minimum System Operating Outdoor Temperature: See Drawings.

J. Seismic Performance: VRF HVAC system(s) shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the system will remain in place without separation of any parts when subjected to the seismic forces specified and the system will be fully operational after the seismic event."
2. Component Importance Factor: As directed, 1.5 or 1.0.

K. Sound Performance: Sound levels generated by operating HVAC equipment shall be within requirements indicated.

1. Indoor: See Drawings or Within design guidelines of "2015 ASHRAE HANDBOOK-HVAC Applications"
2. Outdoor: As directed, See Drawings or Within ordinance of governing authorities.

L. Thermal Movements: Allow for controlled thermal movements from ambient, surface, and system temperature changes.

M. Capacities and Characteristics: As indicated on Drawings.

2.4 INDOOR, CONCEALED, CEILING-MOUNTED UNITS FOR DUCTING

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to ductwork, piping, power, and controls field connections.

B. Cabinet:

1. Material: As directed, Galvanized or painted steel.
2. Insulation: Manufacturer's standard internal insulation, complying with ASHRAE 62.1, to provide thermal resistance and prevent condensation.
3. Duct Connections: Extended collar or flange, or designated exterior cabinet surface, designed for attaching field-installed ductwork.
4. Mounting: Manufacturer-designed provisions for field installation.
5. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. DX Coil Assembly:

1. Coil Casing: Aluminum, galvanized, or stainless steel.
2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
3. Coil Tubes: Copper, of diameter and thickness required by performance.
4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
5. Unit Internal Tubing: Copper tubing with brazed joints.
6. Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
7. Field Piping Connections: Manufacturer's standard.
8. Factory Charge: Dehydrated air or nitrogen.
9. Testing: Factory pressure tested and verified to be without leaks.

D. Drain Assembly:

1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
2. Condensate Removal: Unit-mounted pump or other integral lifting mechanism, capable of lifting drain water to an elevation above top of cabinet.
3. Field Piping Connection: Non-ferrous material with threaded NPT.

E. Fan and Motor Assembly:

1. Fan(s):

    a. Direct-drive arrangement.
    b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
    c. Fabricated from non-ferrous components or ferrous components with corrosion-resistant finish.
    d. Wheels statically and dynamically balanced.

2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.

4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
5. Vibration Control: Integral isolation to dampen vibration transmission.

F. Filter Assembly:

1. Access: Bottom, side, or rear to accommodate field installation without removing ductwork and to accommodate filter replacement without need for tools.
2. Efficiency: As directed, ASHRAE 52.2, MERV 7, ASHRAE 52.2, MERV 11 or ASHRAE 52.2, MERV 13.
3. Media: If more than one filter type is indicated, Contractor has option to choose.

    a. Replaceable: Extended surface, panel, or cartridge with antimicrobial treatment fiber media.
    b. Washable: Manufacturer's standard filter with antimicrobial treatment.

G. Unit Accessories:

1. Outdoor Air Ventilation Kit: Connection, motorized damper, and control sized to allow sequence of operation indicated on Drawings.
2. Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.

H. Unit Controls:

1. Enclosure: Metal, suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors:

    a. Unit inlet air temperature.
    b. Coil entering refrigerant temperature.
    c. Coil leaving refrigerant temperature.

4. Field-Customizable I/O Capability:

    a. Analog Inputs: As directed, Two, Three or Four for use in customizable control strategies.
    b. Digital Inputs: As directed, Two, Three or Four for use in customizable control strategies.
    c. Digital Outputs: As directed, Two, Three or Four for use in customizable control strategies.

5. Features and Functions:

    a. Self-diagnostics.
    b. Time delay.
    c. Auto-restart.
    d. External static pressure control.
    e. Auto operation mode.
    f. Manual operation mode.

g. Filter service notification.
h. Power consumption display.
i. Drain assembly high water level safety shutdown and notification.
j. Run test switch.

6. Communication: Network communication with other indoor and outdoor units.
7. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
8. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

I. Unit Electrical:

1. Enclosure: Metal, suitable for indoor locations.
2. Field Connection: Single point connection to power unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in metal raceways.

2.5 INDOOR, CONCEALED, FLOOR-MOUNTED UNITS FOR DUCTING

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to ductwork, piping, power, and controls field connections.

B. Cabinet:

1. Material: Galvanized or painted steel.
2. Insulation: Manufacturer's standard internal insulation, complying with ASHRAE 62.1, to provide thermal resistance and prevent condensation.
3. Duct Connections: Extended collar or flange, or designated exterior cabinet surface, designed for attaching field-installed ductwork.
4. Mounting: Manufacturer-designed provisions for field installation.
5. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. DX Coil Assembly:

1. Coil Casing: Aluminum, galvanized, or stainless steel.
2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
3. Coil Tubes: Copper, of diameter and thickness required by performance.
4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
5. Unit Internal Tubing: Copper tubing with brazed joints.
6. Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
7. Field Piping Connections: Manufacturer's standard.
8. Factory Charge: Dehydrated air or nitrogen.

9. Testing: Factory pressure tested and verified to be without leaks.

D. Drain Assembly:

1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
2. Condensate Removal: Unit-mounted pump or other integral lifting mechanism, capable of lifting drain water to an elevation above top of cabinet.
3. Field Piping Connection: Non-ferrous material with threaded NPT.

E. Fan and Motor Assembly:

1. Fan(s):

   a. Direct-drive arrangement.
   b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
   c. Materials: Non-ferrous components or ferrous components with corrosion resistant finish.
   d. Statically and dynamically balanced.

2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
5. Vibration Control: Integral isolation to dampen vibration transmission.

F. Filter Assembly:

1. Access: Bottom, side, or rear to accommodate field installation without removing ductwork and to accommodate filter replacement without need for tools.
2. Efficiency: As directed, ASHRAE 52.2, MERV 7, ASHRAE 52.2, MERV 11 or ASHRAE 52.2, MERV 13.
3. Media: If more than one filter type is indicated, Contractor has option to choose.

   a. Replaceable: Extended surface, panel, or cartridge with antimicrobial treatment fiber media.
   b. Washable: Manufacturer's standard filter with antimicrobial treatment.

G. Unit Accessories:

1. Outdoor Air Ventilation Kit: Connection, motorized damper, and control sized to allow sequence of operation indicated on Drawings.
2. Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.

H. Unit Controls:

1. Enclosure: Metal, suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors:

a. Unit inlet air temperature.
b. Coil entering refrigerant temperature.
c. Coil leaving refrigerant temperature.

4. Field-Customizable I/O Capability:

a. Analog Inputs: As directed, Two, Three or Four for use in customizable control strategies.
b. Digital Inputs: As directed, Two, Three or Four for use in customizable control strategies.
c. Digital Outputs: As directed, Two, Three or Four for use in customizable control strategies.

5. Features and Functions:

a. Self-diagnostics.
b. Time delay, auto-restart.
c. External static pressure control.
d. Auto operation mode.
e. Manual operation mode.
f. Filter service notification.
g. Power consumption display.
h. Drain assembly high water level safety shutdown and notification.
i. Run test switch.

6. Communication: Network communication with other indoor units and outdoor unit(s).
7. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
8. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

I. Unit Electrical:

1. Enclosure: Metal, similar to enclosure, and suitable for indoor locations.
2. Field Connection: Single point connection to power unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in metal raceways.

2.6 INDOOR, EXPOSED, FLOOR-MOUNTED UNITS

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

B. Cabinet:

1. Material: Painted steel, or coated steel frame covered by a plastic cabinet, with an architectural acceptable finish suitable for tenant occupancy on exposed surfaces.
2. Insulation: Manufacturer's standard internal insulation, complying with ASHRAE 62.1, to provide thermal resistance and prevent condensation.
3. Mounting: Manufacturer-designed provisions for field installation.
4. Internal Access: Removable panels of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. DX Coil Assembly:

1. Coil Casing: Aluminum, galvanized, or stainless steel.
2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
3. Coil Tubes: Copper, of diameter and thickness required by performance.
4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
5. Unit Internal Tubing: Copper tubing with brazed joints.
6. Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
7. Field Piping Connections: Manufacturer's standard.
8. Factory Charge: Dehydrated air or nitrogen.
9. Testing: Factory pressure tested and verified to be without leaks.

D. Drain Assembly:

1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
2. Condensate Removal: Gravity.

    a. If a floor drain is not available at unit, provide unit with field-installed condensate pump accessory.

3. Field Piping Connection: Non-ferrous material with threaded NPT.

E. Fan and Motor Assembly:

1. Fan(s):

    a. Direct-drive arrangement.
    b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
    c. Materials: Non-ferrous components or ferrous components with corrosion-resistant finish.
    d. Statically and dynamically balanced.

2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
5. Vibration Control: Integral isolation to dampen vibration transmission.

F. Filter Assembly:

1. Access: Front, to accommodate filter replacement without the need for tools.
2. Efficiency: As directed
3. Washable Media: Manufacturer's standard filter with antimicrobial treatment.

G. Grille Assembly: Manufacturer's standard discharge grille with field-adjustable air pattern mounted in top of unit cabinet.

H. Unit Accessories:

1. Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.
2. Condensate Pump: Integral reservoir and control with electrical power connection through unit power.

I. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors:

    a. Unit inlet air temperature.
    b. Coil entering refrigerant temperature.
    c. Coil leaving refrigerant temperature.

4. Field-Customizable I/O Capability:

    a. Analog Inputs: As directed, Two, Three or Four for use in customizable control strategies.
    b. Digital Inputs: As directed, Two, Three or Four for use in customizable control strategies.
    c. Digital Outputs: As directed, Two, Three or Four for use in customizable control strategies.

5. Features and Functions:

    a. Self-diagnostics.
    b. Time delay.
    c. Auto-restart.
    d. External static pressure control.
    e. Auto operation mode.
    f. Manual operation mode.
    g. Filter service notification
    h. Power consumption display.
    i. Drain assembly high water level safety shutdown and notification.
    j. Run test switch.

6. Communication: Network communication with other indoor units and outdoor unit(s).
7. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

8. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

J. Unit Electrical:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in metal raceways.

2.7 INDOOR, EXPOSED, WALL-MOUNTED UNITS

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

B. Cabinet:

1. Material: Painted steel, or coated steel frame covered by a plastic cabinet, with an architectural acceptable finish suitable for tenant occupancy on exposed surfaces.
2. Insulation: Manufacturer's standard internal insulation, complying with ASHRAE 62.1, to provide thermal resistance and prevent condensation.
3. Mounting: Manufacturer-designed provisions for field installation.
4. Internal Access: Removable panels of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. DX Coil Assembly:

1. Coil Casing: Aluminum, galvanized, or stainless steel.
2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
3. Coil Tubes: Copper, of diameter and thickness required by performance.
4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
5. Unit Internal Tubing: Copper tubing with brazed joints.
6. Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
7. Field Piping Connections: Manufacturer's standard.
8. Factory Charge: Dehydrated air or nitrogen.
9. Testing: Factory pressure tested and verified to be without leaks.

D. Drain Assembly:

1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
2. Condensate Removal: Gravity.

    a. If a floor drain is not available at unit, provide unit with field-installed condensate pump accessory.

3. Field Piping Connection: Non-ferrous material with threaded NPT.

E. Fan and Motor Assembly:

1. Fan(s):

a. Direct-drive arrangement.
b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
c. Fabricated from non-ferrous components or ferrous components with corrosion protection finish.
d. Wheels statically and dynamically balanced.

2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
5. Vibration Control: Integral isolation to dampen vibration transmission.

F. Filter Assembly:

1. Access: Front, to accommodate filter replacement without the need for tools.
2. Efficiency: As directed.
3. Washable Media: Manufacturer's standard filter with antimicrobial treatment.

G. Grille Assembly: Manufacturer's standard discharge grille with field-adjustable air pattern mounted in top or front face of unit cabinet.

H. Unit Accessories:

1. Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.
2. Condensate Pump: Integral reservoir and control with electrical power connection through unit power.

I. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors: As directed, Unit inlet air temperature, Coil entering refrigerant temperature or Coil leaving refrigerant temperature.
4. Field-Customizable I/O Capability:

a. Analog Inputs: As directed, Two, Three or Four for use in customizable control strategies.
b. Digital Inputs: As directed, Two, Three or Four for use in customizable control strategies.
c. Digital Outputs: As directed, Two, Three or Four for use in customizable control strategies.

5. Features and Functions: As directed, Self-diagnostics, time delay, auto-restart, external static pressure control, auto operation mode, manual operation mode, filter service notification, power consumption display, drain assembly high water level safety shutdown and notification, run test switch.
6. Communication: Network communication with other indoor units and outdoor unit(s).
7. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
8. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

J. Unit Electrical:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in metal raceways to comply with NFPA 70.

2.8 INDOOR, RECESSED, CEILING-MOUNTED UNITS

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to ductwork, piping, power, and controls field connections.

B. Cabinet:

1. Material: Painted steel, or coated steel frame covered by a plastic cabinet, with an architectural acceptable finish suitable for tenant occupancy on exposed surfaces.
2. Insulation: Manufacturer's standard internal insulation, complying with ASHRAE 62.1, to provide thermal resistance and prevent condensation.
3. Mounting: Manufacturer-designed provisions for field installation.
4. Internal Access: Removable panels of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. DX Coil Assembly:

1. Coil Casing: Aluminum, galvanized, or stainless steel.
2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
3. Coil Tubes: Copper, of diameter and thickness required by performance.
4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
5. Internal Tubing: Copper tubing with brazed joints.
6. Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
7. Field Piping Connections: Manufacturer's standard.
8. Factory Charge: Dehydrated air or nitrogen.
9. Testing: Factory pressure tested and verified to be without leaks.

D. Drain Assembly:

1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
2. Condensate Removal: Unit-mounted pump or other integral lifting mechanism, capable of lifting drain water to an elevation above top of cabinet.
3. Field Piping Connection: Non-ferrous material with threaded NPT.

E. Fan and Motor Assembly:

1. Fan(s):

    a. Direct-drive arrangement.
    b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
    c. Fabricated from non-ferrous components or ferrous components with corrosion protection finish.
    d. Wheels statically and dynamically balanced.

2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
5. Vibration Control: Integral isolation to dampen vibration transmission.

F. Filter Assembly:

1. Access: Bottom, to accommodate filter replacement without the need for tools.
2. Efficiency: As directed, ASHRAE 52.2, MERV 7, ASHRAE 52.2, MERV 11 or ASHRAE 52.2, MERV 13.
3. Media: If more than one filter type is indicated, Contractor has option to choose.

    a. Replaceable: Extended surface, panel, or cartridge with antimicrobial treatment fiber media.
    b. Washable: Manufacturer's standard filter with antimicrobial treatment.

G. Discharge-Air Grille Assembly: Mounted in bottom of unit cabinet.

1. Discharge Pattern: One-, two-, three-, or four-way throw as indicated on Drawings.

    a. Discharge Pattern Adjustment: Field-adjustable limits for up and down range of motion.
    b. Discharge Pattern Closure: Ability to close individual discharges of units with multiple patterns.

2. Motorized Vanes: Modulating up and down flow pattern for uniform room air distribution.
3. Additional Branch Supply Duct Connection: Sheet metal knockout for optional connection to one additional supply branch duct.

H. Return-Air Grille Assembly: Manufacturer's standard grille mounted in bottom of unit cabinet.

I. Outdoor Air Ventilation Connection: Sheet metal knockout for optional connection to outdoor air ventilation duct.

J. Unit Accessories:

1. Outdoor Air Ventilation Kit: Connection, motorized damper, and control to satisfy unit control sequence of operation indicated on Drawings.
2. Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.

K. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors: As directed, Unit inlet air temperature, Coil entering refrigerant temperature or Coil leaving refrigerant temperature.
4. Field-Customizable I/O Capability:

    a. Analog Inputs: As directed, Two, Three or Four for use in customizable control strategies.
    b. Digital Inputs: As directed, Two, Three or Four for use in customizable control strategies.
    c. Digital Outputs: As directed, Two, Three or Four for use in customizable control strategies.

5. Features and Functions: As directed, Self-diagnostics, time delay, auto-restart, external static pressure control, auto operation mode, manual operation mode, filter service notification, power consumption display, drain assembly high water level safety shutdown and notification, run test switch.
6. Communication: Network communication with other indoor units and outdoor unit(s).
7. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
8. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

L. Unit Electrical:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in metal raceways to comply with NFPA 70.

2.9 INDOOR, SUSPENDED, CEILING-MOUNTED UNITS

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

B. Cabinet:

1. Material: Painted steel, or coated steel frame covered by a plastic cabinet, with an architectural acceptable finish suitable for tenant occupancy on exposed surfaces.
2. Insulation: Manufacturer's standard internal insulation, complying with ASHRAE 62.1, to provide thermal resistance and prevent condensation.
3. Mounting: Manufacturer-designed provisions for field installation.
4. Internal Access: Removable panels of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. DX Coil Assembly:

1. Coil Casing: Aluminum, galvanized, or stainless steel.
2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
3. Coil Tubes: Copper, of diameter and thickness required by performance.
4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
5. Internal Tubing: Copper tubing with brazed joints.
6. Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
7. Field Piping Connections: Manufacturer's standard.
8. Factory Charge: Dehydrated air or nitrogen.
9. Testing: Factory pressure tested and verified to be without leaks.

D. Drain Assembly:

1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
2. Condensate Removal: Gravity.

    a. If a floor drain is not available at unit, provide unit with field-installed condensate pump accessory.

3. Field Piping Connection: Non-ferrous material with threaded NPT.

E. Fan and Motor Assembly:

1. Fan(s):

    a. Direct-drive arrangement.
    b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
    c. Fabricated from non-ferrous components or ferrous components with corrosion protection finish.
    d. Wheels statically and dynamically balanced.

2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
5. Vibration Control: Integral isolation to dampen vibration transmission.

F. Filter Assembly:

1. Access: Front, to accommodate filter replacement without the need for tools.
2. Efficiency: As directed.
3. Washable Media: Manufacturer's standard filter with antimicrobial treatment.

G. Discharge-Air Grille Assembly: Mounted in front of unit cabinet.

1. Discharge Pattern: One-way throw.
2. Discharge Pattern Adjustment: Field-adjustable limits for range of pattern.
3. Motorized Vanes: Modulating up and down flow pattern for uniform room air distribution.

H. Return-Air Grille Assembly: Manufacturer's standard.

I. Outdoor Air Ventilation Connection: Sheet metal knockout for optional connection to outdoor air ventilation duct.

J. Unit Accessories:

1. Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.
2. Condensate Pump: Integral reservoir and control with electrical power connection through unit power.

K. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors: As directed, Unit inlet air temperature, Coil entering refrigerant temperature or Coil leaving refrigerant temperature.
4. Field-Customizable I/O Capability:

    a. Analog Inputs: As directed, Two, Three or Four for use in customizable control strategies.
    b. Digital Inputs: As directed, Two, Three or Four for use in customizable control strategies.
    c. Digital Outputs: As directed, Two, Three or Four for use in customizable control strategies.

5. Features and Functions: As directed, Self-diagnostics, time delay, auto-restart, external static pressure control, auto operation mode, manual operation mode, filter service notification, power consumption display, drain assembly high water level safety shutdown and notification, run test switch.

6. Communication: Network communication with other indoor units and outdoor unit(s).
7. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
8. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

L. Unit Electrical:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in metal raceways to comply with NFPA 70.

2.10 OUTDOOR, AIR-SOURCE HEAT-PUMP UNITS

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

1. Specially designed for use in systems with either all heating or all cooling demands, but not for use in systems with simultaneous heating and cooling.
2. Systems shall consist of one unit, or multiple unit modules that are designed by variable refrigerant system manufacturer for field interconnection to make a single refrigeration circuit that connects multiple indoor units.
3. All units installed shall be from the same product development generation.

B. Cabinet:

1. Galvanized steel and coated with a corrosion-resistant finish.

    a. Coating with documented salt spray test performance of 1000 hours according ASTM B117 surface scratch test (SST) procedure.

2. Mounting: Manufacturer-designed provisions for field installation.
3. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. Compressor and Motor Assembly:

1. One or more positive-displacement, direct-drive and hermetically sealed scroll compressor(s) with inverter drive and turndown to 15 percent of rated capacity.
2. Protection: Integral protection against the following:

    a. High refrigerant pressure.
    b. Low oil level.

c. High oil temperature.
d. Thermal and overload.
e. Voltage fluctuations.
f. Phase failure and phase reversal.
g. Short cycling.

3. Speed Control: Variable to automatically maintain refrigerant suction and condensing pressures while varying refrigerant flow to satisfy system cooling and heating loads.
4. Vibration Control: Integral isolation to dampen vibration transmission.
5. Oil management system to ensure safe and proper lubrication over entire operating range.
6. Crankcase heaters with integral control to maintain safe operating temperature.
7. Fusible plug.

D. Condenser Coil Assembly:

1. Plate Fin Coils:

a. Casing: Aluminum, galvanized, or stainless steel.
b. Fins: Aluminum or copper, mechanically bonded to tubes, with arrangement required by performance.
c. Tubes: Copper, of diameter and thickness required by performance.

2. Aluminum Microchannel Coils:

a. Series of flat tubes containing a series of multiple, parallel-flow microchannels layered between refrigerant header manifolds.
b. Single- or multiple-pass arrangement.
c. Construct fins, tubes, and header manifolds of aluminum alloy.

3. Corrosion Protection: Coating with documented salt spray test performance of 1000 hours according ASTM B117 surface scratch test (SST) procedure.
4. Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.

E. Condenser Fan and Motor Assembly:

1. Fan(s): Propeller type.

a. Direct-drive arrangement.
b. Fabricated from non-ferrous components or ferrous components with corrosion protection finish to match performance indicated for condenser coil.
c. Statically and dynamically balanced.

2. Fan Guards: Removable safety guards complying with OSHA regulations. If using metal materials, coat with corrosion-resistant coating to match performance indicated for condenser coil.
3. Motor(s): Brushless dc or electronically commutated with permanently lubricated bearings and rated for outdoor duty.
4. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
5. Speed Settings and Control: Variable speed with a speed range of least 75 percent.
6. Vibration Control: Integral isolation to dampen vibration transmission.

F. Drain Pan: If required by manufacturer's design, provide unit with non-ferrous drain pan with bottom sloped to a low point drain connection.

G. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for unprotected outdoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors:

    a. Refrigerant suction temperature.
    b. Refrigerant discharge temperature.
    c. Outdoor air temperature.
    d. Refrigerant high pressure.
    e. Refrigerant low pressure.
    f. Oil level.

4. Features and Functions: As directed, Self-diagnostics, time delay, auto-restart, fuse protection, auto operation mode, manual operation mode, night setback control, power consumption display, run test switch or equalize run time between multiple same components.
5. Communication: Network communication with indoor units and other outdoor unit(s).
6. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
7. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

H. Unit Electrical:

1. Enclosure: Metal, similar to enclosure, and suitable for unprotected outdoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in metal raceways to comply with NFPA 70.

I. Unit Hardware: Zinc-plated steel, or stainless steel. Coat exposed surfaces with additional corrosion-resistant coating if required to prevention corrosion when exposed to salt spray test for 1000 hours according ASTM B117.

J. Unit Piping:

1. Unit Tubing: Copper tubing with brazed joints.
2. Unit Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
3. Field Piping Connections: Manufacturer's standard.
4. Factory Charge: Dehydrated air or nitrogen.
5. Testing: Factory pressure tested and verified to be without leaks.

2.11 OUTDOOR, AIR-SOURCE HEAT RECOVERY UNITS

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

1. Specially designed for use in systems with simultaneous heating and cooling.
2. Systems shall consist of one unit, or multiple unit modules that are designed by variable refrigerant system manufacturer for field interconnection to make a single refrigeration circuit that connects multiple indoor units.
3. All units installed shall be from the same product development generation.

B. Cabinet:

1. Galvanized steel and coated with a corrosion-resistant finish.

    a. Coating with documented salt spray test performance of 1000 hours according ASTM B117 surface scratch test (SST) procedure.

2. Mounting: Manufacturer-designed provisions for field installation.
3. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. Compressor and Motor Assembly:

1. One or more positive-displacement, direct-drive and hermetically sealed scroll compressor(s) with inverter drive and turndown to 15 percent of rated capacity.
2. Protection: Integral protection against the following:

    a. High refrigerant pressure.
    b. Low oil level.
    c. High oil temperature.
    d. Thermal and overload.
    e. Voltage fluctuations.
    f. Phase failure and phase reversal.
    g. Short cycling.

3. Speed Control: Variable to automatically maintain refrigerant suction and condensing pressures while varying refrigerant flow to satisfy system cooling and heating loads.
4. Vibration Control: Integral isolation to dampen vibration transmission.
5. Oil management system to ensure safe and proper lubrication over entire operating range.
6. Crankcase heaters with integral control to maintain safe operating temperature.
7. Fusible plug.

D. Condenser Coil Assembly:

1. Plate Fin Coils:

    a. Casing: Aluminum, galvanized, or stainless steel.
    b. Fins: Aluminum or copper, mechanically bonded to tubes, with arrangement required by performance.

c. Tubes: Copper, of diameter and thickness required by performance.

2. Aluminum Microchannel Coils:

a. Series of flat tubes containing a series of multiple, parallel-flow microchannels layered between refrigerant header manifolds.
b. Single- or multiple-pass arrangement.
c. Construct fins, tubes, and header manifolds of aluminum alloy.

3. Corrosion Protection: Coating with documented salt spray test performance of 1000 hours according ASTM B117 surface scratch test (SST) procedure.
4. Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.

E. Condenser Fan and Motor Assembly:

1. Fan(s): Propeller type.

a. Direct-drive arrangement.
b. Fabricated from non-ferrous components or ferrous components with corrosion protection finish to match performance indicated for condenser coil.
c. Statically and dynamically balanced.

2. Fan Guards: Removable safety guards complying with OSHA regulations. If using metal materials, coat with corrosion-resistant coating to match performance indicated for condenser coil.
3. Motor(s): Brushless dc or electronically commutated with permanently lubricated bearings and rated for outdoor duty.
4. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
5. Speed Settings and Control: Variable speed with a speed range of least 75 percent.
6. Vibration Control: Integral isolation to dampen vibration transmission.

F. Drain Pan: If required by manufacturer's design, provide unit with non-ferrous drain pan with bottom sloped to a low point drain connection.

G. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for unprotected outdoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors:

a. Refrigerant suction temperature.
b. Refrigerant discharge temperature.
c. Outdoor air temperature.
d. Refrigerant high pressure.
e. Refrigerant low pressure.
f. Oil level.

4. Features and Functions: Self-diagnostics, time delay, auto-restart, fuse protection, auto operation mode, manual operation mode, night setback control, power consumption display, run test switch or equalize run time between multiple same components.
5. Communication: Network communication with indoor units and other outdoor unit(s).
6. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
7. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

H. Unit Electrical:

1. Enclosure: Metal, similar to enclosure, and suitable for unprotected outdoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in metal raceways to comply with NFPA 70.

I. Unit Hardware: Zinc-plated steel, or stainless steel. Coat exposed surfaces with additional corrosion-resistant coating if required to prevention corrosion when exposed to salt spray test for 1000 hours according ASTM B117.

J. Unit Piping:

1. Unit Tubing: Copper tubing with brazed joints.
2. Unit Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
3. Field Piping Connections: Manufacturer's standard.
4. Factory Charge: Dehydrated air or nitrogen.
5. Testing: Factory pressure tested and verified to be without leaks.

2.12 HEAT RECOVERY CONTROL UNITS (HRCUs)

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

1. Specially designed for use in systems with simultaneous heating and cooling.
2. Systems shall consist of one unit, or multiple unit that are designed by variable refrigerant system manufacturer for field interconnection to make a single refrigeration circuit that connects multiple indoor units.

B. Cabinet:

1. Galvanized-steel construction.
2. Insulation: Manufacturer's standard internal insulation to provide thermal resistance and prevent condensation.

3. Mounting: Manufacturer-designed provisions for field installation.
4. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. Drain Pan: If required by manufacturer's design, provide unit with non-ferrous drain pan with bottom sloped to a low point drain connection.

D. Refrigeration Assemblies and Specialties:

1. Specially designed by manufacturer for type of VRF HVAC system being installed, either two or three pipes.
2. Each refrigerant branch circuit shall have refrigerant control valve(s) to control refrigerant flow.
3. Spares: As directed, each heat recovery control unit shall include at least one or two branch circuit port(s) for future use.
4. Each system piping connection upstream of heat recovery unit shall be fitted with an isolation valve to allow for service to any heat recovery control unit in the system without interrupting operation of the system.
5. Each branch circuit connection shall be fitted with an isolation valve and capped service port to allow for service to any individual branch circuit without interrupting operation of the system.

    a. If not available as an integral part of the heat recovery control unit, isolation valves shall be field installed adjacent to the unit pipe connection.

E. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors: As directed.
4. Features and Functions: Self-diagnostics, fuse protection, As directed.
5. Communication: Network communication with indoor units and outdoor unit(s).
6. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
7. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

F. Unit Electrical:

1. Enclosure: Metal, similar to enclosure, and suitable for indoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in metal raceways to comply with NFPA 70.

G. Unit Piping:

1. Unit Tubing: Copper tubing with brazed joints.
2. Unit Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
3. Field Piping Connections: Manufacturer's standard.
4. Factory Charge: Dehydrated air or nitrogen.
5. Testing: Factory pressure tested and verified to be without leaks.

2.13 SYSTEM CONTROLS

A. General Requirements:

1. Network: Indoor units, HRCUs, and outdoor units shall include integral controls and connect through a TIA-485A or manufacturer-selected control network.
2. Network Communication Protocol: Manufacturer proprietary or open control communication between interconnected units.
3. Integration with Building Automation System: ASHRAE 135, BACnet IP and certified by BACnet Testing Lab (BTL), including the following:

    a. Ethernet connection via RJ-45 connectors and port with transmission at 100 Mbps or higher.
    b. Integration devices shall be connected to local uninterruptible power supply unit(s) to provide at least 5 minutes of battery backup operation after a power loss.
    c. Integration shall include control, monitoring, scheduling or change of value notifications as directed.

4. Operator Interface:

    a. Operators shall interface with system and unit controls through the following:

        1) Operator interfaces integral to controllers.
        2) Owner-furnished PC connected to central controller(s).
        3) Web interface through web browser software.
        4) Integration with Building Automation System.

    b. Users shall be capable of interface with controllers for control of indoor units to extent privileges are enabled. Control features available to users shall include the following:

        1) On/off control.
        2) Temperature set-point adjustment.

B. VRF HVAC System Operator Software for PC:

1. Software offered by VRF HVAC system manufacturer shall provide system operators with ability to monitor and control VRF HVAC system(s) from a single dedicated Owner-furnished PC.
2. Software shall provide operator with a graphic user interface to allow monitoring and control of multiple central controllers from a single device location through point-and-click mouse exchange.

3. Plan views shall show building plans with location of indoor units and identification superimposed on plans.
4. Controls operation mode of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Operation modes available through central controller shall match those operation modes of controllers for indoor units.
5. Schedules operation of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Schedules daily, weekly, and annual events.
6. Changes operating set points of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.
7. Optimized start feature to start indoor units before scheduled time to reach temperature set-point at scheduled time based on operating history.
8. Night setback feature to operate indoor units at energy-conserving heating and cooling temperature set-points during unoccupied periods.
9. Supports Multiple Languages: As directed, English or French or Spanish.
10. Supports Imperial and Metric Temperature Units: As directed, Fahrenheit or Celsius or Fahrenheit and Celsius.
11. Displays service notifications and error codes.
12. Monitors and displays up to 3000 item error history and 10000 item operation history for regular reporting and further archiving.
13. Monitors and displays cumulative operating time of indoor units.
14. Able to disable and enable operation of individual controllers for indoor units.
15. Information displayed on individual controllers shall also be available for display.
16. Information displayed for outdoor units, including refrigerant high and low pressures percent capacity.

C. Central Controllers:

1. Centralized control for all indoor and outdoor units from a single central controller location.

    a. Include multiple interconnected controllers as required.

2. Controls operation mode of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Operation modes available through central controller shall match those operation modes of controllers for indoor units.
3. Schedule operation of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.

    a. Sets schedule for daily, weekly, and annual events.
    b. Schedule options available through central controller shall at least include the schedule options of controllers for indoor units.

4. Changes operating set points of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.
5. Optimized start feature to start indoor units before scheduled time to reach temperature set-point at scheduled time based on operating history.
6. Night setback feature to operate indoor units at energy-conserving heating and cooling temperature set-points during unoccupied periods.
7. Service diagnostics tool.
8. Able to disable and enable operation of individual controllers for indoor units.

9. Information displayed on individual controllers shall also be available for display through central controller.
10. Information displayed for outdoor units, including refrigerant high and low pressures percent capacity.
11. Multiple RJ-45 ports for direct connection to a local PC and an Ethernet network switch.
12. Operator interface through a backlit, high-resolution color display touch panel and web accessible through standard web browser software.

D. Wired Controllers for Indoor Units:

1. Single controller capable of controlling multiple indoor units as group.
2. Auto Timeout Touch Screen LCD: Timeout duration shall be adjustable.
3. Multiple Language: As directed, English or French or Spanish.
4. Temperature Units: As directed, Fahrenheit or Celsius Fahrenheit and Celsius.
5. On/Off: Turns indoor unit on or off.
6. Hold: Hold operation settings until hold is released.
7. Operation Mode: Cool, Heat, Auto, Dehumidification, Fan Only, and Setback.
8. Temperature Display: 1-degree increments.
9. Temperature Set-Point: Separate set points for Cooling, Heating, and Setback. Adjustable in 1-degree increments between temperature range As directed.
10. Relative Humidity Display: 1 percent increments.
11. Relative Humidity Set-Point: Adjustable in 1 percent increments between humidity range As directed.
12. Fan Speed Setting: Select between available options furnished with the unit.
13. Airflow Direction Setting: If applicable to unit, select between available options furnished with the unit.
14. Seven-day programmable operating schedule with up to five or eight events per day as directed. Operations shall include On/Off, Operation Mode, and Temperature Set-Point.
15. Auto Off Timer: Operates unit for an adjustable time duration and then turns unit off.
16. Occupancy detection.
17. Service Notification Display: "Filter" As directed.
18. Service Run Tests: Limit use by service personnel to troubleshoot operation.
19. Error Code Notification Display: Used by service personnel to troubleshoot abnormal operation and equipment failure.
20. User and Service Passwords: Capable of preventing adjustments by unauthorized users.
21. Setting stored in nonvolatile memory to ensure that settings are not lost if power is lost. Battery backup for date and time only.
22. Low-voltage power required for controller shall be powered through non-polar connections to indoor unit.

E. Wireless Controllers for Indoor Units:

1. Wireless Communication:

    a. Controller communicates to remote-mounted receiver that is wired to indoor unit(s).

        1) Include receivers with wireless controllers as required to complete installation.
        2) Low-voltage power required for receivers shall be powered through non-polar connections to indoor unit.

b. One wireless controller shall be capable of communicating with one or multiple receivers to control one or multiple indoor units as a group.

2. Controller Battery Life: Three years.
3. Auto Timeout Touch Screen LCD: Timeout duration shall be adjustable.
4. Multiple Language: As directed, English or French or Spanish.
5. Temperature Units: As directed, Fahrenheit or Celsius or Fahrenheit and Celsius.
6. On/Off: Turns indoor unit on or off.
7. Hold: Hold operation settings until hold is released.
8. Operation Mode: Cool, Heat, Auto, Dehumidification, Fan Only, and Setback.
9. Temperature Display: 1-degree increments.
10. Temperature Set-Point: Separate set points for Cooling, Heating, and Setback. Adjustable in 1-degree increments between temperature range As directed.
11. Relative Humidity Display: 1 percent increments.
12. Relative Humidity Set-Point: Adjustable in 1 percent increments between humidity range As directed.
13. Fan Speed Setting: Select between available options furnished with the unit.
14. Airflow Direction Setting: If applicable to unit, select between available options furnished with the unit.
15. Seven-day programmable operating schedule with up to five or eight events per day As directed. Operations shall include On/Off, Operation Mode, and Temperature Set-Point.
16. Auto Off Timer: Operates unit for an adjustable time duration and then turns unit off.
17. Occupancy detection.
18. Service Notification Display: "Filter" As directed.
19. Service Run Tests: Limit use by service personnel to troubleshoot operation.
20. Error Code Notification Display: Used by service personnel to troubleshoot abnormal operation and equipment failure.
21. User and Service Passwords: Capable of preventing adjustments by unauthorized users.
22. Setting stored in non-volatile memory to ensure that settings are not lost if power is lost. Battery for date and time only.

2.14 SYSTEM REFRIGERANT AND OIL

A. Refrigerant:

1. As required by VRF HVAC system manufacturer for system to comply with performance requirements indicated.
2. ASHRAE 34, Class A1 or refrigerant classification.
3. R-410a or refrigerant as directed.

B. Oil:

1. As required by VRF HVAC system manufacturer and to comply with performance requirements indicated.

2.15 SYSTEM CONDENSATE DRAIN PIPING

A. If more than one material is listed, material selection is Contractor's option.

B. Copper Tubing:

1. Drawn-Temper Tubing: As directed, According to ASTM B88, Type L (ASTM B88M, Type B) or ASTM B88, Type M (ASTM B88M, Type C) or Type DWV according to ASTM B306.
2. Wrought-Copper Fittings: ASME B16.22.
3. Wrought-Copper Unions: ASME B16.22.
4. Solder Filler Metals: ASTM B32, lead-free alloys, and water-flushable flux according to ASTM B813.

C. CPVC plastic pipe according to ASTM F441/F441M, Schedule 40, with socket-type pipe fittings according to ASTM F438 and solvent cement according to ASTM F493.

D. PVC plastic pipe according to ASTM D1785, Schedule 40, with socket-type pipe fittings according to ASTM D2466 and solvent cement according to ASTM D2564, primer according to ASTM F656.

2.16 SYSTEM HYDRONIC PIPING

A. Comply with requirements in Section 232113 "Hydronic Piping" for system piping requirements.

2.17 SYSTEM REFRIGERANT PIPING

A. Comply with requirements in Section 232300 "Refrigerant Piping" for system piping requirements.

B. Refrigerant Piping:

1. Copper Tube: ASTM B280, Type ACR.
2. Wrought-Copper Fittings: ASME B16.22.
3. Brazing Filler Metals: AWS A5.8/A5.8M.

C. Refrigerant Tubing Kits:

1. Furnished by VRF HVAC system manufacturer.
2. Factory-rolled and -bundled, soft-copper tubing with tubing termination fittings at each end.
3. Standard one-piece length for connecting to indoor units.
4. Pre-insulated with flexible elastomeric insulation of thickness to comply with governing energy code and sufficient to eliminate condensation.
5. Factory Charge: Dehydrated air or nitrogen or charge as directed.

D. Divided-Flow Specialty Fittings: Where required by VRF HVAC system manufacturer for proper system operation, VRF HVAC system manufacturer shall furnish specialty fittings with identification and instructions for proper installation by Installer.

E. Refrigerant Isolation Ball Valves:

1. Description: Uni-body full port design, rated for maximum system temperature and pressure, and factory tested under pressure to ensure tight shutoff. Designed for valve operation without removing seal cap.
2. Seals: Compatible with system refrigerant and oil. Seal service life of at least 20 years.
3. Valve Connections: Flare or sweat depending on size.

2.18 METAL HANGERS AND SUPPORTS

A. Copper Tube Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: As directed, Continuous-thread rod, nuts, and washer made of galvanized or copper-coated steel or stainless steel.

B. Plastic Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, galvanized-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized steel or stainless steel as directed.

2.19 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:
1. Description: Shop- or field-fabricated, pipe-support assembly for supporting multiple parallel pipes.
2. Standard: MFMA-4.
3. Channels: Continuous slotted steel channel with inturned lips.
4. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized steel for use indoors and of stainless steel for use outdoors.
6. Metallic Coating for Use Indoors: Electroplated zinc or hot-dip galvanized or mill galvanized as directed.
7. Plastic Coating for Use Outdoors: As directed, PVC, polyurethane, epoxy or polyester.

2.20 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded, zinc-coated steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Expansion Anchors: Insert-wedge-type anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

1. Indoor Applications: Zinc-coated or stainless steel.

2. Outdoor Applications: Stainless steel.

2.21 PIPE STANDS

A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

C. Low-Type, Single-Pipe Stand: As directed, One-piece plastic or stainless-steel base unit with plastic roller, for roof installation without membrane penetration.

D. High-Type, Single-Pipe Stand:

1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
2. Base: As directed, Plastic or Stainless steel.
3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

E. High-Type, Multiple-Pipe Stand:

1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
2. Bases: One or more; plastic.
3. Vertical Members: Two or more protective-coated-steel channels.
4. Horizontal Member: Protective-coated-steel channel.
5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

F. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.22 MISCELLANEOUS SUPPORT MATERIALS

A. Grout: ASTM C1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

B. Structural Steel: ASTM A36/A36M, carbon-steel plates, shapes, and bars; galvanized.

C. Threaded Rods: Continuously threaded. Zinc-plated steel or galvanized steel for indoor applications and stainless steel for outdoor applications. Mating nuts and washers of similar material as rods.

2.23 PIPING AND TUBING INSULATION

A. Comply with requirements in Section 230719 "HVAC Piping Insulation" for system piping insulation requirements.

B. Condensate Drain Piping and Tubing Insulation and Jacket Requirements:

1. Flexible Elastomeric Insulation:

   a. Closed-cell, sponge- or expanded-rubber materials, complying with ASTM C534, Type I for tubular materials.
   b. Indoors: As directed, 1/2 inch (13 mm), 3/4 inch (19 mm) or 1 inch (25 mm) thick.
   c. Outdoors: As directed, 1/2 inch (13 mm), 3/4 inch (19 mm) or 1 inch (25 mm) thick.

2. Field-Applied Jacket:

   a. Concealed: None required.
   b. Indoors, Exposed to View: As directed, none required, PVC, 20 mils (0.5 mm) thick or PVC, color selected by Architect, 20 mils (0.5 mm) thick.
   c. Outdoors, Exposed to View: As directed, none required or Aluminum, smooth, 0.020 inch (0.51 mm) thick.

C. Refrigerant Tubing Insulation and Jacket Requirements:

1. Flexible Elastomeric Insulation:

   a. Closed-cell, sponge- or expanded-rubber materials, complying with ASTM C534, Type I for tubular materials.
   b. Indoors: 1 inch (25 mm) thick.
   c. Outdoors: 1 inch (25 mm) thick.

2. Field-Applied Jacket:

   a. Concealed: None required.
   b. Indoors, Exposed to View: As directed, none required, PVC, 20 mils (0.5 mm) thick or PVC, color selected by Architect, 20 mils (0.5 mm) thick.
   c. Outdoors, Exposed to View: As directed, none required or Aluminum, smooth, 0.020 inch (0.51 mm) thick.

D. Flexible Elastomeric Insulation Adhesive: Comply with MIL-A-24179A, Type II, Class I.

E. PVC Jacket Adhesive: Compatible with PVC jacket.

F. Metal Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
4. Color: Aluminum.

2.24 SYSTEM CONTROL CABLE AND RACEWAYS

A. Low-Voltage Control Cabling:

1. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.

B. TIA-485A Network Cabling:

1. Standard Cable: NFPA 70, Type CMG.
2. Plenum-Rated Cable: NFPA 70, Type CMP.

C. Ethernet Network Cabling: As directed, TIA-568-C.2 Category 6 or 6a cable with RJ-45 connectors.

D. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for control wiring and cable raceways.

2.25 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect factory-assembled equipment.

B. Equipment will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports for historical record. Submit reports only if requested.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

A. Clearance:

1. Maintain manufacturer's recommended clearances for service and maintenance.
2. Maintain clearances required by governing code.

B. Loose Components: Install components, devices, and accessories furnished by manufacturer, with equipment, that are not factory mounted.

1. Loose components shall be installed by manufacturer's service representative or system Installer under supervision of manufacturer's service representative.

C. Equipment Restraint Installation: Install equipment with seismic-restraint device. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

D. Indoor Unit Installations:

1. Install units to be level and plumb while providing a neat and finished appearance.
2. Unless otherwise required by VRF HVAC system manufacturer, support ceiling-mounted units from structure above using threaded rods; minimum rod size of 3/8 inch (10 mm).

3. Adjust supports of exposed and recessed units to draw units tight to adjoining surfaces.
4. Protect finished surfaces of ceilings, floors, and walls that come in direct contact with units. Refinish or replaced damaged areas after units are installed.
5. In rooms with ceilings, conceal piping and tubing, controls, and electrical power serving units above ceilings.
6. In rooms without ceiling, arrange piping and tubing, controls, and electrical power serving units to provide a neat and finished appearance.
7. Provide lateral bracing if needed to limit movement of suspended units to not more than 0.25 inch (13 mm).
8. For floor- and wall-mounted units that are exposed, conceal piping and tubing, controls, and electrical power serving units within walls.
9. Floor-mounted units located in mechanical rooms.
10. Install floor-mounted units on support structure indicated on Drawings.
11. Install floor-mounted units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" As directed
12. Attachment: Install hardware for proper attachment to supported equipment.
13. Grouting: Place grout under equipment supports and make bearing surface smooth.

E. Outdoor Unit Installations:

1. Install units to be level and plumb while providing a neat and finished appearance.
2. Install outdoor units on support structures indicated on Drawings.
3. Pad-Mounted Installations: Install outdoor units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.

    a. Attachment: Install anchor bolts to elevations required for proper attachment to supported equipment.
    b. Grouting: Place grout under equipment supports and make bearing surface smooth.

4. Roof-Mounted Installations: Install outdoor units on equipment supports specified in Section 077200 "Roof Accessories." Anchor units to supports with removable, stainless-steel fasteners.

3.2 GENERAL REQUIREMENTS FOR PIPING AND TUBING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping and tubing systems. Install piping and tubing as indicated unless deviations to layout are approved on coordination drawings.

B. Install piping and tubing in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping and tubing at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping and tubing above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping and tubing to permit valve servicing.

F. Install piping and tubing at indicated slopes.

G. Install piping and tubing free of sags.

H. Install fittings for changes in direction and branch connections.

I. Install piping and tubing to allow application of insulation.

J. Install groups of pipes and tubing parallel to each other, spaced to permit applying insulation with service access between insulated piping and tubing.

K. Install sleeves for piping and tubing penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

L. Install escutcheons for piping and tubing penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.3 CONDENSATE DRAIN PIPE AND TUBING INSTALLATION

A. General Requirements for Drain Piping and Tubing:

1. Install a union in piping at each threaded unit connection.
2. Install an adjustable stainless-steel hose clamp with adjustable gear operator on unit hose connections. Tighten clamp to provide a leak-free installation.
3. If required for unit installation, provide a trap assembly in drain piping to prevent air circulated through unit from passing through drain piping. Comply with more stringent of the following:

    a. Details indicated on Drawings.
    b. Manufacturer's requirements.
    c. Governing codes.
    d. In the absence of requirements, comply with requirements of ASHRAE handbooks.

4. Extend drain piping from units with drain connections to drain receptors as indicated on Drawings. If not indicated on Drawings, terminate drain connection at nearest accessible location that is not exposed to view by occupants.
5. Provide each 90-degree change in direction with a Y- or T-fitting. Install a threaded plug connection in the dormant side of fitting or future use as a service cleanout.

B. Gravity Drains:

1. Slope piping from unit connection toward drain termination at a constant slope of not less than one or two percent As directed.

C. Pumped Drains:

1. If unit condensate pump or lift mechanism is not included with an integral check valve, install a full-size check valve in each branch pipe near unit connection to prevent backflow into unit.

3.4 HYDRONIC PIPING AND TUBING INSTALLATION

A. Comply with requirements for hydronic pipe and tubing specified in Section 232113 "Hydronic Piping."

B. Comply with requirements for hydronic specialties specified in Section 232116 "Hydronic Piping Specialties."

C. Comply with requirements for ball valves specified in Section 230523.12 "Ball Valves for HVAC Piping."

D. Comply with requirements for butterfly valves specified in Section 230523.13 "Butterfly Valves for HVAC Piping."

E. Comply with requirements for check valves specified in Section 230523.14 "Check Valves for HVAC Piping."

F. Install continuous-thread hanger rods and elastomeric or spring hangers of size required to support equipment weight As directed.

1. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC." Fabricate brackets or supports as required.
2. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

G. Where installing piping and tubing adjacent to equipment, allow space for service and maintenance.

3.5 REFRIGERANT PIPING AND TUBING INSTALLATION

A. Refrigerant Tubing Kits:

1. Unroll and straighten tubing to suit installation. Deviations in straightness of exposed tubing shall be unnoticeable to observer.
2. Support tubing using hangers and supports indicated at intervals not to exceed 5 feet (1.5 m). Minimum rod size, 1/4 inch (6.4 mm).
3. Prepare tubing ends and make mating connections to provide a pressure tight and leak-free installation.

B. Install refrigerant piping according to ASHRAE 15 and governing codes.

C. Select system components with pressure rating equal to or greater than system operating pressure.

D. Install piping as short and direct as possible, with a minimum number of joints and fittings.

E. Arrange piping to allow inspection and service of equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Section 083113 "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.

F. Install refrigerant piping and tubing in protective conduit where installed belowground.

G. Install refrigerant piping and tubing in rigid or flexible conduit in locations where exposed to mechanical damage.

H. Unless otherwise required by VRF HVAC system manufacturer, slope refrigerant piping and tubing as follows:

1. Install horizontal hot-gas discharge piping and tubing with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Install traps to entrain oil in vertical runs.
4. Liquid lines may be installed level.

I. When brazing, remove or protect components that could be damaged by heat.

J. Before installation, clean piping, tubing, and fittings to cleanliness level required by VRF HVAC system manufacturer.

K. Joint Construction:

1. Ream ends of tubes and remove burrs.
2. Remove scale, slag, dirt, and debris from inside and outside of tube and fittings before assembly.
3. Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.

    a. Use Type BCuP (copper-phosphorus) alloy for joining copper fittings with copper tubing.
    b. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze.

3.6 PIPE AND TUBING INSULATION INSTALLATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated. Installation to maintain a continuous vapor barrier.

B. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are unavailable, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

E. Where metal jackets are indicated, install with 2-inch (50-mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches (300 mm) o.c. and at end joints.

3.7 DUCT, ACCESSORIES, AND AIR OUTLETS INSTALLATION

A. Where installing ductwork adjacent to equipment, allow space for service and maintenance.

B. Comply with requirements for metal ducts specified in Section 233113 "Metal Ducts."

C. Comply with requirements for nonmetal ducts specified in Section 233116 "Nonmetal Ducts."

D. Comply with requirements for air duct accessories specified in Section 233300 "Air Duct Accessories."

E. Comply with requirements for flexible ducts specified in Section 233346 "Flexible Ducts."

F. Comply with requirements for air diffusers specified in Section 233713.13 "Air Diffusers."

G. Comply with requirements for registers and grilles specified in Section 233713.23 "Registers and Grilles."

3.8 SOFTWARE

A. Cybersecurity:

1. Software:

a. Coordinate security requirements with IT department or CIO As directed.
b. Ensure that latest stable software release is installed and properly operating.
c. Disable or change default passwords to password using a combination of uppercase and lower letters, numbers, and symbols at least eight characters in length. Record passwords and turn over to party responsible for system operation and administration.

2. Hardware:

    a. Coordinate location and access requirements with IT department or CIO As directed.
    b. Enable highest level of wireless encryption that is compatible with Owner's ICT network.
    c. Disable dual network connections.

3.9 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-D, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping" Chapter.

3.10 IELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of manufacturer's service representative:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Refrigerant Tubing Positive Pressure Testing:

1. Comply with more stringent of VRF HVAC system manufacturer's requirements and requirements indicated.
2. After completion of tubing installation, pressurize tubing systems to a test pressure of not less than 1.2 or 1.5 times VRF HVAC system operating pressure As directed, but not less than 600 psig (4137 kPa), using dry nitrogen.
3. Successful testing shall maintain a test pressure for a continuous and uninterrupted period of 24 hours. Allowance for pressure changes attributed to changes in ambient temperature are acceptable.
4. Prepare test report to record the following information for each test:

    a. Name of person starting test, company name, phone number, and e-mail address.
    b. Name of manufacturer's service representative witnessing test, company name, phone number, and e-mail address.
    c. Detailed description of extent of tubing tested.
    d. Date and time at start of test.
    e. Test pressure at start of test.
    f. Outdoor temperature at start of test.

g. Name of person ending test, company name, phone number, and e-mail address.
h. Date and time at end of test.
i. Test pressure at end of test.
j. Outdoor temperature at end of test.
k. Remarks:

5. Submit test reports for Project record.

C. Refrigerant Tubing Evacuation Testing:

1. Comply with more stringent of VRF HVAC system manufacturer's requirements and requirements indicated.
2. After completion of tubing positive-pressure testing, evacuate tubing systems to a pressure of 500 microns.
3. Successful testing shall maintain a test pressure for a continuous and uninterrupted period of one hour(s) with no change.
4. Prepare test report to record the following information for each test:

a. Name of person starting test, company name, phone number, and e-mail address.
b. Name of manufacturer's service representative witnessing test, company name, phone number, and e-mail address.
c. Detailed description of extent of tubing tested.
d. Date and time at start of test.
e. Test pressure at start of test.
f. Outdoor temperature at start of test.
g. Name of person ending test, company name, phone number, and e-mail address.
h. Date and time at end of test.
i. Test pressure at end of test.
j. Outdoor temperature at end of test.
k. Remarks:

5. Submit test reports for Project record.
6. Upon successful completion of evacuation testing, system shall be charged with refrigerant.

D. System Refrigerant Charge:

1. Using information collected from the refrigerant tubing evacuation testing, system Installer shall consult variable refrigerant system manufacturer to determine the correct system refrigerant charge.
2. Installer shall charge system following VRF HVAC system manufacturer's written instructions.
3. System refrigerant charging shall be witnessed by system manufacturer's representative.
4. Total refrigerant charge shall be recorded and permanently displayed at the system's outdoor unit.

E. Products will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.11 STARTUP SERVICE

A. Engage a VRF HVAC system manufacturer's service representative to perform system(s) startup service.

1. Service representative shall be an employee or a factory-trained and -authorized service representative of VRF HVAC system manufacturer As directed.
2. Complete startup service of each separate system.
3. Complete system startup service according to manufacturer's written instructions.

B. Startup checks shall include, but not be limited to, the following:

1. Check control communications of equipment and each operating component in system(s).
2. Check each indoor unit's response to demand for cooling and heating.
3. Check each indoor unit's response to changes in airflow settings.
4. Check each indoor unit, HRCU, and outdoor unit for proper condensate removal.
5. Check sound levels of each indoor and outdoor unit.

C. Installer shall accompany manufacturer's service representative during startup service and provide manufacturer's service representative with requested documentation and technical support during startup service.

1. Installer shall correct deficiencies found during startup service for reverification.

D. System Operation Report:

1. After completion of startup service, manufacturer shall issue a report for each separate system.
2. Report shall include complete documentation describing each startup check, the result, and any corrective action required.
3. Manufacturer shall electronically record not less than two hours of continuous operation of each system and submit with report for historical reference.

    a. All available system operating parameters shall be included in the information submitted.

E. Witness:

1. As directed, Invite Architect, Owner and Commissioning Agent to witness startup service procedures.
2. Provide written notice not less than 20 business days before start of startup service.

3.12 ADJUSTING

A. Adjust equipment and components to function smoothly, and lubricate as recommended by manufacturer.

B. Adjust initial temperature and humidity set points. Adjust initial airflow settings and discharge airflow patterns.

C. Set field-adjustable switches and circuit-breaker trip ranges according to VRF HVAC system manufacturer's written instructions, and as indicated.

D. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.13 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.14 DEMONSTRATION

A. Engage a VRF HVAC system manufacturer's employed training instructor or factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain entire system.

END OF SECTION 238129

SECTION 238146 - WATER-SOURCE UNITARY HEAT PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes unitary heat pumps with refrigerant-to-water heat exchangers, refrigeration circuits, and refrigerant compressor(s).

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings:

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For water-source unitary heat pumps, accessories, and components, from manufacturer.

B. Field quality-control reports.

C. Sample Warranty: For manufacturer's warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of water-source unitary heat pumps that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, refrigeration components.
2. Warranty Period: Four years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. ASHRAE Compliance:

1. ASHRAE 15.

B. Comply with NFPA 70.

C. Comply with safety requirements in UL 484 for assembly of free-delivery, water-source heat pumps.

2.2 WATER-SOURCE UNITARY HEAT PUMPS, 6 TONS (21 kW) AND SMALLER

A. Description: Packaged water-source unitary heat pump with temperature controls; factory assembled, piped, wired, tested, and rated according to ASHRAE/ARI/ISO-13256-1.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Cabinet and Chassis: Galvanized-steel casing with the following features:

1. Access panel for access and maintenance of internal components.
2. Knockouts for electrical and piping connections.
3. Cabinet Insulation: As directed, Glass-fiber liner, minimum 1/2 inch (13 mm), 3/4 inch (19 mm) thick, complying with UL 181, ASTM C1071, and ASTM G21.

C. Water Circuits:

1. Refrigerant-to-Water Heat Exchangers:

a. As directed, source-side coaxial heat exchangers with copper, cupronickel or internal vented double wall water tube, with enhanced heat-transfer surfaces inside a steel shell; both shell and tube are leak tested to 450 psig (3102 kPa) on refrigerant side and 400 psig (2758 kPa) on water side.
b. As directed, load-side coaxial heat exchangers with copper or cupronickel water tube, with enhanced heat-transfer surfaces inside a steel shell; both shell and tube are leak tested to 450 psig (3102 kPa) on refrigerant side and 400 psig (2758 kPa) on water side.
c. Stainless-steel, brazed-plate heat exchanger is leak tested to 450 psig (3102 kPa) on refrigerant side and 400 psig (2758 kPa) on water side. Factory mount heat exchanger in unit on resilient rubber vibration isolators.
d. As directed, Hot-water generator, copper water tube or vented double wall copper tube with enhanced heat-transfer surfaces inside a steel shell; both shell and tube are leak tested to 450 psig (3102 kPa) on refrigerant side and 400 psig (2758 kPa) on water side, pump, circuit breaker, high water temperature and low water refrigerant cutoffs, and tank connection.

D. Refrigerant Circuit Components:

1. Sealed Refrigerant Circuit: Charge with R-410A refrigerant.
2. Filter-Dryer: Factory installed to clean and dehydrate the refrigerant circuit.
3. Charging Connections: Service fittings on suction and liquid for charging and testing on each circuit.
4. Reversing Valve: Four-way, solenoid-activated valve designed to be fail-safe in heating position with replaceable magnetic coil.
5. Compressor:

    a. Scroll.
    b. As directed, Single stage, Two stage or Variable speed.
    c. Installed on vibration isolators and mounted on a structural steel base plate and full-length channel stiffeners.
    d. Exterior of compressor shall be wrapped with a high-density sound-attenuating blanket and housed in an acoustically treated enclosure.
    e. Factory-Installed Safeties:

        1) Antirecycle timer.
        2) High-pressure cutout.
        3) Low-pressure cutout or loss of charge switch.
        4) Internal thermal-overload protection.
        5) Freezestat to stop compressor if water-loop temperature in refrigerant-to-water heat exchanger falls below 35 deg F (2 deg C).
        6) Water-coil, low-temperature switch.

6. Refrigerant Piping Materials: ASTM B743 copper tube with wrought-copper fittings and brazed joints.
7. Pipe Insulation: Refrigerant minimum 3/8-inch- (10-mm-) thick, flexible elastomeric insulation on piping exposed to airflow through the unit. Maximum 25/50 flame-spread/smoke-developed indexes according to ASTM E84.
8. Refrigerant Metering Device: Thermal-expansion valve.
9. Refrigerant Metering Device: Dual-port, thermal-expansion valve to allow specified operation with entering-water temperatures from 25 to 125 deg F (minus 4 to plus 52 deg C).

E. Controls: Control equipment and sequence of operation are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."

F. Controls:

1. Basic Unit Control Modes and Devices:

    a. Unit shutdown on high or low refrigerant pressures.
    b. Unit shutdown on low water temperature.
    c. Low- and high-voltage protection.
    d. Overcurrent protection for compressor.
    e. Random time delay, three to 10 seconds, start on power-up.
    f. Time delay override for servicing.
    g. Control voltage transformer.

h. Water-coil freeze protection (selectable for water or antifreeze).
i. Automatic intelligent reset. Unit shall automatically reset five minutes after trip if the fault has cleared. Should a fault reoccur three times sequentially, lockout requiring manual reset occurs.
j. Ability to defeat time delays for servicing.
k. Digital display to indicate high pressure, low pressure, low voltage, and high voltage.
l. The low-pressure switch shall not be monitored for the first 90 seconds after a compressor start command to prevent nuisance safety trips.
m. Remote fault-type indication at thermostat.
n. Selectable 24-V dc or pilot duty dry contact alarm output.
o. 24-V dc output to cycle a motorized water valve with compressor contactor.
p. Service test mode for troubleshooting and service.
q. Unit-performance sentinel warns when heat pump is running inefficiently.
r. Compressor soft start.

2. Thermostat:

a. Wall-Mounted Thermostat:

1) Heat-cool-off switch.
2) As directed, Five day or Seven day, programmable.
3) As directed, Manual or Automatic changeover.
4) As directed, Concealed or Exposed temperature set point.
5) As directed, Concealed or Exposed temperature indication.
6) As directed, Deg F or C indication.

b. Wall-mounted temperature sensor.
c. Duct-mounted temperature sensor
d. Unoccupied period override push button.
e. Digital display to indicate fault condition at heat pump.
f. Data entry and access port.

1) Input data include room temperature and humidity set points for occupied and unoccupied periods.
2) Output data include room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.

3. Terminal Controller:

a. Scheduled operation for occupied and unoccupied periods on seven or 36-day clock As directed, with minimum of four programmable periods per day.
b. Two-hour unoccupied override period.
c. Remote-control panel to contain programmable timer and digital display for fault condition.
d. Compressor-disable relay to stop compressor operation for demand limiting or switch to unoccupied operation.
e. Automatic restart after five minutes if fault clears. Lockout after three attempts to restart following fault. Indicate fault for service technician.
f. Backup for volatile memory.

G. Electrical Connection: Single electrical connection with fused disconnect.

H. Capacities and Characteristics:

1. Source-Side Water Supply:

a. Water Flow: As directed.
b. Pressure Loss: As directed.
c. Entering-Water Temperature (Cooling): As directed.
d. Entering-Water Temperature (Heating): As directed.
e. Antifreeze Protection Chemical: As directed.
f. Antifreeze Concentration: As directed.

2. Load-Side Water Supply:

a. Water Flow: As directed.
b. Pressure Loss: As directed.
c. Entering-Water Temperature (Cooling): As directed.
d. Entering-Water Temperature (Heating): As directed.
e. Antifreeze Protection Chemical: As directed.
f. Antifreeze Concentration: As directed.

3. Cooling:

a. Total Capacity: As directed.
b. Sensible Capacity: As directed.
c. Minimum Energy-Efficiency Ratio (EER): As directed.

4. Heating:

a. Capacity: As directed.
b. Minimum Coefficient of Performance (COP): As directed.

5. Electrical Characteristics for Single Connection:

a. Volts: As directed, 120, 208 or 230 V.
b. Phase: As directed, Single or Three.
c. Hertz: 60.
d. Full-Load Amperes (FLA): As directed.
e. Maximum Circuit Amperage (MCA): As directed.
f. Maximum Overcurrent Protection (MOCP): As directed.

2.3 ACCESSORIES

A. Hose Kits: Tag hose kits to equipment designations.

1. Minimum Working Pressure: 400 psig (2758 kPa).
2. Operating Temperatures: From 33 to 211 deg F (1 to 100 deg C).
3. Hose Length: As directed, 24 inches (600 mm) or 36 inches (900 mm) As directed.
4. Minimum Hose Diameter: Equal to water-source unitary heat-pump piping connection.

5. Hose Material: Braided stainless steel with adapters for pipe connections.
6. Isolation Valves: Two-piece, bronze-body ball valves with stainless-steel ball and stem, standard-port threaded connections, and galvanized-steel lever handle. Valves shall be factory installed on supply and return connections of both load-side and source-side heat exchangers. If balancing valve is combination shutoff type with memory stop, the isolation valve may be omitted on the return.
7. Strainer: Y-pattern with blowdown valve in supply connections of both load and source side of heat exchangers.
8. Balancing Valves: Mount in return connection. Include meter ports to allow flow measurement with differential pressure gage.

    a. Automatic balancing valve, factory set to operate within 10 percent of design flow rate over a pressure range of 2 to 80 psig (13.8 to 552 kPa).
    b. Manual, calibrated-orifice balancing valve with memory stop.
    c. Manual, venturi-type balancing valve with memory stop.

9. Water-Regulating Valve Assemblies: A direct acting valve regulates discharge pressure during the cooling cycle, and a reverse acting valve regulates the suction pressure during the heating cycle. Valves shall close when heat-pump compressor is not running.
10. Motorized Water Valve: Stop water flow through the unit when compressor is off. Slow-acting, 24-V dc valve with threaded connections is installed between isolation valves and heat exchanger.

B. Hose Kit Assemblies:

1. Minimum Working Pressure: 400-psig (2758-kPa).
2. Operating Temperatures: From 33 to 211 deg F (1 to 100 deg C).
3. Hose Length: As directed, 24 inches (600 mm) or 36 inches (900 mm).
4. Minimum Hose Diameter: Equal to water-source unitary heat-pump piping connection.
5. Hose Material: Braided stainless steel with adapters for pipe connections.
6. Supply and return hoses having ball valve with pressure-temperature port.
7. Supply hose having ball valve with pressure-temperature port; return hose having automatic flow regulator valve with pressure-temperature ports and ball valve.
8. Supply hose having Y-pattern strainer with blowdown valve and ball valve with pressure-temperature port; return hose having automatic flow regulator with pressure-temperature ports and ball valve.
9. Supply hose having Y-pattern strainer with blowdown valve and ball valve with pressure-temperature port; return hose having ball valve with pressure-temperature port.

C. Loop Controller: Six stages; two stages for heating and four stages for cooling.

D. Pump Module:

1. As directed, minimum 1/6-hp, 230-V or 120-V, single-phase pump, rated for at least 16 gpm (1 L/s) at 20 feet of head (59 kPa).
2. General requirements for motors are specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
3. Include pump module hose kit with thread to barb fittings, hose, and hose clamps.
4. Three-way brass shut-off/flushing/purging valve.
5. Include controls to operate pump as required to maintain room temperature and ventilation set points.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment Mounting:

1. Install water-source, unitary heat pumps on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" As directed
2. Comply with requirements for vibration-isolation and seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration-isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

B. Suspend water-source, unitary heat pumps from structure with all-thread hanger rods and elastomeric hangers, spring hangers or spring hangers with vertical-limit stop As directed. Hanger rods and attachments to structure are specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment." Vibration hangers are specified in Section 230548 "Vibration and Seismic Controls for HVAC" or Section 230548.13 "Vibration Controls for HVAC" As directed.

C. Install wall-mounting thermostats and switch controls in electrical outlet boxes at heights to match lighting controls or as required in Section 230923 "Direct Digital Control (DDC) System for HVAC."

D. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

1. Connect supply and return hydronic piping to heat pump with unions and shutoff valves or hose kits as directed.

E. Install electrical devices furnished by manufacturer but not specified to be factory mounted.

F. Install piping adjacent to machine to allow space for service and maintenance.

3.2 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections:

1. After installing water to water heat pumps and after electrical circuitry has been energized, test units for compliance with requirements.
2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Heat pumps will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 238146

SECTION 238146.13 - WATER-TO-AIR HEAT PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Concealed horizontal or vertical units, 6 tons (21 kW) and smaller.
2. Exposed, floor-mounted console units.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data

1.5 QUALITY ASSURANCE

A. ASHRAE Compliance:

1. ASHRAE 15.
2. Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

B. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

C. Comply with NFPA 70.

D. Comply with safety requirements in UL 484 for assembly of free-delivery, water-source heat pumps.

E. Comply with safety requirements in UL 1995 for duct-system connections.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of water-source heat pumps that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, refrigeration components.
2. Warranty Period: Four years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 CONCEALED WATER-SOURCE HEAT PUMPS, 6 TONS (21 kW) AND SMALLER

A. Description: Packaged water-source heat pump with temperature controls; factory assembled, tested, and rated according to ASHRAE/ARI/ISO-13256-1.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended location and application.

B. Cabinet and Chassis: Galvanized-steel casing with the following features:

1. Access panel for access and maintenance of internal components.
2. Knockouts for electrical and piping connections.
3. Flanged duct connections.
4. Cabinet Insulation: Glass-fiber liner, minimum 1/2 inch (13 mm) thick, complying with UL 181, ASTM C1071, and ASTM G21.
5. Units field convertible for various discharge configurations.
6. Condensate Drainage: High-density polyethylene plastic or stainless-steel drain pan with condensate drain piping projecting through unit cabinet and complying with ASHRAE 62.1.

a. Condensate Overflow Protection Switch: Solid state electronic; mechanical float switch not permitted.

7. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Fan: Direct driven, centrifugal, with multispeed motor resiliently mounted in fan inlet and with inlet rings to allow wheel removal from one side without removing housing.

1. General requirements for motors are specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Motor: As directed, Multispeed, permanently lubricated, permanent split capacitor or ECM motor.

D. Water Circuit:

1. Refrigerant-to-Water Heat Exchangers:

   a. As directed, coaxial heat exchangers with copper or cupronickel water tube with enhanced heat-transfer surfaces inside a steel shell; both shell and tube are leak tested to 450 psig (3102 kPa) on refrigerant side and 400 psig (2758 kPa) on water side. Factory mount heat exchanger in unit on resilient rubber vibration isolators.
   b. Stainless-steel, brazed-plate heat exchanger is leak tested to 450 psig (3102 kPa) on refrigerant side and 400 psig (2758 kPa) on water side. Factory mount heat exchanger in unit on resilient rubber vibration isolators.

2. Water-Regulating Valves: Limit water flow through refrigerant-to-water heat exchanger, and control head pressure on compressor during cooling and heating. Valves shall close when heat-pump compressor is not running.
3. Motorized Water Valve: Stop water flow through the unit when compressor is off.

E. Refrigerant-to-Air Coils: Copper tubes with aluminum fins, leak tested to 450 psig (3102 kPa).

F. Refrigerant Circuit Components:

1. Sealed Refrigerant Circuit: Charge with R-410A refrigerant.
2. Filter-Dryer: Factory installed to clean and dehydrate the refrigerant circuit.
3. Charging Connections: Service fittings on suction and liquid for charging and testing on each circuit.
4. Reversing Valve: Four-way, solenoid-activated valve designed to be fail-safe in heating position with replaceable magnetic coil.
5. Compressor: As directed, Hermetic rotary, reciprocating, scroll, single-stage or two-stage compressor installed on vibration isolators and housed in an acoustically treated enclosure with factory-installed safeties as follows:

   a. Antirecycle timer.
   b. High-pressure cutout.
   c. Low-pressure cutout or loss of charge switch.
   d. Internal thermal-overload protection.
   e. Freezestat to stop compressor if water-loop temperature in refrigerant-to-water heat exchanger falls below 35 deg F (2 deg C).
   f. Condensate overflow switch to stop compressor with high condensate level in condensate drain pan.
   g. Water-coil, low-temperature switch.
   h. Air-coil, low-temperature switch.

6. Refrigerant Piping Materials: ASTM B743 copper tube with wrought-copper fittings and brazed joints.
7. Pipe Insulation: Refrigerant minimum 3/8-inch- (10-mm-) thick, flexible elastomeric insulation on piping exposed to airflow through the unit. Maximum 25/50 flame-spread/smoke-developed indexes according to ASTM E84.
8. Refrigerant Metering Device: Thermal-expansion valve.
9. Refrigerant Metering Device: Dual-port, thermal-expansion valve to allow specified operation with entering-water temperatures from 25 to 125 deg F (minus 4 to plus 52 deg C).

10. Hot-Gas Reheat Valve: Pilot-operated, sliding-type valve with replaceable magnetic coil.

G. Electric Heating Coil: Helix-wound, nickel-chromium, wire-heating elements in ceramic insulators mounted on steel supports. As directed, energize on call for heating when entering-water-loop temperature is less than 25 deg F (minus 4 deg C), 40 deg F (5 deg C) or 60 deg F (15 deg C).

H. Hot-Gas Reheat: Reheat valve diverts refrigerant hot gas to reheat coil when remote humidistat calls for dehumidification.

I. Filters: Disposable, glass-fiber, flat type, 1 inch (25 mm) thick, treated with adhesive, and having a minimum efficiency reporting value of 5 according to ASHRAE 52.2.

J. Filters: Disposable, pleated type, 1 inch (25 mm) thick and with a minimum efficiency reporting value of 7 according to ASHRAE 52.2.

K. Controls:

1. Basic Unit Control Modes and Devices:

a. Dehumidification mode.
b. Unit shutdown on high or low refrigerant pressures.
c. Unit shutdown on low water temperature.
d. Low- and high-voltage protection.
e. Overcurrent protection for compressor and fan motor.
f. Random time delay, three to ten seconds, start on power-up.
g. Time delay override for servicing.
h. Control voltage transformer.
i. Water-coil freeze protection (selectable for water or antifreeze).
j. Air-coil freeze protection (check filter switch).
k. Condensate overflow shutdown switch.
l. Option to reset unit at thermostat or disconnect.
m. Fault type shall be retained in memory if reset at thermostat.
n. Automatic intelligent reset. Unit shall automatically reset five minutes after trip if the fault has cleared. Should a fault reoccur three times sequentially, lockout requiring manual reset occurs.
o. Ability to defeat time delays for servicing.
p. Light-emitting diodes (LED) to indicate high pressure, low pressure, low voltage, and high voltage.
q. The low-pressure switch SHALL NOT be monitored for the first 90 seconds after a compressor start command to prevent nuisance safety trips.
r. Remote fault-type indication at thermostat.
s. Selectable 24-V dc or pilot duty dry contact alarm output.
t. 24-V dc output to cycle a motorized water valve with compressor contactor.
u. Electric heat output to control two stages of electric heat (emergency heat).
v. Service test mode for troubleshooting and service.
w. Unit-performance sentinel warns when the heat pump is running inefficiently.

2. Thermostat:

a. Wall-Mounted Thermostat:

1) Heat-cool-off switch.
2) Fan on-auto switch.
3) As directed, Manual or Automatic changeover.
4) As directed, Concealed or Exposed temperature set point.
5) As directed, Concealed or Exposed temperature indication.
6) Deg F or C indication as directed.

b. Wall-Mounted Humidistat: As directed, Concealed or Exposed.

1) Temperature set point.
2) Temperature indication.

c. Wall-mounted temperature sensor.
d. Unoccupied period override push button.
e. LED to indicate fault condition at heat pump.
f. Data entry and access port.

1) Input data include room temperature and humidity set points for occupied and unoccupied periods.
2) Output data include room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.

3. Terminal Controller:

a. As directed, Scheduled operation for occupied and unoccupied periods on seven or 365-day clock with minimum of four programmable periods per day.
b. Two-hour unoccupied override period.
c. Remote-control panel to contain programmable timer and LED for fault condition.
d. Compressor disable relay to stop compressor operation for demand limiting or switch to unoccupied operation.
e. Automatic restart after five minutes if fault clears. Lockout after three attempts to restart following fault. Indicate fault for service technician.
f. Return-air temperature high-limit (firestat). Stop unit on high temperature.
g. Backup for volatile memory.
h. Differential pressure switch to indicate fan status. Fan failure alarm.
i. Differential pressure switch to indicate filter status. Dirty filter alarm.

L. Electrical Connection: Single electrical connection with fused disconnect.

M. Capacities and Characteristics:

1. Fan:

a. Airflow: As directed.
b. External Static Pressure: As directed.
c. Fan Speed: As directed.
d. Motor Speed: As directed.
e. Motor Horsepower: As directed.

2. Water Supply:

   a. Water Flow: As directed.
   b. Pressure Loss: As directed.
   c. Entering-Water Temperature (Cooling): As directed.
   d. Entering-Water Temperature (Heating): As directed.
   e. Antifreeze Protection Chemical: As directed.
   f. Antifreeze Concentration: As directed.

3. Cooling:

   a. Total Capacity: As directed.
   b. Sensible Capacity: As directed.
   c. Minimum Energy-Efficiency Ratio (EER): As directed.
   d. Entering-Air Temperature Dry Bulb: As directed.
   e. Entering-Air Temperature Wet Bulb: As directed.

4. Heating:

   a. Capacity: As directed.
   b. Entering-Air Temperature: As directed.
   c. Air Temperature Rise: As directed.
   d. Minimum Coefficient of Performance (COP): As directed.

5. Electric Heating Coil (Optional Feature):

   a. Capacity: As directed.
   b. Number of Steps: As directed.

6. Filters:

   a. Face Area: As directed.
   b. Maximum Face Velocity: As directed.

7. Electrical Characteristics for Single Connection:

   a. Volts: As directed, 120, 208 or 230.
   b. Phase: As directed, Single or Three.
   c. Hertz: 60.
   d. Full-Load Amperes (F.L.A.): As directed.
   e. Maximum Circuit Amperage (MCA): As directed.
   f. Maximum Overcurrent Protection (MOCP): As directed.

2.2 EXPOSED, CONSOLE WATER-SOURCE HEAT PUMPS

A. Description: Packaged water-source heat pump with temperature controls; factory assembled, tested, and rated according to ASHRAE/ARI/ISO-13256-1.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended location and application.

B. Cabinet and Chassis: As directed, Manufacturer's standard, low standard- and low-height, flat or sloped-top, extended galvanized-steel casing with the following features:

1. Access panel for access and maintenance of internal components.
2. Knockouts for electrical and piping connections.
3. Cabinet Insulation: Glass-fiber liner, minimum 1/2 inch (13 mm) thick, complying with UL 181, ASTM C1071, and ASTM G21.
4. Cabinet Insulation: Glass-fiber liner, minimum 1/2 inch (13 mm) thick, complying with ASTM C1071 and NAIMA AH124, "Fibrous Glass Duct Liner Standard."
5. Condensate Drainage: High-density polyethylene plastic or stainless-steel drain pan with condensate drain piping projecting to unit exterior and complying with ASHRAE 62.1.

    a. Condensate Overflow Protection: Solid state electronic; mechanical float switch not permitted.

6. Discharge Grille: Steel, aluminum, or plastic grille for adjustable discharge air pattern.
7. Color: As directed, Selected by Architect from manufacturer's standard or custom color selection.
8. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Fan: Direct driven, centrifugal, with multispeed motor mounted on a removable fan-motor board.

1. General requirements for motors are specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Motor: As directed, Multispeed, permanently lubricated, permanent split capacitor or ECM.

D. Water Circuit:

1. Refrigerant-to-Water Heat Exchanger: As directed, Coaxial heat exchanger with copper or cupronickel water tube with enhanced heat-transfer surfaces inside a steel shell; both shell and tube are leak tested to 450 psig (3102 kPa) for refrigerant side and 400 psig (2758 kPa) for water side. Factory mount heat exchanger in unit on resilient rubber vibration isolators.
2. Water-Regulating Valves: Limit water flow through refrigerant-to-water heat exchanger and control head pressure on compressor during cooling and heating. Valves shall close when heat-pump compressor is not running.

E. Refrigerant-to-Air Coils: Copper tubes with aluminum fins, leak tested to 450 psig (3102 kPa).

F. Refrigerant Circuit Components:

1. Sealed Refrigerant Circuit: Charge with R-410A refrigerant.
2. Filter-Dryer: Factory installed to clean and dehydrate the refrigerant circuit.
3. Charging Connections: Service fittings on suction and liquid for charging and testing.

4. Reversing Valve: Four-way, solenoid-activated valve designed to be fail-safe in heating position with replaceable magnetic coil.
5. Compressor: Hermetic rotary compressor installed on vibration isolators housed in an acoustically treated enclosure with factory-installed safeties as follows:

    a. Antirecycle timer.
    b. High-pressure cutout.
    c. Low-pressure cutout or loss of charge switch.
    d. Internal thermal-overload protection.
    e. Freezestat to stop compressor if water-loop temperature in refrigerant-to-water heat exchanger falls below 35 deg F (2 deg C).
    f. Condensate overflow switch to stop compressor with high condensate level in condensate drain pan.
    g. Water-coil, low-temperature switch.
    h. Air-coil, low-temperature switch.

6. Refrigerant Piping Materials: ASTM B743 copper tube with wrought-copper fittings and brazed joints.
7. Pipe Insulation: Refrigerant minimum 3/8-inch- (10-mm-) thick, flexible elastomeric insulation on piping exposed to airflow through the unit. Maximum 25/50 flame-spread/smoke-developed indexes per ASTM E84.
8. Refrigerant Metering Device: Dual-port, thermal-expansion valve to allow specified operation with entering-water temperatures from 25 to 125 deg F (minus 4 to 52 deg C).
9. Hot-Gas Reheat Valve: Pilot-operated, sliding-type valve with replaceable magnetic coil.

G. Electric Heating Coil: Energized on call for heating when entering-water-loop temperature is less than 60 deg F (15 deg C).

H. Hot-Gas Reheat: As directed Reheat valve diverts refrigerant hot gas to reheat coil when remote or unit-mounted humidistat calls for dehumidification.

I. Outdoor-Air Damper: As directed Two-position, manual or motorized outdoor-air damper for fixed minimum intake up to 25 percent of fan capacity.

J. Filters: Disposable, glass-fiber, flat type, 1 inch (25 mm) thick, treated with adhesive, and having a minimum efficiency reporting value of 5 according to ASHRAE 52.2.

K. Filters: Disposable, pleated type, 1 inch (25 mm) thick and with a minimum efficiency reporting value of 7 according to ASHRAE 52.2.

L. Controls:

1. Basic Unit Control Modes and Devices:

    a. Dehumidification mode.
    b. Unit shutdown on high or low refrigerant pressures.
    c. Unit shutdown on low water temperature.
    d. Low- and high-voltage protection.
    e. Overcurrent protection for compressor and fan motor.
    f. Random time delay, three to ten seconds, start on power-up.
    g. Time delay override for servicing.

h. Control voltage transformer.
i. Water-coil freeze protection (selectable for water or antifreeze).
j. Air-coil freeze protection (check filter switch).
k. Condensate overflow shutdown switch.
l. Option to reset unit at thermostat or disconnect.
m. Fault type shall be retained in memory if reset at thermostat.
n. Automatic intelligent reset. Unit shall automatically reset five minutes after trip if the fault has cleared. Should a fault reoccur three times sequentially, lockout requiring manual reset occurs.
o. Ability to defeat time delays for servicing.
p. Light-emitting diodes (LED) to indicate high pressure, low pressure, low voltage, and high voltage.
q. The low-pressure switch SHALL NOT be monitored for the first 90 seconds after a compressor start command to prevent nuisance safety trips.
r. Remote fault-type indication at thermostat.
s. Selectable 24-V dc or pilot duty dry contact alarm output.
t. 24V dc output to cycle a motorized water valve with compressor contactor.
u. Electric heat output to control two stages of electric heat (emergency heat).
v. Service test mode for troubleshooting and service.
w. Unit-performance sentinel warns when the heat pump is running inefficiently.

2. Thermostat:

a. As directed Wall or Unit-Mounted Thermostat:

1) Heat-cool-off switch.
2) Fan on-auto switch.
3) As directed Manual or Automatic changeover.
4) As directed Concealed or Exposed temperature set point.
5) As directed Concealed or Exposed temperature indication.
6) As directed Deg F or C indication.

b. As directed Wall or Unit-Mounted Humidistat: As directed Concealed or Exposed.

1) Temperature set point.
2) Temperature indication.

c. As directed Wall or Unit-mounted temperature sensor.
d. Unoccupied period override push button.
e. LED to indicate fault condition at heat pump.
f. Data entry and access port.

1) Input data include room temperature and humidity set points for occupied and unoccupied periods.
2) Output data include room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.

3. Terminal Controller:

a. As directed Scheduled operation for occupied and unoccupied periods on seven or 365-day clock with minimum of four programmable periods per day.

b. Two-hour unoccupied override period.
c. Compressor disable relay to stop compressor operation for demand limiting or switch to unoccupied operation.
d. Automatic restart after five minutes if fault clears. Lockout after three attempts to restart following fault. Indicate fault for service technician.
e. Backup for volatile memory.
f. Differential pressure switch to indicate fan status. Fan failure alarm.
g. Differential pressure switch to indicate filter status. Dirty filter alarm.

M. Electrical Connection: Single electrical connection with fused disconnect.

N. Capacities and Characteristics:

1. Fan:

a. Airflow: As directed.
b. External Static Pressure: As directed.
c. Fan Speed: As directed.
d. Motor Speed: As directed.
e. Motor Horsepower: As directed.

2. Water Supply:

a. Water Flow: As directed.
b. Pressure Loss: As directed.
c. Entering-Water Temperature (Cooling): As directed.
d. Entering-Water Temperature (Heating): As directed.
e. Antifreeze Protection Chemical: As directed.
f. Antifreeze Concentration: As directed.

3. Cooling:

a. Total Capacity: As directed.
b. Sensible Capacity: As directed.
c. Minimum Energy-Efficiency Ratio (EER): As directed.
d. Entering-Air Temperature Dry Bulb: As directed.
e. Entering-Air Temperature Wet Bulb: As directed.

4. Heating:

a. Capacity: As directed.
b. Entering-Air Temperature: As directed.
c. Air Temperature Rise: As directed.
d. Minimum Coefficient of Performance (COP): As directed.

5. Electric Heating Coil (Optional Feature):

a. Capacity: As directed.
b. Number of Steps: As directed.

6. Filters:

a. Face Area: As directed.
b. Maximum Face Velocity: As directed.

7. Electrical Characteristics for Single Connection:

a. Volts/Phase/Hertz: As directed.
b. Full-Load Amperes (F.L.A.): As directed.
c. Maximum Circuit Amperage (MCA): As directed.
d. Maximum Overcurrent Protection (MOCP): As directed.

2.3 HOSE KITS

A. General: Hose kits shall be designed for minimum 400-psig (2758-kPa) working pressure and operating temperatures from 33 to 211 deg F (0.5 to 99 deg C). Tag hose kits to equipment designations.

B. Hose: As directed Length 24 inches (600 mm) or 36 inches (900 mm) braided stainless steel, complete with adapters, dimension As directed. Minimum diameter, equal to water-source, heat-pump connection size.

C. Isolation Valves: Two-piece, bronze-body ball valves with stainless-steel, standard-port ball and stem with normal pipe thread (NPT) connections, and galvanized-steel lever handle. Provide valve for supply and return. If balancing device is combination shutoff type with memory stop, the isolation valve may be omitted on the return.

D. Strainer: Y-type with blowdown valve in supply connection.

E. Balancing Device: Mount in return connection. Include meter ports to allow flow measurement with differential pressure gage.

1. Automatic balancing valve, factory set to operate within 10 percent of design flow rate over a 40:1 differential pressure range of 2 to 80 psig (13.8 to 552 kPa).
2. Manual, calibrated-orifice balancing valve.
3. Manual, venturi-type balancing valve.

F. Motorized Water Valve: Slow-acting, 24-V dc, with NPT connections.

2.4 HOSE KIT ASSEMBLIES

A. Supply and return hoses having ball valve with pressure temperature port.

B. Supply hose having ball valve with pressure temperature port; return hose having automatic flow regulator valve with pressure temperature ports, and ball valve.

C. Supply hose having "Y" strainer with blowdown valve, and ball valve with pressure temperature port; return hose having automatic flow regulator with PT ports, and ball valve.

D. Supply hose having "Y" strainer with blowdown valve, and ball valve with pressure temperature port.

E. Return hose having ball valve with pressure temperature port.

2.5 PUMP MODULE

A. Minimum 1/6-hp, 230-V, single-phase pump rated to move at least 16 gpm (1 L/s) at 20-feet wg (59-kPa) head pressure.

1. General requirements for motors are specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

B. Include pump module hose kit with thread to barb fittings, hose, and hose clamps.

C. Three-way brass shut-off/flushing/purging valve.

D. Include controls to operate pump as required to maintain room temperature and ventilation set points.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Floor Mounting: As directed Install water-source heat pumps using elastomeric pads, elastomeric mounts or restrained spring isolators. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Minimum Deflection: As directed 1/4 inch (6 mm) or 1 inch (25 mm).

B. Suspended Units: As directed Install water-source heat pumps with continuous-thread hanger rods and elastomeric hangers, spring hangers or spring hangers with vertical-limit stop of size required to support weight of water-source heat pump unit.

1. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."
2. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

C. Install wall-mounting thermostats, humidistats, and switch controls in electrical outlet boxes at heights to match lighting controls or as required in Section 230923.27 "Temperature Instruments," Section 230923.19 "Moisture Instruments," and Section 230923 "Direct Digital Control (DDC) System for HVAC."

D. Connect supply and return hydronic piping to heat pump.

E. Connect heat-pump condensate drain pan to indirect waste connection with condensate trap of adequate depth to seal against fan pressure. Install cleanouts in piping at changes of direction.

F. Connect supply and return ducts to water-source heat pumps with flexible duct connectors specified in Section 233300 "Air Duct Accessories."

G. Install electrical devices furnished by manufacturer but not specified to be factory mounted.

H. Install piping adjacent to machine to allow service and maintenance.

I. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

J. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.2 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections:

1. After installing water-source heat pumps and after electrical circuitry has been energized, test units for compliance with requirements.
2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Heat pumps will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 238146.13

SECTION 238213 - VALANCE HEATING AND COOLING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Electric radiant heaters.
2. Hydronic heating and cooling panels.

1.2 ACTION SUBMITTALS

A. Product Data: Include rated capacities, specialties, and accessories for each product indicated.

B. Shop Drawings:

1. Include plans, elevations, sections, details, and attachments to other work. Detail equipment assemblies and suspension and attachment.
2. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 ELECTRIC RADIANT HEATERS

A. Quartz Lamp Heating Elements: Coiled tungsten-wire heating element enclosed in clear quartz tube.

B. Quartz Tube Heating Elements: Nickel-chromium-wire heating element enclosed in quartz tube.

C. Metal-Sheathed Heating Elements: Nickel-chromium-wire heating element embedded in magnesium oxide powder enclosed in metal sheath. Comply with UL 1030.

D. Comply with UL 499 and UL 2021.

E. Enclosures: As directed, Aluminized, Stainless or Painted-steel housing with anodized-aluminum reflector.

1. Finish: As directed, Baked-enamel finish in manufacturer's standard or custom paint color as selected by Architect.

F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Unit Controls:

1. Line-voltage thermostat.
2. Enclosed contactor for remote thermostat.
3. Snow and ice detector with moisture sensor and integral temperature sensor.

H. Capacities and Characteristics:

1. Enclosure Length: As directed.
2. Mounting Height: As directed.
3. Heating Capacity: As directed.
4. Radiation Pattern: As directed, 30, 60 or 90 symmetric or asymmetric-degree-included angle.
5. Electrical Characteristics for Single-Point Connection:

    a. Volts: As directed.
    b. Phase: As directed.
    c. Hertz: As directed.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed.
    f. Maximum Overcurrent Protection: As directed.

2.2 HYDRONIC HEATING AND COOLING PANELS

A. Description: As directed, Modular or Linear sheet-metal panel with serpentine water piping, suitable for lay-in installation flush with T-bar ceiling grid, surface mounting or recessed mounting.

1. Panels: As directed, Minimum 0.0336-inch- (0.86-mm-) thick, galvanized-steel or 0.0396-inch- (1.0-mm-) thick, aluminum sheet.
2. Backing Insulation: As directed, Minimum 1-inch- (25-mm-) or 2-inch- (50-mm-) thick, mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C612, Type IA or Type IB with factory-applied jacket.
3. Exposed-Side Panel Finish: Apply silk-screened finish to match appearance of acoustical ceiling tiles selected by Architect.
4. Exposed-Side Panel Finish: Factory prime coated, ready for field painting.
5. Exposed-Side Panel Finish: As directed, Baked-enamel finish in manufacturer's standard or custom paint color as selected by Architect.
6. Factory Piping: As directed, ASTM B88, Type L (ASTM B88M, Type B) or ASTM B88, Type M (ASTM B88M, Type C) copper tube with ASME B16.22 wrought-copper fittings and brazed joints. Piping shall be mechanically bonded to panel.
7. Surface-Mounted Trim: As directed, Sheet metal with baked-enamel finish in manufacturer's standard or custom paint color as selected by Architect.
8. Accessories:

a. As directed, 5-inch (127-mm), 6-inch (152-mm) or 8-inch (203-mm) panel with drape track recess.
b. 5-inch (127-mm) male bullnose panel.
c. 5-inch (127-mm) female bullnose panel.
d. 4-inch (102-mm) male corner panel.
e. 4-inch (102-mm) female corner panel.
f. Inside corner panel.
g. 1/2-inch (13-mm) filler panel.

B. Capacities and Characteristics:

1. Nominal Panel Size: As directed, 24 by 24 inches (600 by 600 mm), 24 by 36 inches (600 by 900 mm), 24 by 48 inches (600 by 1200 mm) or 24 by 60 inches (600 by 1500 mm).
2. Piping Inlet and Outlet: NPS 1/2 (DN 15).
3. Heating:

a. Capacity: As directed.
b. Room Temperature: As directed.
c. Entering-Water Temperature: As directed.
d. Average Water Temperature: As directed.
e. Water Flow: As directed.
f. Water-Side Pressure Loss: As directed.

4. Cooling:

a. Sensible Capacity: As directed.
b. Dry-Bulb Room Temperature: As directed.
c. Wet-Bulb Room Temperature: As directed.
d. Entering-Water Temperature: As directed.
e. Average Water Temperature: As directed.
f. Water Flow: As directed.
g. Water-Side Pressure Loss: As directed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install radiant heating and cooling units level and plumb.

B. Suspend radiant heaters from structure.

C. Coordinate layout and installation of radiant heaters and suspension-system components with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, communications system, security system, and partition assemblies.

D. Support for Radiant Heating and Cooling Panels in or on Grid-Type Suspended Ceilings: Use grid as a support element.

1. Install a minimum of four ceiling support-system rods or wires for each panel. Locate not more than 6 inches (150 mm) from panel corners.
2. Support Clips: Fasten to panel and to ceiling grid members at or near each panel corner with clips designed for the application.
3. Panels of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans, or center in acoustical panel and support panels independently with at least two 3/4-inch (19-mm) metal channels spanning and secured to ceiling tees.

E. Install devices As directed, 48 inches (1220 mm) or 60 inches (1525 mm above finished floor.

F. Piping installation requirements are specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties. "Section 15179 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

G. Unless otherwise indicated, install shutoff valve and union or flange at each connection.

H. Install piping adjacent to unit to allow service and maintenance.

I. Ground electric units according to Section 260526 "Grounding and Bonding for Electrical Systems."

J. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operate electric heating elements through each stage to verify proper operation and electrical connections.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and units.

B. Remove and replace malfunctioning units and retest as specified above.

C. After installing panels, inspect unit cabinet for damage to finish. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

D. Prepare test and inspection reports.

END OF SECTION 238213

SECTION 238214 - CHILLED BEAMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes active chilled beams.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for chilled beams.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories for chilled beams.

B. Shop Drawings: For chilled beams.

1. As directed, include plans, elevations, sections, and mounting or attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for chilled beams, accessories, and components, from manufacturer.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Chilled beams shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 ACTIVE CHILLED BEAMS

A. Standards:

1. Comply with ASHRAE 55.

B. Description: Sheet metal with primary air plenum, secondary chilled-water coil and heating-water coil assembly, and mounting-bracket supports suitable for surface mounting, exposed hangers, recessed mounting or lay-in installation flush with T-bar ceiling grid.

C. Components:

1. Other building components integrated into chilled-beam configuration including the following:

    a. Lighting fixtures.
    b. Air inlets and outlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels.

2. Panel: Minimum 0.0375-inch- (0.95-mm-) thick, galvanized-steel sheet.
3. Factory Piping: As directed, ASTM B88, Type L (ASTM B88M, Type B) or ASTM B88, Type M (ASTM B88M, Type C) copper tube with ASME B16.22 wrought-copper fittings and brazed joints.
4. Hydronic Coils: Copper tube, with mechanically bonded 0.006-inch- (0.15-mm-) thick, aluminum fins spaced no closer than 0.1 inch (2.5 mm), rated for a minimum working pressure of 200 psig (1378 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve.

    a. Cooling Coil: NPS 1/2 (DN 15).
    b. Heating Coil: NPS 1/2 (DN 15).

5. Number of Nozzles: Four.
6. Electrical Connections: Nonheating, high-temperature, insulated-copper leads.

D. Exposed Metal Finish: As directed, Sheet metal with baked enamel, Silk-screened finish to match appearance of acoustical ceiling tiles as selected by Architect or Factory prime coated, ready for field painting.

1. Color: As directed, Manufacturer's standard or custom paint color as selected by Architect.
2. Surface-Mounted Trim: As directed, Sheet metal with baked-enamel finish in manufacturer's standard or custom paint color as selected by Architect.

E. Capacities and Characteristics:

1. Nominal Panel Size: As directed, 12 by 48 inches (300 by 1200 mm), 24 by 48 inches (600 by 1200 mm), 12 by 96 inches (300 by 2400 mm) or 12 by 118 inches (300 by 3000 mm).
2. Nominal Depth: As directed, 4 inches (100 mm) or 7 inches (180 mm).
3. Room Temperature for Cooling: 75 deg F (24 deg C).
4. Cooling Capacity: As directed.
5. Chilled-Water Inlet Temperature: As directed.

6. Average Chilled-Water Temperature: As directed.
7. Chilled-Water Flow: As directed.
8. Room Temperature for Heating: 72 deg F (21 deg C).
9. Heating Capacity: As directed.
10. Heating-Water Inlet Temperature: As directed.
11. Heating-Water Flow: As directed.
12. Average Heating-Water Temperature: As directed.

2.3 CONTROLS AND SAFETIES

A. Wall Thermostat: Bimetal sensing elements calibrated from 55 to 90 deg F (13 to 32 deg C); with contacts suitable for low or control-voltage circuit As directed, and manually operated on-off switch with contactors, relays, and control transformers.

B. Humidistat: As directed, Wall mounted or Unit mounted with concealed or exposed set point and contacts suitable for low or control-voltage circuit, and manually operated on-off switch with contactors, relays, and control transformers.

2.4 ACCESSORIES

A. Purging Nipple: Copper, with threaded end connection.

B. Chilled-Beam Unit Frame: As directed, Aluminum, Steel, clear anodized finish, silk-screened finish to match appearance of acoustical ceiling panels selected by Architect, factory prime coated, ready for field painting or baked-enamel finish.

1. Color: As directed, Manufacturer's standard or custom paint color, selected by Architect.

C. Flexible Water-Connector Hose: As directed, 20 inches (500 mm), 30 inches (750 mm) or 39 inches (1000 mm) long.

D. Access Door: Hinged with four spring-loaded cabinet roller latches.

2.5 GENERAL FINISH REQUIREMENTS

A. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Finish chilled beams after assembly.

C. Appearance of Finished Work: Variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

PART 3 - EXECUTION

3.1 INSTALLATION

A. As directed, Install surface-mounted, exposed hanger-mounted, recessed-mounted or lay-in ceiling-mounted chilled-beam units level and plumb.

B. Coordinate layout and installation of chilled beams and suspension-system components with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, communications system, security system, and partition assemblies.

C. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

D. Comply with requirements for general-duty valves specified in Section 230523.11 "Globe Valves for HVAC Piping," Section 230523.12 "Ball Valves for HVAC Piping," Section 230523.13 "Butterfly Valves for HVAC Piping," Section 230523.14 "Check Valves for HVAC Piping," and Section 230523.15 "Gate Valves for HVAC Piping."

E. Install continuous-thread hanger rods of size required to support chilled-beam weight.

F. Comply with NECA 1.

G. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceways and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for cable trays specified in Section 260536 "Cable Trays for Electrical Systems."
3. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

H. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

I. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.2 IDENTIFICATION

A. Identify electrical-system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Identify hydronic piping and valves. Comply with requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust thermostatic controls and equipment. Replace damaged and malfunctioning controls and equipment.

C. Chilled beam will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.4 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

END OF SECTION 238214

SECTION 238216.11 - HYDRONIC AIR COILS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes hydronic heating and cooling air coils.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 DESCRIPTION

A. ASHRAE Compliance: Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

2.2 COILS

A. Performance Ratings: Tested and rated according to AHRI 410 and ASHRAE 33.

B. Minimum Working-Pressure/Temperature Ratings: 200 psig (1380 kPa), 325 deg F (163 deg C).

C. Source Quality Control: Factory tested to 300 psig (2070 kPa).

D. Tubes: As directed, ASTM B743 copper, minimum 0.020 inch (0.508 mm), 0.035 inch (0.889 mm) or 0.049 inch (1.245 mm) thick.

E. Fins: As directed, Aluminum or Copper, minimum 0.006 inch (0.152 mm) or 0.010 inch (0.254 mm) thick.

F. Headers: As directed, cast iron with drain and air vent tappings, Cast iron with cleaning plugs and drain and air vent tappings, Seamless copper tube with brazed joints, prime coated or Steel with brazed joints, prime coated.

G. Frames: As directed, Galvanized-steel channel frame, minimum 0.052 inch (1.3 mm), 0.064 inch (1.6 mm) or 0.079 inch (2.0 mm) thick for slip-in or flanged mounting.

H. Hot-Water Coil Capacities and Characteristics:

1. Coil Face Dimensions:

    a. Finned Length: As directed.
    b. Finned Width: As directed.

2. Minimum Fin Spacing: As directed, 0.125 inch (3.18 mm), 0.091 inch (2.31 mm), 0.071 inch (1.81 mm), 0.067 inch (1.70 mm), 0.056 inch (1.41 mm) or 0.0075 inch (0.19 mm).
3. Tube Diameter: As directed, 0.375 inch (9.5 mm), 0.50 inch (12.7 mm), 0.625 inch (15.9 mm), 0.75 inch (19.0 mm) or 1.0 inch (25.4 mm).
4. Number of Rows: As directed.
5. Serpentine: As directed, Single, Half or Full.
6. Mounting: As directed, Slip in or Flanged.
7. Coating: As directed, Baked phenolic or Cathodic epoxy e-coat.
8. Air Side:

    a. Flow Rate: As directed.
    b. Finned Area Face Velocity: As directed.
    c. Static Pressure Drop: As directed.
    d. Total Capacity: As directed.
    e. Entering Temperature: As directed.
    f. Leaving Temperature: As directed.

9. Water Side:

    a. Flow Rate: As directed.
    b. Tube Velocity: As directed.
    c. Glycol Type: As directed, Ethylene or Propylene.
    d. Aqueous Glycol Solution Concentration: As directed.
    e. Pressure Drop: As directed.
    f. Entering Temperature: As directed.
    g. Leaving Temperature: As directed.

I. Chilled-Water Coil Capacities and Characteristics:

1. Coil Face Dimensions:

    a. Finned Length: As directed.
    b. Finned Width: As directed.

2. Minimum Fin Spacing: As directed, 0.125 inch (3.18 mm), 0.091 inch (2.31 mm), 0.071 inch (1.81 mm), 0.067 inch (1.70 mm), 0.056 inch (1.41 mm) or 0.0075 inch (0.19 mm).
3. Tube Diameter: As directed, 0.375 inch (9.5 mm), 0.50 inch (12.7 mm), 0.625 inch (15.9 mm), 0.75 inch (19.0 mm) or 1.0 inch (25.4 mm).
4. Number of Rows: As directed.
5. Serpentine: As directed, Half, Single or Double.

6. Mounting: As directed, Slip in or Flanged.
7. Coating: As directed, Baked phenolic or Cathodic epoxy e-coat.
8. Air Side:

    a. Flow Rate: As directed.
    b. Finned Area Face Velocity: As directed.
    c. Static Pressure Drop: As directed.
    d. Total Capacity: As directed.
    e. Sensible Capacity: As directed.
    f. Entering Dry-Bulb Temperature: As directed.
    g. Entering Wet-Bulb Temperature: As directed.
    h. Leaving Dry-Bulb Temperature: As directed.
    i. Leaving Wet-Bulb Temperature: As directed.

9. Water Side:

    a. Flow Rate: As directed.
    b. Tube Velocity: As directed.
    c. Glycol Type: As directed, Ethylene or Propylene.
    d. Aqueous Glycol Solution Concentration: As directed.
    e. Pressure Drop: As directed.
    f. Entering Temperature: As directed.
    g. Leaving Temperature: As directed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install coils level and plumb.

B. Install coils in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

C. As directed, Install galvanized or stainless-steel drain pan under each cooling coil.

1. Construct drain pans with connection for drain; insulated and complying with ASHRAE 62.1.
2. Construct drain pans to extend beyond coil length and width and to connect to condensate trap and drainage.
3. Extend drain pan upstream and downstream from coil face.
4. Extend drain pan under coil headers and exposed supply piping.

D. Install moisture eliminators for cooling coils. Extend drain pan under moisture eliminator.

E. Straighten bent fins on air coils.

F. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to coils to allow service and maintenance.

C. Connect water piping with unions and shutoff valves to allow coils to be disconnected without draining piping. Control valves are specified in Section 230923.11 "Control Valves," and other piping specialties are specified in Section 232116 "Hydronic Piping Specialties."

END OF SECTION 238216.11

SECTION 238216.12 - STEAM AIR COILS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes steam heating air coils.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 DESCRIPTION

A. ASHRAE Compliance: Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

2.2 COILS

A. Performance Ratings: Tested and rated according to AHRI 410 and ASHRAE 33.

B. Minimum Working-Pressure/Temperature Ratings: 100 psig (690 kPa), 400 deg F (204 deg C).

C. Source Quality Control: Factory tested to 300 psig (2070 kPa).

D. Tubes: As directed, ASTM B743 copper, minimum 0.025 inch (0.635 mm), 0.035 inch (0.889 mm) or 0.049 inch (1.245 mm) thick.

E. Fins: As directed, Aluminum or Copper, minimum 0.006 inch (0.152 mm) or 0.010 inch (0.254 mm) thick.

F. Headers: As directed, Cast iron with drain and air vent tappings, Cast iron with cleaning plugs, and drain and air vent tappings, Seamless copper tube with brazed joints, prime coated or Steel with brazed joints, prime coated.

G. Tube Type: Single or distributing as indicated.

H. Frames: As directed, Galvanized-steel channel frame, minimum 0.052 inch (1.3 mm), 0.064 inch (1.6 mm) or 0.079 inch (2.0 mm) thick for slip-in or flanged mounting.

I. Capacities and Characteristics:

1. Coil Face Dimensions:

   a. Finned Length: As directed.
   b. Finned Width: As directed.

2. Minimum Fin Spacing: As directed, 0.125 inch (3.18 mm), 0.091 inch (2.31 mm), 0.071 inch (1.81 mm), 0.067 inch (1.70 mm), 0.056 inch (1.41 mm) or 0.0075 inch (0.19 mm).
3. Tube Diameter: As directed, 0.375 inch (9.5 mm), 0.50 inch (12.7 mm), 0.625 inch (15.9 mm), 0.75 inch (19.0 mm) or 1.0 inch (25.4 mm).
4. Number of Rows: As directed.
5. Mounting: As directed, Slip in or Flanged.
6. Air Side:

   a. Flow Rate: As directed.
   b. Finned Area Face Velocity: As directed.
   c. Static Pressure Drop: As directed.
   d. Total Capacity: As directed.
   e. Entering Temperature: As directed.
   f. Leaving Temperature: As directed.

7. Steam Side:

   a. Inlet Pressure: As directed.
   b. Tube Type: As directed, Single or Distributing.
   c. Condensing Capacity: As directed.
   d. Pressure Drop: As directed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install coils level and plumb.

B. Install coils in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

C. Straighten bent fins on air coils.

D. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to coils to allow service and maintenance.

C. Connect steam piping with gate valve and union and steam condensate piping with union, strainer, trap, and gate valve to allow coils to be disconnected without draining piping. Control valves are specified in Section 230923.11 "Control Valves," and other piping specialties are specified in Section 232213 "Steam and Condensate Heating Piping."

END OF SECTION 238216.12

SECTION 238216.13 - REFRIGERANT AIR COILS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes refrigerant air coils.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 DESCRIPTION

A. ASHRAE Compliance: Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

2.2 REFRIGERANT AIR COILS

A. Performance Ratings: Tested and rated according to AHRI 410 and ASHRAE 33.

B. Minimum Working-Pressure Rating: 300 psig (2070 kPa).

C. Source Quality Control: Factory tested to 450 psig (3105 kPa).

D. Tubes: As directed, ASTM B743 copper, minimum 0.020 inch (0.508 mm), 0.035 inch (0.889 mm) or 0.049 inch (1.245 mm) thick.

E. Fins: As directed, Aluminum or Copper, minimum 0.006 inch (0.152 mm) or 0.010 inch (0.254 mm) thick.

F. Suction and Distributor Piping: ASTM B88, Type L (ASTM B88M, Type B) copper tube with brazed joints.

G. Frames: Galvanized-steel channel frame, minimum 0.052 inch (1.3 mm), 0.064 inch (1.6 mm) or 0.079 inch (2.0 mm) thick for slip-in or flanged mounting.

H. Capacities and Characteristics:

1. Coil Face Dimensions:

   a. Finned Length: As directed.
   b. Finned Width: As directed.

2. Minimum Fin Spacing: As directed, 0.125 inch (3.18 mm), 0.091 inch (2.31 mm), 0.071 inch (1.81 mm), 0.067 inch (1.70 mm), 0.056 inch (1.41 mm) or 0.0075 inch (0.19 mm).
3. Tube Diameter: As directed, 0.375 inch (9.5 mm), 0.50 inch (12.7 mm), 0.625 inch (15.9 mm), 0.75 inch (19.0 mm) or 1.0 inch (25.4 mm).
4. Number of Rows: As directed.
5. Coil Split: As directed, Row, Face or Interlaced.
6. Mounting: As directed, Slip in or Flanged.
7. Coating: As directed, Baked phenolic or Cathodic epoxy e-coat.
8. Air Side:

   a. Flow Rate: As directed.
   b. Finned Area Face Velocity: As directed.
   c. Static Pressure Drop: As directed.
   d. Total Capacity: As directed.
   e. Sensible Capacity: As directed.
   f. Entering Dry-Bulb Temperature: As directed.
   g. Entering Wet-Bulb Temperature: As directed.
   h. Leaving Dry-Bulb Temperature: As directed.
   i. Leaving Wet-Bulb Temperature: As directed.

9. Refrigerant Side:

   a. Refrigerant Type: As directed, R-410A, HFC-134a or HFC refrigerant.
   b. Saturated Suction Temperature: As directed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install coils level and plumb.

B. Install coils in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

C. As directed, Install galvanized or stainless-steel drain pan under each cooling coil.

1. Construct drain pans with connection for drain; insulated and complying with ASHRAE 62.1.
2. Construct drain pans to extend beyond coil length and width and to connect to condensate trap and drainage.
3. Extend drain pan upstream and downstream from coil face.
4. Extend drain pan under coil headers and exposed supply piping.

D. Install moisture eliminators for cooling coils. Extend drain pan under moisture eliminator.

E. Straighten bent fins on air coils.

F. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

G. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

H. Install piping adjacent to coils to allow service and maintenance.

I. Connect refrigerant piping according to Section 232300 "Refrigerant Piping."

END OF SECTION 238216.13

SECTION 238216.14 - ELECTRIC-RESISTANCE AIR COILS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes electric resistance air coils.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 DESCRIPTION

A. ASHRAE Compliance: Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

2.2 COILS

A. Testing Agency Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Coil Assembly: Comply with UL 1995.

C. Heating Elements: Coiled resistance wire of 80 percent nickel and 20 percent chromium; surrounded by compacted magnesium-oxide powder in tubular-steel sheath; with spiral-wound, copper-plated, steel fins continuously brazed to sheath.

D. High-Temperature Coil Protection: Disk-type, automatically reset, thermal-cutout, safety device; serviceable through terminal box without removing heater from duct or casing.

1. Secondary Protection: Load-carrying, manually reset or manually replaceable, thermal cutouts; factory wired in series with each heater stage.

E. Frames: As directed, Galvanized-steel channel frame, minimum 0.052 inch (1.3 mm), 0.064 inch (1.6 mm) or 0.079 inch (2.0 mm) thick for slip-in or flanged mounting.

F. Control Panel: As directed, Unit or Remote mounted with disconnecting means and overcurrent protection. Include the following controls:

1. Magnetic contactor.
2. Mercury contactor.
3. Toggle switches; one per step.
4. Step controller.
5. Time-delay relay.
6. Pilot lights; one per step.
7. Airflow proving switch.

G. See Section 230923.27 "Temperature Instruments" for thermostat.

H. Capacities and Characteristics:

1. Coil Face Dimensions:

   a. Length: As directed.
   b. Height: As directed.

2. Mounting: As directed, Slip in or Flanged.
3. Air Side:

   a. Flow Rate: As directed.
   b. Face Velocity: As directed.
   c. Static Pressure Drop: As directed.
   d. Total Capacity: As directed.
   e. Entering Temperature: As directed.
   f. Leaving Temperature: As directed.

4. Electrical Characteristics:

   a. Capacity: As directed.
   b. Number of Steps: As directed.
   c. Volts: As directed.
   d. Phase: As directed.
   e. Hertz: As directed.
   f. Full-Load Amperes: As directed.
   g. Minimum Circuit Ampacity: As directed.
   h. Maximum Overcurrent Protection: As directed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install coils level and plumb.

B. Install coils in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

C. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

3.2 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

END OF SECTION 238216.14

SECTION 238219 - FAN COIL UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes ductless fan coil units and accessories.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed

C. Shop Drawings:

1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.

D. Samples: For units with factory-applied color finishes.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale and coordinated with each other based on input from installers of the items involved:

B. Seismic Qualification Certificates: For fan coil units, accessories, and components, from manufacturer.

C. Field quality-control reports.

D. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Comply with NFPA 70.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Factory-packaged and -tested units rated according to AHRI 440, ASHRAE 33, and UL 1995.

2.2 DUCTLESS FAN COIL UNITS

A. Fan Coil Unit Configurations: As directed, Row or Face split.

1. Number of Heating Coils: One with two-pipe system.
2. Number of Cooling Coils: One or Three with two or four-pipe system.

B. Coil Section Insulation: As directed, 1/2-inch- (13-mm-) or 1-inch- (25-mm-) thick, coated glass fiber, foil-covered, closed-cell foam or matte-finish, closed-cell foam complying with ASTM C1071 and attached with adhesive complying with ASTM C916.

1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E84 by a qualified testing agency.
2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Coil Section Insulation: Insulate coil section according to Section 230616 "HVAC Equipment Insulation."

1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E84 by a qualified testing agency.
2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. As directed, Main and Auxiliary Drain Pans: As directed, Plastic, Stainless steel or Insulated galvanized steel with plastic liner. Fabricate pans and drain connections to comply with ASHRAE 62.1. Drain pans shall be removable.

E. Chassis: Galvanized steel where exposed to moisture, with baked-enamel finish and removable access panel, with powder-coat finish and removable access panel. Floor-mounting units shall have leveling screws.

F. Cabinet: As directed, Steel with factory prime coating, ready for field painting, baked-enamel finish in manufacturer's standard paint color as selected by Architect or baked-enamel finish in manufacturer's custom paint color as selected by Architect.

1. Vertical Unit Front Panels: As directed, Removable, steel, with integral stamped, polyethylene or steel discharge grille and channel-formed edges, cam fasteners, and insulation on back of panel.
2. Horizontal Unit Bottom Panels: Fastened to unit with cam fasteners and hinge and attached with safety chain; with integral stamped or cast-aluminum discharge grilles As directed.
3. Stack Unit Discharge and Return Grille: Aluminum double-deflection discharge grille, and louvered- or panel-type return grille; color as selected by Architect from manufacturer's standard or custom colors as directed. Return grille shall provide maintenance access to fan coil unit.
4. Steel recessing flanges for recessing fan coil units into ceiling or wall.

G. Filters: Minimum arrestance and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2 and all addendums.

1. MERV Rating: As directed, 6 or 13 when tested according to ASHRAE 52.2.
2. Washable Foam: 70 percent arrestance and MERV 3.
3. Glass Fiber Treated with Adhesive: 80 percent arrestance and MERV 5.
4. Pleated Cotton-Polyester Media: 90 percent arrestance and MERV 7.

H. Hydronic Coils: Copper tube with corrosion-resistant coating, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), rated for a minimum working pressure of 200 psig (1378 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve.

I. Corrosion-Resistant Coating: Coat coils with a corrosion-resistant coating capable of withstanding a 3,000-hour salt-spray test according to ASTM B117.

1. Standards:

   a. ASTM B117 for salt spray.
   b. ASTM D2794 for minimum impact resistance of 100 in-lb (11.3 N-m).
   c. ASTM D3359 for cross hatch adhesion of 5B.

2. Application: As directed, Immersion or Spray.
3. Thickness: 1 mil.
4. Gloss: Minimum gloss of 50 gloss units on a single angle 60 degree meter.
5. UV Protection: Spray applied topcoat.

J. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with fuses in terminal box for overcurrent protection and limit controls for high-temperature protection. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.

K. Fan and Motor Board: Removable.

1. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.

2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
3. Wiring Termination: Connect motor to chassis wiring with plug connection.

L. Factory, Hydronic Piping Package: As directed, ASTM B88, Type L (ASTM B88M, Type B) or ASTM B88, Type M (ASTM B88M Type C) copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.

1. As directed, Two or Three-way, two-position or modulating control valve for dual-temperature coil.
2. As directed, Two or Three-way, two-position or modulating control valve for chilled-water coil.
3. As directed, Two or Three-way, two-position or modulating control valve for hot-water heating coil.
4. Hose Kits: Minimum 400-psig (2758-kPa) working pressure and operating temperatures from 33 to 211 deg F (0.5 to 99 deg C). Tag hose kits to equipment designations.

    a. Length: As directed, 24 inches (600 mm) or 36 inches (900 mm).
    b. Minimum Diameter: Equal to fan coil unit connection size.

5. Two-Piece Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig (4140-kPa) minimum CWP rating and blowout-proof stem.
6. Calibrated-Orifice Balancing Valves: Bronze body, ball type; 125-psig (860-kPa) working pressure, 250 deg F (121 deg C) maximum operating temperature; with calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, threaded ends, and a memory stop to retain set position.
7. Automatic Flow-Control Valve: Brass or ferrous-metal body; 300-psig (2070-kPa) working pressure at 250 deg F (121 deg C); with removable, corrosion-resistant, tamperproof, self-cleaning piston spring; factory set to maintain constant indicated flow with plus or minus 10 percent over differential pressure range of 2 to 80 psig (13.8 to 552 kPa).
8. Y-Pattern Hydronic Strainers: Cast-iron body (ASTM A126, Class B); 125-psig (860-kPa) working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 (DN 15) hose-end, full-port, ball-type blowdown valve in drain connection.
9. Wrought-Copper Unions: ASME B16.22.
10. Risers: As directed, ASTM B88, Type L (ASTM B88M, Type B) or ASTM B88, Type M (ASTM B88M Type C) copper pipe with hose and ball valve for system flushing.

M. Control devices and operational sequences are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."

N. Basic Unit Controls:

1. Control voltage transformer.
2. As directed, Wall-mounting or Unit-mounted thermostat with the following features:

    a. Heat-cool-off switch.
    b. Fan on-auto switch.

c. Fan-speed switch.
d. As directed, Manual or Automatic changeover.
e. Adjustable deadband.
f. As directed, Concealed or Exposed set point.
g. As directed, Concealed or Exposed indication.
h. As directed, Degree F or Degree C indication.

3. As directed, Wall-mounting or Unit-mounted humidistat.

a. As directed, Concealed or Exposed set point.
b. As directed, Concealed or Exposed indication.

4. As directed, wall-mounting or Unit-mounted temperature sensor.
5. Unoccupied-period-override push button.
6. Data entry and access port.

a. Input data includes room temperature, and humidity set points and occupied and unoccupied periods.
b. Output data includes room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.

O. DDC Terminal Controller:

1. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
2. Unoccupied-Period-Override Operation: Two hours.
3. Unit Supply-Air Fan Operation:

a. Occupied Periods: Fan runs continuously.
b. Unoccupied Periods: Fan cycles to maintain room setback temperature.

4. Hydronic-Cooling-Coil Operation:

a. Occupied Periods: As directed, Open or Modulate control valve to maintain room temperature.
b. Unoccupied Periods: Close control valve.

5. Supplemental Heating-Coil Operation:

a. Occupied Periods: As directed, Open control valve, Modulate control valve or Energize electric-resistance coil to provide heating if room temperature falls below thermostat set point.
b. Unoccupied Periods: As directed, Start fan and open control valve, modulate control valve or energize electric-resistance coil if room temperature falls below setback temperature.

6. Dual-Temperature Hydronic-Coil Operation:

a. Occupied Periods: When chilled water is available, As directed, open or modulate control valve if room temperature exceeds thermostat set point. When hot water is available, open control valve if temperature falls below thermostat set point.

b. Unoccupied Periods: When chilled water is available, close control valve. When hot water is available, As directed, open or modulate control valve if room temperature falls below thermostat setback temperature.

7. Controller shall have volatile-memory backup.

P. Electrical Connection: Factory wire motors and controls for a single electrical connection.

Q. Capacities and Characteristics:

1. Fan:

a. Airflow: As directed.
b. External Static Pressure: As directed.
c. Fan Speed: As directed.
d. Motor Speed: As directed.
e. Motor Horsepower: As directed.
f. Drive: As directed, Direct or Belt.

2. Cooling Capacity:

a. Total: As directed.
b. Sensible: As directed.
c. Entering-Air Dry-Bulb Temperature: As directed.
d. Entering-Air Wet-Bulb Temperature: As directed.

3. Chilled-Water Coil:

a. Water Flow: As directed.
b. Water-Side Pressure Loss: As directed.
c. Entering-Water Temperature: As directed.
d. Air-Side Pressure Drop: As directed.

4. Heating Capacity:

a. Output: As directed.
b. Entering-Air Temperature: As directed.
c. Air-Temperature Rise: As directed.

5. Hot-Water Heating Coil:

a. Water Flow: As directed.
b. Water-Side Pressure Loss: As directed.
c. Air-Side Pressure Drop: As directed.
d. Entering-Water Temperature: As directed.

6. Electric-Resistance Heating Coil:

a. Capacity: As directed.
b. Number of Steps: As directed.
c. Air-Side Pressure Drop: As directed.

7. Filters:

    a. Face Area: As directed.
    b. Thickness: As directed, 1 inch (25 mm) or 2 inches (50 mm).

8. Electrical Characteristics for Single-Point Connection:

    a. Voltage/Phase/Hertz: As directed.
    b. Full-Load Amperes: As directed.
    c. Maximum Circuit Amperes: As directed.
    d. Maximum Overcurrent Protection: As directed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install fan coil units level and plumb.

B. Install fan coil units to comply with NFPA 90A.

C. Suspend fan coil units from structure with elastomeric hangers. Vibration isolators are specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

D. Verify locations of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. As directed, Install devices 48 inches (1220 mm) or 60 inches (1525 mm) above finished floor.

E. Install new filters in each fan coil unit within two weeks after Substantial Completion.

F. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

1. Install piping adjacent to machine to allow service and maintenance.
2. Connect piping to fan coil unit factory hydronic piping package. Install piping package if shipped loose.
3. Connect condensate drain to indirect waste.

    a. Install condensate trap of adequate depth to seal against fan pressure. Install cleanouts in piping at changes of direction.

G. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

H. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

B. Remove and replace malfunctioning units and retest as specified above.

C. Prepare test and inspection reports.

3.3 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

END OF SECTION 238219

SECTION 238223 - UNIT VENTILATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes unit ventilators and accessories with the following heating and cooling features:

1. As directed Hydronic or Electric heating coil.
2. As directed Hydronic or Electric reheat coil.
3. As directed Hydronic or Direct-expansion refrigerant cooling coil.

B. Related Requirements:

1. Section 238146.13 "Water-to-Air Heat Pumps" for ground-loop, water-source heat-pump-type unit ventilators.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product

B. Sustainable Design Submittals:
1.

C. Shop Drawings:

1. Include plans, elevations, sections, and details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail anchorages and attachments to structure and to supported equipment.
4. Include diagrams for power, signal, and control wiring.

D. Samples for Initial Selection: For units with factory-applied color finishes.

E. Samples for Verification: For each type of unit ventilator and auxiliary shelves and cabinets indicated.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale and coordinated with each other, based on input from installers of the items involved:

B. Seismic Qualification Certificates: For unit ventilators, accessories, and components, from manufacturer.

C. Field quality-control reports.

D. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Comply with NFPA 70.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.6 COORDINATION

A. Coordinate layout and installation of unit ventilators and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

B. Coordinate size and location of wall sleeves for outdoor-air intake.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of condensing units that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

    a. Compressor failure.
    b. Condenser coil leak.

2. Warranty Period: As directed Four, Five or 10 years from date of Substantial Completion.
3. Warranty Period (Compressor Only): As directed Five or 10 years from date of Substantial Completion.
4. Warranty Period (Condenser Coil Only): Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Factory-packaged and -tested units rated according to AHRI 840, ASHRAE 33, and UL 1995.

2.2 MANUFACTURERS

2.3 MANUFACTURED UNITS

A. Description: Unit ventilators consisting of finished cabinet, filter, cooling coil, drain pan, supply-air fan and motor in blow- or draw-through configuration, and hydronic cooling coil.

1. Unit Ventilator Coil Configurations: As directed Row or Face split.

a. Number of Heating Coils: One with two-pipe system.
b. Number of Cooling Coils: As directed One or Three with two or four-pipe system.

2.4 CABINETS

A. Insulation: Minimum As directed 1/2-inch- (13-mm-) or 1-inch- (25-mm-) thick, coated glass fiber or foil-covered, closed-cell foam or matte-finish, closed-cell foam complying with ASTM C1071 and attached with adhesive complying with ASTM C916.

1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E84 by a qualified testing agency.
2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. Coil Section Insulation: Insulate coil section according to Section 230616 "HVAC Equipment Insulation."

1. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E84 by a qualified testing agency.
2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Main and Auxiliary Drain Pans: As directed Plastic or Insulated galvanized steel with plastic liner, formed as required by ASHRAE 62.1. Drain pans shall be removable.

D. Cabinet Frame and Access Panels: Welded-steel frame with removable panels fastened with hex-head tamperproof fasteners and key-operated control and valve access doors.

1. As directed Steel components exposed to moisture shall be hot-dip galvanized after fabrication, baked-enamel finished or powder-coat finished.

E. Cabinet Finish: Baked-on primer ready for field painting.

F. Cabinet Finish: As directed Baked enamel or Powder coat, in manufacturer's standard or custom color as selected by Architect.

G. Indoor-Supply-Air Grille: As directed Steel, Aluminum, double deflection, adjustable or adjustable linear bar.

H. Return-Air Inlet: As directed Front toe space or Back inlet with top inlet grille.

I. End Panels: Matching material and finish of unit ventilator.

J. Outdoor-Air Wall Box: Minimum 0.1265-inch- (3.2-mm-) thick, aluminum, rain-resistant louver and box with integral eliminators and bird screen.

1. Louver Configuration: As directed Horizontal or Vertical, rain-resistant louver.
2. Louver Material: As directed Aluminum or Steel.
3. Bird Screen: 1/2-inch (13-mm) mesh screen on interior side of louver.
4. Decorative Grille: On outside of intake.
5. Finish: As directed Anodized aluminum or Baked enamel, color as selected by Architect from manufacturer's standard or custom colors.

2.5 COILS

A. Test and rate unit ventilator coils according to ASHRAE 33.

B. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), rated for a minimum working pressure of 200 psig (1378 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve.

C. Electric-Resistance Heating Coils: Nickel-chromium heating wire or tubular elements in coil fins, free of expansion noise and hum, with fuses in terminal box for overcurrent protection and continuous limit controls for high-temperature protection. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.

D. Indoor Refrigerant Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), and brazed joints at fittings. Comply with AHRI 210/240, and leak test to minimum 450 psig (3105 kPa) for a minimum 300-psig (2070-kPa) working pressure. Include thermal expansion valve.

2.6 INDOOR FAN

A. Fan and Motor Board: Removable.

1. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.
2. Fan Shaft and Bearings: Hollow-steel shaft with permanently lubricated, resiliently mounted bearings.
3. Motor: Permanently lubricated, multispeed, resiliently mounted on motor board. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
4. Wiring Termination: Connect motor to chassis wiring with plug connection.

2.7 DAMPERS

A. Mixing Dampers: As directed Galvanized-steel blades with edge and end seals and nylon bearings; with electric or pneumatic actuator.

B. Outdoor-Air Dampers: As directed Galvanized-steel blades with edge and end seals and nylon bearings; with electric or pneumatic actuator.

C. Comply with ASHRAE/IES 90.1.

2.8 ACCESSORIES

A. Exhaust Shutter: As directed Barometric or Motorized, modulating type designed to limit room pressure to maximum 0.10-inch wg (25 kPa) with steel, aluminum or fabric damper blades, including edge and end seals, in galvanized-steel frame with outdoor and interior wall grille.

B. Subbase: Sheet metal floor-mounting base with leveling screws and black enamel finish.

C. Insulated false back with gasket seals on wall and outdoor-air plenum.

1. Insulation: Minimum As directed 1/2-inch- (13-mm-) or 1-inch- (25-mm-) thick, coated glass fiber, foil-covered, closed-cell foam or matte-finish, closed-cell foam complying with ASTM C1071 and attached with adhesive complying with ASTM C916.

    a. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E84 by a qualified testing agency.
    b. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Return-air plenum, 6 inches (150 mm) thick, designed to take return air from top inlet grilles in cabinets on both sides of unit ventilator with gasket seals on wall and outdoor-air plenum extension.

E. Duct flanges for supply-, return-, and outdoor-air connections.

F. Radiation Grille: As directed Steel, Aluminum, linear-bar or stamped grille with finish to match discharge-air grille.

G. Filters:

1. Minimum Efficiency Reporting Value and Average Arrestance: According to ASHRAE 52.2.
2. Minimum Efficiency Reporting Value: According to ASHRAE 52.2.
3. Material: Glass fiber, treated with adhesive, MERV 5.

2.9 FACTORY HYDRONIC PIPING PACKAGE

A. Piping: As directed ASTM B88, Type L (ASTM B88M, Type B) or ASTM B88, Type M (ASTM B88M Type C) copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet. As directed Crossover piping, NPS 1-1/2 (DN 40) or NPS 2 (DN 50) with shutoff valves.

B. Control Valves: As directed Electric or Pneumatic actuators compatible with terminal controller and building controls.

1. As directed Two or Three-way, two-position or modulating control valve for dual-temperature-water coil.
2. As directed Two or Three-way, two-position or modulating control valve for chilled-water coil.
3. As directed Two or Three-way, two-position or modulating control valve for hot-water heating coil.
4. As directed Two or Three-way, two-position or modulating control valve for hot-water reheat coil.

C. Hose Kits: Minimum 400-psig (2758-kPa) working pressure and operating temperatures from 33 to 211 deg F (0.5 to 99 deg C). Tag hose kits to equipment designations.

1. Length: As directed 24 inches (600 mm) or 36 inches (900 mm).
2. Minimum Diameter: Equal to unit ventilator connection size.

D. Isolation Valves, Strainers, Unions, and Balance Valves:

1. Two-Piece Ball Valves: Bronze body with stainless-steel ball and stem and galvanized-steel lever handle for each supply and return connection. If balancing device is combination shutoff type with memory stop, isolation valve may be omitted on the return.
2. Calibrated-Orifice Balancing Valves: Bronze body, ball type; 125-psig (860-kPa) working pressure, 250 deg F (121 deg C) maximum operating temperature; with calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, threaded ends, and a memory stop to retain set position.
3. Automatic Flow-Control Valve: Brass or ferrous-metal body; 300-psig (2070-kPa) working pressure at 250 deg F (121 deg C); with removable, corrosion-resistant, tamperproof, self-cleaning piston spring; factory set to maintain constant indicated flow with plus or minus 10 percent over differential pressure range of 2 to 80 psig (13.8 to 552 kPa).
4. Y-Pattern Hydronic Strainers: Cast-iron body (ASTM A126, Class B); 125-psig (860-kPa) working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 (DN 15) hose-end, full-port, ball-type blowdown valve in drain connection.
5. Wrought-Copper Unions: ASME B16.22.

2.10 INTEGRAL COOLING CHASSIS

A. Description: Assembly mounted within unit ventilator, factory assembled and tested; consisting of compressors, condenser coils, fans, motors, and refrigerant receivers; removable for maintenance, with plug and receptacle connections for control and power wiring. Construct, test, and rate condensing units according to AHRI 210/240 and ASHRAE 15.

B. Casing: Galvanized steel with removable panels for access to controls and refrigerant piping.

C. Exterior Louver: Extruded aluminum.

D. Compressor: As directed Hermetic, scroll or reciprocating type; internally isolated for vibration with factory-installed safety devices as follows:

1. Antirecycle timer.
2. High-pressure cutout.
3. Low-pressure cutout or loss-of-charge switch.
4. Internal thermal-overload protection.
5. Current- and voltage-sensitive safety devices.

E. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IES 90.1, "Energy Standard for Buildings except Low-Rise Residential Buildings."

F. Refrigerant Piping Materials:

1. Drawn-Temper Copper Tube: ASTM B88, Type L (ASTM B88M, Type B).
2. Annealed-Temper Copper Tube: As directed ASTM B88, Type L (ASTM B88M, Type B) or ASTM B88, Type K (ASTM B88M, Type A).
3. Wrought-Copper Fittings: ASME B16.22.

G. Refrigerant: R-407C or R-410A.

H. Low ambient controls to permit operation down to 45 deg F (7 deg C).

I. Crankcase heater.

J. Charging and service fittings.

K. Filter dryer.

L. Air-to-Air Heat Pump: Pilot-operated, sliding-type reversing valve with replaceable magnetic coil, and controls for air-to-air heat pump operation with supplemental heat.

M. HGBP, constant-pressure expansion valve and controls to maintain continuous refrigeration system operation at 10 percent of full load.

N. Condenser: Copper-tube, aluminum-fin coil, with liquid subcooler.

O. Direct-Driven Condenser Fan: Forward curved, double width, centrifugal; thermoplastic or painted-steel wheels and galvanized-steel fan scrolls.

1. Motor: Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

2.11 BASIC UNIT CONTROLS

A. Control devices and operational sequences are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."

B. Basic Unit Controls:

1. Control voltage transformer.
2. As directed Wall-mounting or Unit-mounted thermostat with the following features.

    a. Heat-cool-off switch.
    b. Fan on-auto switch.
    c. Fan-speed switch.
    d. As directed Manual or Automatic changeover.
    e. Adjustable deadband.
    f. As directed Concealed or Exposed set point.
    g. As directed Concealed or Exposed indication.
    h. As directed Degree F or Degree C indication.

3. As directed Wall-mounting or Unit-mounted humidistat.

    a. As directed Concealed or Exposed set point.
    b. As directed Concealed or Exposed indication.

4. As directed Wall-mounting or Unit-mounted temperature sensor.
5. Unoccupied-period-override push button.
6. Data entry and access port.

    a. Input data includes room temperature, and humidity set points and occupied and unoccupied periods.
    b. Output data includes room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.

C. DDC Terminal Controller:

1. Safety Controls Operation: Freezestat shall stop fan and close outdoor-air damper if air less than 38 deg F (3 deg C) enters coils.
2. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
3. Unoccupied-Period-Override Operation: Two hours.
4. Dual-Temperature Coil Operation:

    a. Occupied Periods: When chilled water is available, As directed open or modulate control valve if room temperature exceeds thermostat set point. When hot water is available, As directed open or modulate control valve if room temperature falls below thermostat set point.

b. Unoccupied Periods: When chilled water is available, close control valve. When hot water is available, As directed open or modulate control valve if room temperature falls below thermostat setback temperature.

5. Hydronic Cooling-Coil Operation:

   a. Occupied Periods: As directed Open or Modulate control valve to provide cooling if room temperature exceeds thermostat set point.
   b. Unoccupied Periods: Close control valve.

6. Refrigerant-Coil Operation:

   a. Occupied Periods: Start compressor to maintain room temperature.
   b. Unoccupied Periods: As directed Stop compressor cooling or Cycle compressor for heating to maintain setback temperature.

7. Supplemental Heating-Coil Operation:

   a. Occupied Periods: As directed Open control valve, Modulate control valve or Energize electric-resistance coil to provide heating if room temperature falls below thermostat set point.
   b. Unoccupied Periods: As directed Start fan and open control valve, modulate control valve or energize electric-resistance coil if room temperature falls below setback temperature.
   c. Switch refrigerant-reversing valve to operate supplemental coil for heating when outdoor temperature is below 25 deg F (4 deg C).

8. Reheat-Coil Operation:

   a. Humidity Control for Occupied Periods: As directed Humidistat opens control valve, modulates control valve or energizes electric-resistance coil to provide heating. As directed as room temperature rises above set point, cooling-coil valve opens or modulates to maintain room temperature.
   b. Humidity Control for Unoccupied Periods: As directed Close control valve or De-energize.

9. Outdoor-Air Damper Operation: Open to 25 percent fixed minimum intake during occupied periods, and close during unoccupied periods.
10. Outdoor-Air Damper Operation: Open to 25 percent fixed minimum intake, and maximum 100 percent of the fan capacity to comply with ASHRAE Cycle II during occupied periods, and close during unoccupied periods. Microprocessor controller shall permit air-side economizer operation when outdoor air is less than 60 deg F (15 deg C).
11. Carbon Dioxide Sensor Operation: During occupied periods, reset minimum outdoor-air ratio down to minimum 10 percent to maintain maximum 800-ppm concentration.
12. Cooling Lockout: During economizer cycle operation, block out cooling.
13. HGBP: Open HGBP solenoid valve to maintain minimum suction pressure at compressor.
14. Controller shall have volatile-memory backup.

D. Electrical Connection: Factory wire motors and controls for a single electrical connection.

2.12 METAL SHELVES AND CABINETS

A. Include manufacturer's standard cabinets to match unit ventilators with required installation hardware as indicated:

1. Open Shelving with Reinforced Shelves:

    a. As directed Return-air plenum or Radiation enclosure and aluminum bar grille with finish to match unit ventilator grille.
    b. Through-piping enclosure with solid top.

2. Closed Shelving with Reinforced Shelves:

    a. As directed Return-air plenum or Radiation enclosure and aluminum bar grille with finish to match unit ventilator grille.
    b. Through-piping enclosure with solid top.
    c. Two sliding doors with key-operated locks.

3. Utility compartment with access panel with key-operated lock.
4. Wall and corner filler sections, and end panels finished to match shelving.

B. Painted Finish: As directed Manufacturer's standard or custom baked enamel, in color selected by Architect, applied to shelving before shipping.

C. Cabinet Top: As directed Plastic-laminate top in color and pattern selected by Architect from manufacturer's standard or custom colors.

2.13 CAPACITIES AND CHARACTERISTICS

A. Fan:

1. Airflow: As directed.
2. External Static Pressure: As directed.
3. Fan Speed: As directed.
4. Motor Horsepower: As directed.
5. Drive: As directed Direct or Belt.

B. Cooling Capacity:

1. Total: As directed.
2. Sensible: As directed.
3. Entering-Air Dry-Bulb Temperature: As directed.
4. Entering-Air Wet-Bulb Temperature: As directed.

C. Chilled-Water Coil:

1. Water Flow: As directed.
2. Water-Side Pressure Loss: As directed.
3. Entering-Water Temperature: As directed.
4. Air-Side Pressure Drop: As directed.

D. Refrigerant Coil:

1. Suction Temperature: As directed.
2. Air-Side Pressure Drop: As directed.

E. Condensing Unit:

1. Ambient Temperature: As directed.
2. Compressor Power Input: As directed.
3. Cooling Energy Efficiency (EER) or (SEER) As directed: As directed.
4. Heating Coefficient of Performance: As directed.
5. Voltage/Phase/Hertz: As directed.
6. Full-Load Amperes: As directed.
7. Maximum Circuit Amperes: As directed.
8. Maximum Overcurrent Protection: As directed.

F. Heating Capacity:

1. Output: As directed.
2. Entering-Air Temperature: As directed.
3. Air-Temperature Rise: As directed.

G. Hot-Water Heating Coil:

1. Water Flow: As directed.
2. Water-Side Pressure Loss: As directed.
3. Air-Side Pressure Drop: As directed.
4. Entering-Water Temperature: As directed.

H. Electric-Resistance Heating Coil:

1. Capacity: As directed.
2. Number of Steps: As directed.
3. Air-Side Pressure Drop: As directed.

I. Reheat Capacity:

1. Output: As directed.
2. Entering-Air Temperature: As directed.
3. Air-Temperature Rise: As directed.

J. Electrical Characteristics for Single-Point Connection:

1. Voltage/Phase/Hertz: As directed.
2. Full-Load Amperes: As directed.
3. Maximum Circuit Amperes: As directed.
4. Maximum Overcurrent Protection: As directed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install unit ventilators to comply with NFPA 90A.

B. As directed suspend horizontal unit ventilators from structure with threaded steel rods and minimum 0.25-inch (6.35-mm) static-deflection, elastomeric vibration isolation hanger or 1.0-inch (25-mm) static-deflection spring hangers. Vibration isolators are specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

C. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. As directed Install devices 48 inches (1220 mm) or 60 inches (1525 mm) above finished floor.

D. Comply with requirements in Section 236200 "Packaged Compressor and Condenser Units" for condensing units matched to refrigerant cooling coil packaged in unit ventilators.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

1. Install piping adjacent to machine to allow service and maintenance.
2. Connect piping to unit ventilator factory hydronic piping package. Install piping package if shipped loose.
3. Connect condensate drain to indirect waste.

B. Install refrigerant piping as required by Section 232300 "Refrigerant Piping," and add refrigerant as required to compensate for length of piping.

C. Connect supply-air and return-air ducts to unit ventilators with flexible duct connectors specified in Section 233300 "Air Duct Accessories." Comply with safety requirements in UL 1995 for duct connections.

D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Testing Agency: As directed Owner will engage or Engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
4. Record temperatures entering and leaving energy recovery wheel when outdoor-air temperature is a minimum of 15 deg F (8.3 deg C) higher, or 20 deg F (11 deg C) lower, than room temperature.

C. Remove and replace malfunctioning units and retest as specified above.

D. Prepare test and inspection reports.

3.4 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.5 DEMONSTRATION

A. As directed Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain unit ventilators.

END OF SECTION 238223

SECTION 238229 - RADIATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes flat-pipe steel radiators.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings:

1. Include plans, elevations, sections, and details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Indicate location and size of each field connection.
4. Indicate location and arrangement of piping valves and specialties.
5. Indicate location and arrangement of integral controls and other accessories.

C. Samples: For each exposed product and for each color and texture specified.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 FLAT-PIPE STEEL RADIATORS

A. Heating Elements: Steel, welded and formed into flat, square, steel header with minimum thickness of 0.109 inch (2.76 mm). Include threaded piping and air-vent connections.

1. Working Pressure: 56 psig (386 kPa); 0.048 inch (1.22 mm).
2. Working Pressure: 85 psig (585 kPa); 0.058 inch (1.47 mm).
3. Working Pressure: 128 psig (881 kPa); 0.078 inch (1.98 mm).
4. Tube Height: As directed.
5. Tube Depth: As directed.
6. Tube Length: As directed.
7. Number of Tubes High: As directed.
8. Number of Tubes Deep: As directed.

9. Room Air Temperature: 65 deg F (18 deg C).
10. Heat Output: As directed.
11. Average Water Temperature: 180 deg F (82 deg C).
12. Temperature Drop: As directed, 10 deg F (5.56 deg C), 20 deg F (11.1 deg C) or 30 deg F (16.6 deg C).
13. Pressure Loss: As directed.

B. Mounting: As directed, wall brackets or Floor pedestals with maximum spacing of 36 inches (914 mm).

C. Finish: Baked-enamel finish in manufacturer's standard or custom color as selected by Architect.

D. Accessories:

1. Steel piping covers finished to match radiator finish.
2. Flexible Expansion Compensation Hoses: Minimum 400-psig (2758-kPa) working pressure, and operating temperatures from 33 to 211 deg F (0.5 to 99.5 deg C).

a. Length: As directed, 24 inches (600 mm) or 36 inches (900 mm).
b. Minimum Diameter: Equal to connection size.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb.

B. Install expansion compensation hoses.

C. Install piping covers.

3.2 CONNECTIONS

A. Piping installation requirements are specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties. "Section 15179 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect radiators and components to piping according to Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties. "Section 15179 "Hydronic Piping Specialties."

1. Install shutoff valves on inlet and outlet, and balancing valve on outlet.

C. Install control valves as required by Section 230923.11 "Control Valves."

D. Install piping adjacent to radiators to allow service and maintenance.

3.3 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

B. Units will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 238229

SECTION 238233 - CONVECTORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes hydronic or electric convectors as directed.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings:

1. Include plans, elevations, sections, and details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include details and dimensions of custom-fabricated enclosures.
4. Indicate location and size of each field connection.
5. Indicate location and arrangement of piping valves and specialties.
6. Indicate location and arrangement of integral controls.
7. Include enclosure joints, corner pieces, access doors, and other accessories.
8. Include diagrams for power, signal, and control wiring.

C. Samples: For each exposed product and for each color and texture specified.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 ELECTRIC CONVECTORS

A. Description: Factory-packaged units constructed according to UL 499, UL 1030, and UL 2021.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Heating Elements: Nickel-chromium-wire heating element enclosed in metallic sheath mechanically bonded to fins, with high-temperature cutout and sensor running the full length of element. Element supports shall eliminate thermal expansion noise.

1. Volts: As directed.
2. Phase: As directed.
3. Hertz: As directed.
4. Heat Output: As directed, 300, 500, 750, 1000, 1250, 1500, 1750, 2000, 2250 or 2500 W.

C. Front and Top Panel: As directed, Minimum 0.0528-inch- (1.35-mm-) or 0.0677-inch- (1.7-mm-) thick steel with exposed corners rounded; removable front panels with tamper-resistant fasteners braced and reinforced for stiffness.

D. Wall-Mounted Back and End Panels: Minimum 0.0428-inch- (1.1-mm-) thick steel.

E. Floor-Mounted Pedestals: Conceal conduit for power and control wiring at maximum 36-inch (914-mm) spacing. Pedestal-mounted back panel shall be solid panel matching front panel.

F. Support Brackets: Locate at maximum 36-inch (914-mm) spacing to support front panel and element.

G. Insulation: 1/2-inch- (13-mm-) thick, fibrous glass on inside of the back of the enclosure.

H. Finish: As directed, Baked-enamel finish in manufacturer's standard or custom color as selected by Architect.

I. Damper: Knob-operated internal damper.

J. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size 6 by 7 inches (150 by 175 mm), integral with enclosure.

K. Enclosure Style: As directed, Sloped or Flat top.

1. Front Inlet Grille: Punched louver; painted to match enclosure.
2. Front Inlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.

    a. Mill-finish aluminum.
    b. As directed, Anodized finish, color as selected by Architect from manufacturer's standard or custom colors.
    c. Painted to match enclosure.

3. As directed, Top or Front Outlet Grille: Punched louver; painted to match enclosure.
4. As directed, Top or Front Outlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.

    a. Mill-finish aluminum.
    b. As directed, Anodized finish, color as selected by Architect from manufacturer's standard or custom colors.
    c. Painted to match enclosure.

5. Enclosure Height: As directed.

6. Enclosure Depth: As directed.
7. Enclosure Length: As directed.

L. Unit Controls: As directed, Integral line-voltage thermostat with minimum range of 60 to 90 deg F (15 to 32 deg C) or low-voltage relay and control transformer for remote thermostat.

M. Accessories: Integral disconnect switch, recessing flanges finished to match enclosure or overlapping front cover for fully recessed units, and rubber gaskets to seal cabinet at wall.

2.2 HOT-WATER CONVECTORS

A. Heating Elements: Seamless copper tubing mechanically expanded into evenly spaced aluminum fins and rolled into cast-iron or brass headers with inlet/outlet and air vent; steel side plates and supports. Factory-pressure-test element at minimum 100 psig (690 kPa).

1. Element Height: As directed.
2. Element Depth: As directed.
3. Element Length: As directed.
4. Entering-Air Temperature: 65 deg F (18 deg C).
5. Heat Output: As directed.
6. Average Water Temperature: 180 deg F (82 deg C).
7. Temperature Drop: As directed, 10 deg F (5.56 deg C), 20 deg F (11.1 deg C) or 30 deg F (16.6 deg C).
8. Pressure Loss: As directed.

B. Front and Top Panel: As directed, Minimum 0.0528-inch- (1.35-mm-) or 0.0677-inch- (1.7-mm) thick steel with exposed corners rounded; removable front panels with tamper-resistant fasteners braced and reinforced for stiffness.

C. Wall-Mounted Back and End Panels: Minimum 0.0428-inch- (1.1-mm-) thick steel.

D. Floor-Mounted Pedestals: Conceal conduit for power and control wiring at maximum 36-inch (914-mm) spacing. Pedestal-mounted back panel shall be solid panel matching front panel.

E. Support Brackets: Locate at maximum 36-inch (914-mm) spacing to support front panel and element.

F. Insulation: 1/2-inch- (13-mm-) thick, fibrous glass on inside of the back of the enclosure.

G. Finish: As directed, Baked-enamel finish in manufacturer's standard or custom color as selected by Architect.

H. Damper: Knob-operated internal damper.

I. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size 6 by 7 inches (150 by 175 mm), integral with enclosure.

J. Enclosure Style: As directed, Sloped or Flat top.

1. Front Inlet Grille: Punched louver; painted to match enclosure.
2. Front Inlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.

a. Mill-finish aluminum.
b. Anodized finish, color as selected by Architect from manufacturer's standard or custom colors.
c. Painted to match enclosure.

3. As directed, Top or Front Outlet Grille: Punched louver; painted to match enclosure.
4. As directed, Top or Front Outlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.

a. Mill-finish aluminum.
b. As directed, Anodized finish, color as selected by Architect from manufacturer's standard or custom colors.
c. Painted to match enclosure.

5. Enclosure Height: As directed.
6. Enclosure Depth: As directed.
7. Enclosure Length: As directed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install convectors level and plumb.

B. Install valves within reach of access door provided in enclosure.

C. Install air-seal gasket between wall and recessed flanges or front cover of fully recessed unit.

D. Install piping within pedestals for freestanding units.

3.2 CONNECTIONS

A. Piping installation requirements are specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect hot-water convectors and components to piping according to Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."

1. Install shutoff valves on inlet and outlet, and balancing valve on outlet.
2. Install shutoff valve on inlet; install strainer, steam trap, and shutoff valve on outlet.

C. Install control valves as required by Section 230923.11 "Control Valves."

D. Install piping adjacent to convectors to allow service and maintenance.

E. Ground electric convectors according to Section 260526 "Grounding and Bonding for Electrical Systems."

F. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start convectors to confirm proper operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Convectors will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 238233

SECTION 238236 - FINNED-TUBE RADIATION HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes hydronic, electric, baseboard and finned-tube radiation heaters as directed.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings:

1. Include plans, elevations, sections, and details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include details and dimensions of custom-fabricated enclosures.
4. Indicate location and size of each field connection.
5. Indicate location and arrangement of piping valves and specialties.
6. Indicate location and arrangement of integral controls.
7. Include enclosure joints, corner pieces, access doors, and other accessories.
8. Include diagrams for power, signal, and control wiring.

C. Samples: For each exposed product and for each color and texture specified.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 ELECTRIC BASEBOARD RADIATION HEATERS

A. Description: Factory-packaged units constructed according to UL 499, UL 1030, and UL 2021.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Heating Elements: Nickel-chromium-wire heating element enclosed in metallic sheath mechanically bonded to fins, with high-temperature cutout and sensor running the full length of the element. Element supports shall eliminate thermal expansion noise.

1. Volts: As directed.
2. Phase: As directed.
3. Hertz: As directed.
4. Heat Output: As directed.

C. Enclosures: Minimum As directed, 0.0329-inch- (0.85-mm-) or 0.0428-inch- (1.1-mm-) thick steel, removable front cover.

1. Full-height back.
2. Full-length damper.
3. End panel.
4. As directed, Plastic end or End caps.
5. Inside and outside corners.
6. Joiner pieces to snap together.
7. Enclosure Height: As directed.
8. Enclosure Depth: As directed.
9. Finish: As directed, Baked-enamel finish in manufacturer's standard or custom color as selected by Architect.
10. Element Brackets: Primed and painted steel to support front panel and element.

D. Rust-Resistant Enclosures: As directed, Minimum 0.040-inch- (1.0-mm-) or 0.052-inch- (1.3-mm-) thick ASTM A653/A653M, G60 (Z180) galvanized-steel, removable front cover.

1. Full-height back.
2. Full-length damper.
3. End panel.
4. As directed, Plastic end or End caps.
5. Inside and outside corners.
6. Joiner pieces to snap together.
7. Enclosure Height: As directed.
8. Enclosure Depth: As directed.
9. Finish: As directed, Baked-enamel finish in manufacturer's standard or custom color as selected by Architect.
10. Element Brackets: Primed and painted steel to support front panel and element.

E. Unit Controls: As directed, Integral line-voltage thermostat, Integral electronic thermostat or Remote line-voltage thermostat.

F. Accessories:

1. Filler sections without a heating element matching the adjacent enclosure.
2. Straight-blade-type receptacles complying with DSCC W-C-596G/GEN, NEMA WD 1, NEMA WD 6, and UL 498; in color selected by Architect.

2.2 HOT-WATER BASEBOARD RADIATION HEATERS

A. Performance Ratings: Rate baseboard radiation heaters according to Hydronics Institute's "I=B=R Testing and Rating Standard for Baseboard Radiation."

B. Heating Elements: Copper tubing mechanically expanded into flanged collars of evenly spaced aluminum fins resting on polypropylene element glides. One end of tube shall be belled.

1. Tube Diameter: As directed, NPS 1/2 (DN 15), NPS 3/4 (DN 20), NPS 1 (DN 25) or NPS 1-1/4 (DN 32).
2. Fin Size: As directed, 2-1/2 by 2-1/2 inches (63 by 63 mm) or 3 by 3 inches (76 by 76 mm).
3. Fin Spacing: As directed, 40 per foot (131 per m), 50 per foot (164 per m) or 58 per foot (190 per m) As directed.
4. Number of Tiers: As directed.
5. Heat Output: As directed.
6. Entering-Air Temperature: 65 deg F (18 deg C).
7. Average Water Temperature: 180 deg F (82 deg C).
8. Minimum Water Velocity: 1/2 fps (0.15 m/s).

C. Heating Elements: Steel tubing mechanically expanded into flanged collars of evenly spaced steel fins resting on polypropylene element glides. Tube ends shall be threaded.

1. Tube Diameter: NPS 1-1/4 (DN 32).
2. Fin Size: 3 by 3 inches (76 by 76 mm).
3. Fin Spacing: 52 per foot (171 per m).
4. Number of Tiers: As directed.
5. Heat Output: As directed.
6. Entering-Air Temperature: 65 deg F (18 deg C).
7. Average Water Temperature: 180 deg F (82 deg C).
8. Minimum Water Velocity: 1/2 fps (0.15 m/s).

D. Enclosures: Minimum As directed, 0.0329-inch- (0.85-mm-) or 0.0428-inch- (1.1-mm-) thick steel, removable front cover.

1. Full-height back.
2. Full-length damper.
3. End panel.
4. End caps.
5. Inside and outside corners.
6. Valve access door.
7. Joiner pieces to snap together.
8. Enclosure Height: As directed.
9. Enclosure Depth: As directed.
10. Finish: Baked-enamel finish in manufacturer's standard or custom color as selected by Architect.
11. Element Brackets: Primed and painted steel to support front panel and element.

E. Rust-Resistant Enclosures: As directed, Minimum 0.040-inch- (1.0-mm-) or 0.052-inch- (1.3-mm-) thick ASTM A653/A653M, G60 (Z180) galvanized-steel, removable front cover.

1. Full-height back.
2. Full-length damper.
3. End panel.
4. End caps.
5. Inside and outside corners.
6. Valve access door.
7. Joiner pieces to snap together.
8. Enclosure Height: As directed.
9. Enclosure Depth: As directed.
10. Finish: As directed, Baked-enamel finish in manufacturer's standard or custom color as selected by Architect.
11. Element Brackets: Primed and painted steel to support front panel and element.

2.3 ELECTRIC FINNED-TUBE RADIATION HEATERS

A. Description: Factory-packaged units constructed according to UL 499, UL 1030, and UL 2021.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Heating Elements: Nickel-chromium-wire heating element enclosed in metallic sheath mechanically bonded to fins, with high-temperature cutout and sensor running the full length of the element. Element supports shall eliminate thermal expansion noise.

1. Volts: As directed.
2. Phase: As directed.
3. Hertz: As directed.
4. Heat Output: As directed.

C. Front Panel: As directed, Minimum 0.0428-inch- (1.1-mm-) or 0.0528-inch- (1.35-mm-) thick steel.

D. Rust-Resistant Front Panel: As directed, Minimum 0.052-inch- (1.3-mm-) or 0.064-inch- (1.6-mm-) thick, ASTM A653/A653M, G60 (Z180) galvanized steel.

E. Wall-Mounted Back Panel: Minimum 0.0329-inch- (0.85-mm-) thick steel, full height, with full-length channel support for front panel without exposed fasteners.

F. Floor-Mounted Pedestals: Conceal conduit for power and control wiring at maximum 36-inch (914-mm) spacing. Pedestal-mounted back panel shall be solid panel matching front panel.

G. Support Brackets: Locate at maximum 36-inch (914-mm) spacing to support front panel and element.

H. Finish: As directed, Baked-enamel or -epoxy finish in manufacturer's standard or custom color as selected by Architect.

I. Damper: Knob-operated internal damper at enclosure outlet.

J. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size 6 by 7 inches (150 by 175 mm), integral with enclosure.

K. Enclosure Style: As directed, Sloped or Flat top.

1. Front Inlet Grille: Punched louver; painted to match enclosure.
2. Front Inlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.

    a. Mill-finish aluminum.
    b. As directed, Anodized finish, color as selected by Architect from manufacturer's standard or custom colors.
    c. Painted to match enclosure.

3. As directed, Top or Front Outlet Grille: Punched louver; painted to match enclosure.
4. As directed, Top or Front Outlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.

    a. Mill-finish aluminum.
    b. As directed, Anodized finish, color as selected by Architect from manufacturer's standard or custom colors.
    c. Painted to match enclosure.

5. Enclosure Height: As directed.
6. Enclosure Depth: As directed.

L. Unit Controls: As directed, Integral line-voltage thermostat with minimum range of 60 to 90 deg F (15 to 32 deg C) or low-voltage relay and control transformer for remote thermostat.

M. Accessories: Integral disconnect switch, filler sections, corners, relay sections, and splice plates all matching the enclosure and grille finishes.

2.4 HOT-WATER FINNED-TUBE RADIATION HEATERS

A. Performance Ratings: Rate finned-tube radiation heaters according to Hydronics Institute's "I=B=R Testing and Rating Standard for Finned-Tube (Commercial) Radiation."

B. Heating Elements: Copper tubing mechanically expanded into flanged collars of evenly spaced aluminum fins resting on element supports. One end of tube shall be belled.

1. Tube Diameter: As directed, NPS 3/4 (DN 20), NPS 1 (DN 25) or NPS 1-1/4 (DN 32).
2. Fin Size: As directed, 3 by 3 inches (76 by 76 mm) or 4 by 4 inches (102 by 102 mm).
3. Fin Spacing: As directed, 40 per foot (131 per m), 50 per foot (164 per m) or 58 per foot (190 per m).
4. Number of Tiers: As directed.
5. Heat Output: As directed.
6. Entering-Air Temperature: 65 deg F (18 deg C).
7. Average Water Temperature: 180 deg F (82 deg C).
8. Minimum Water Velocity: 1/2 fps (0.15 m/s).

C. Heating Elements: Steel tubing mechanically expanded into flanged collars of evenly spaced steel fins resting on element supports. Tube ends shall be threaded.

1. Tube Diameter: NPS 1-1/4 (DN 32).
2. Fin Size: 4 by 4 inches (102 by 102 mm) As directed.
3. Fin Spacing: 52 per foot (171 per m) As directed.
4. Number of Tiers: As directed.
5. Heat Output: As directed.
6. Entering-Air Temperature: 65 deg F (18 deg C).
7. Average Water Temperature: 180 deg F (82 deg C).
8. Minimum Water Velocity: 1/2 fps (0.15 m/s).

D. Element Supports: Ball-bearing cradle type to permit longitudinal movement on enclosure brackets.

E. Front Panel: As directed, Minimum 0.0428-inch- (1.1-mm-) or 0.0528-inch- (1.35-mm-) thick steel.

F. Rust-Resistant Front Panel: As directed, Minimum 0.052-inch- (1.3-mm-) or 0.064-inch- (1.6-mm-) thick, ASTM A653/A653M, G60 (Z180) galvanized steel.

G. Wall-Mounted Back Panel: Minimum 0.0329-inch- (0.85-mm-) thick steel, full height, with full-length channel support for front panel without exposed fasteners.

H. Floor-Mounted Pedestals: Conceal insulated piping at maximum 36-inch (914-mm) spacing. Pedestal-mounted back panel shall be solid panel matching front panel. Provide stainless-steel escutcheon for floor openings at pedestals.

I. Support Brackets: Locate at maximum 36-inch (914-mm) spacing to support front panel and element.

J. Finish: As directed, Baked-enamel or -epoxy finish in manufacturer's standard or custom color as selected by Architect.

K. Damper: Knob-operated internal damper at enclosure outlet.

L. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size 6 by 7 inches (150 by 175 mm), integral with enclosure.

M. Enclosure Style: As directed, Sloped or Flat top.

1. Front Inlet Grille: Punched louver; painted to match enclosure.
2. Front Inlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
    a. Mill-finish aluminum.
    b. As directed, Anodized finish, color as selected by Architect from manufacturer's standard or custom colors.
    c. Painted to match enclosure.
3. As directed, Top or Front Outlet Grille: Punched louver; painted to match enclosure.

4. As directed, Top or Front Outlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.

    a. Mill-finish aluminum.
    b. As directed, Anodized finish, color as selected by Architect from manufacturer's standard or custom colors.
    c. Painted to match enclosure.

5. Enclosure Height: As directed.
6. Enclosure Depth: As directed.

N. Accessories: Filler sections, corners, relay sections, and splice plates all matching the enclosure and grille finishes.

PART 3 - EXECUTION

3.1 BASEBOARD RADIATION HEATER INSTALLATION

A. Install units level and plumb.

B. Install enclosure continuously around corners, using outside and inside corner fittings.

C. Join sections with splice plates and filler pieces to provide continuous enclosure.

D. Install access doors for access to valves.

E. Install enclosure continuously from wall to wall.

F. Terminate enclosures with manufacturer's end caps except where enclosures are indicated to extend to adjoining walls.

G. Install valves within reach of access door provided in enclosure.

H. Install air-seal gasket between wall and recessed flanges or front cover of fully recessed unit.

I. Install piping within pedestals for freestanding units.

3.2 FINNED-TUBE RADIATION HEATER INSTALLATION

A. Install units level and plumb.

B. Install enclosure continuously around corners, using outside and inside corner fittings.

C. Join sections with splice plates and filler pieces to provide continuous enclosure.

D. Install access doors for access to valves.

E. Install enclosure continuously from wall to wall.

F. Terminate enclosures with manufacturer's end caps except where enclosures are indicated to extend to adjoining walls.

G. Install valves within reach of access door provided in enclosure.

H. Install air-seal gasket between wall and recessed flanges or front cover of fully recessed unit.

I. Install piping within pedestals for freestanding units.

3.3 CONNECTIONS

A. Piping installation requirements are specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect hot-water finned-tube radiation heaters and components to piping according to Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."

1. Install shutoff valves on inlet and outlet, and balancing valve on outlet.

C. Install control valves as required by Section 230923.11 "Control Valves."

D. Install piping adjacent to finned-tube radiation heaters to allow service and maintenance.

E. Ground electric finned-tube radiation heaters according to Section 260526 "Grounding and Bonding for Electrical Systems."

F. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Units will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 238236

SECTION 238239.13 - CABINET UNIT HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes cabinet unit heaters with centrifugal fans and hot-water coils.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Sustainable Design Submittals: As directed

C. Shop Drawings:

1. Include plans, elevations, sections, and details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include location and size of each field connection.
4. Include details of anchorages and attachments to structure and to supported equipment.
5. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
6. Indicate location and arrangement of piping valves and specialties.
7. Indicate location and arrangement of integral controls.
8. Wiring Diagrams: Power, signal, and control wiring.

D. Samples: For each exposed product and for each color and texture specified.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which cabinet unit heaters will be attached.
3. Method of attaching hangers to building structure.
4. Size and location of initial access modules for acoustical tile.
5. Items penetrating finished ceiling, including the following:

a. Lighting fixtures.
b. Air outlets and inlets.
c. Speakers.

d. Sprinklers.
e. Access panels.

6. Perimeter moldings for exposed or partially exposed cabinets.

B. Seismic Qualification Data: Submit certification that cabinet unit heaters, accessories, and components will withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC."

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 DESCRIPTION

A. Factory-assembled and -tested unit complying with AHRI 440.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 PERFORMANCE REQUIREMENTS

A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

B. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

C. Seismic Performance: Cabinet unit heaters shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.4 COIL SECTION INSULATION

A. Insulation Materials: ASTM C1071; as directed, surfaces exposed to airstream shall have aluminum-foil facing or erosion-resistant coating to prevent erosion of glass fibers.

1. Thickness: As directed, 1/2 inch (13 mm), 1 inch (25 mm) or 1-1/2 inches (38 mm).
2. Thermal Conductivity (k-Value): 0.26 Btu x in./h x sq. ft. at 75 deg F (0.037 W/m x K at 24 deg C) mean temperature.
3. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E84.
4. Adhesive: Comply with ASTM C916 and with NFPA 90A or NFPA 90B.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. Insulation Materials: Comply with NFPA 90A or NFPA 90B. Unicellular polyethylene thermal plastic, preformed sheet insulation complying with ASTM C534, Type II, except for density.

1. Thickness: As directed, 3/8 inch (9 mm), 1/2 inch (13 mm), 3/4 inch (19 mm) or 1 inch (25 mm).
2. Thermal Conductivity (k-Value): 0.24 Btu x in./h x sq. ft. at 75 deg F (0.034 W/m x K at 24 deg C) mean temperature.
3. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM C411.
4. Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

2.5 CABINETS

A. Material: As directed, Steel with factory prime coating, ready for field painting, baked-enamel finish with manufacturer's standard paint, in color selected by Architect or baked-enamel finish with manufacturer's custom paint, in color selected by Architect.

1. Vertical Unit, Exposed Front Panels: As directed, Minimum 0.0528-inch- (1.35-mm-) or 0.0677-inch- (1.7-mm-) thick galvanized sheet steel, removable panels with channel-formed edges secured with tamperproof cam fasteners.
2. Horizontal Unit, Exposed Bottom Panels: As directed, Minimum 0.0528-inch- (1.35-mm-), 0.0677-inch- (1.7-mm-) thick galvanized sheet steel, removable panels secured with tamperproof cam fasteners and safety chain.
3. Recessed Flanges: Steel, finished to match cabinet.
4. Control Access Door: Key operated.
5. Base: As directed, Minimum 0.0528-inch- (1.35-mm-) thick steel, finished to match cabinet, 4 inches (100 mm) or 6 inches (150 mm) high with leveling bolts.
6. Extended Piping Compartment: 8-inch- (200-mm-) wide piping end pocket.
7. False Back: Minimum 0.0428-inch- (1.1-mm-) thick steel, finished to match cabinet.
8. Outdoor-Air Wall Box: Minimum 0.1265-inch- (3.2-mm-) thick, aluminum, rain-resistant louver and box with integral eliminators and bird screen; As directed, aluminum louver with anodized or baked-enamel finish in color selected by Architect from manufacturer's standard or custom colors.

    a. Outdoor-Air Damper: As directed, Galvanized-steel blades with edge and end seals and nylon bearings; with manual, electronic or pneumatic, two-position actuators.

2.6 FILTERS

A. Minimum Efficiency Reporting Value and Average Arrestance": According to ASHRAE 52.2.

B. Minimum Efficiency Reporting Value: According to ASHRAE 52.2.

C. Material: Washable foam, MERV 3.

D. Material: Glass fiber treated with adhesive, MERV 5.

E. Material: Pleated cotton-polyester media, MERV 7.

2.7 COILS

A. Hot-Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of 200 psig (1378 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain.

2.8 CONTROLS

A. Fan and Motor Board: Removable.

1. Fan: Forward curved, high static, double width, centrifugal, directly connected to motor; thermoplastic or painted-steel wheels and aluminum, painted-steel, or galvanized-steel fan scrolls.
2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
3. Wiring Terminations: Connect motor to chassis wiring with plug connection.

B. Factory, Hot-Water Piping Package: As directed, ASTM B88, Type L (ASTM B88M, Type B) or ASTM B88, Type M (ASTM B88M Type C) copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.

1. As directed, Two or Three-way, two-position or modulating control valve. Three-way valve packages shall include bypass line with manually adjustable balance device.
2. Hose Kits: Minimum 400-psig (2758-kPa) working pressure, and operating temperatures from 33 to 211 deg F (0.5 to 99 deg C). Tag hose kits to equipment designations.

    a. Length: As directed, 24 inches (600 mm) or 36 inches (900 mm).
    b. Minimum Diameter: Equal to cabinet unit-heater connection size.

3. Two-Piece, Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig (4140-kPa) minimum CWP rating and blowout-proof stem.
4. Calibrated-Orifice Balancing Valves: Bronze body, ball type, 125-psig (860-kPa) working pressure, 250 deg F (121 deg C) maximum operating temperature; with calibrated orifice or venture, connection for portable differential pressure meter with integral seals, threaded ends, and equipped with a memory stop to retain set position.

5. Automatic Flow-Control Valve: Brass or ferrous-metal body, 300-psig (2068-kPa) working pressure at 250 deg F (121 deg C), with removable, corrosion-resistant, tamperproof, self-cleaning piston spring; factory set to maintain constant indicated flow within plus or minus 10 percent of differential pressure range of 2 to 80 psig (13.8 to 552 kPa).
6. Y-Pattern, Hot-Water Strainers: Cast-iron body (ASTM A126, Class B); 125-psig (860-kPa) minimum working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 (DN 15) threaded pipe and full-port ball valve in strainer drain connection.
7. Wrought-Copper Unions: ASME B16.22.

C. Control devices and operational sequences are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."

D. Basic Unit Controls:

1. Control voltage transformer.
2. As directed, Wall or Unit-mounted thermostat with the following features:

    a. Heat-off switch.
    b. Fan on-auto switch.
    c. Manual fan-speed switch.
    d. Adjustable deadband.
    e. As directed, Concealed or Exposed set point.
    f. As directed, Concealed or Exposed indication.
    g. Deg F (Deg C) indication.

3. As directed, wall or Unit-mounted temperature sensor.
4. Unoccupied period override push button.
5. Data entry and access port.

    a. Input data includes room temperature and occupied and unoccupied periods.
    b. Output data includes room temperature, supply-air temperature, entering-water temperature, operating mode, and status.

E. DDC Terminal Controller:

1. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
2. Unoccupied Period Override: Two hours.
3. Unit Supply-Air Fan Operations:

    a. Occupied Periods: Fan runs continuously.
    b. Unoccupied Periods: Fan cycles to maintain setback room temperature.

4. Heating-Coil Operations:

    a. Occupied Periods: As directed, Open or Modulate control valve to provide heating if room temperature falls below thermostat set point.

b. Unoccupied Periods: As directed, Start fan and open or modulate control valve if room temperature falls below setback temperature.

5. Outdoor-Air Damper Operation:

a. Occupied Periods: Open dampers. Delay damper opening if room temperature is more than three degrees below set point.
b. Unoccupied Periods: Close damper.

6. Controller shall have volatile-memory backup.

F. Interface with DDC System for HVAC Requirements:

1. Interface relay for scheduled operation.
2. Interface relay to provide indication of fault at central workstation.
3. Interface shall be BAC-net or LonWorks compatible for central DDC system for HVAC workstation and include the following functions:

a. Adjust set points.
b. Cabinet unit-heater start, stop, and operating status.
c. Data inquiry, including outdoor-air damper position and supply-air and room-air temperature.
d. Occupied and unoccupied schedules.

G. Electrical Connection: Factory-wired motors and controls for a single field connection.

2.9 CAPACITIES AND CHARACTERISTICS

A. Cabinet:

1. Vertical, Surface Mounted: Upflow.

a. Top: As directed, Flat, Sloped or Flat or sloped.
b. Air Inlet: As directed, Open bottom, Front, punched louver or Front, extruded-aluminum bar grille.
c. Air Outlet: As directed, Front, Top, Front or top, quad louver, punched louver or extruded-aluminum bar grille.

2. Vertical, Surface Mounted: Downflow.

a. Top: As directed, Flat, Sloped or Flat or sloped.
b. Air Inlet: As directed, Front, Top, Front or top, punched louver or extruded-aluminum bar grille.
c. Air Outlet: As directed, Front, quad louver, punched louver or extruded-aluminum bar grille.

3. Vertical, Semirecessed: Upflow.

a. Air Inlet: As directed, Open bottom, Front, punched louver or Front, extruded-aluminum bar grille.

b. Air Outlet: As directed, Front, Top, Front or top, quad louver, punched louver or extruded-aluminum bar grille.

4. Vertical, Semirecessed: Downflow.

a. Air Inlet: As directed, Front, Top, Front or top, punched louver or extruded-aluminum bar grille.
b. Air Outlet: As directed, Front, quad louver, punched louver or extruded-aluminum bar grille.

5. Vertical, Fully Recessed: As directed, Upflow or Downflow.

a. Air Inlet: As directed, Front, Duct connection, punched louver or extruded-aluminum bar grille.
b. Air Outlet: As directed, Front, Duct connection, quad louver, punched louver or extruded-aluminum bar grille.

6. Horizontal, Surface Mounted:

a. Air Inlet: As directed, Bottom, Front, Bottom or front, punched louver or extruded-aluminum bar grille.
b. Air Outlet: As directed, Front, Top, Front or top, quad louver, punched louver or extruded-aluminum bar grille.

7. Horizontal, Semirecessed:

a. Air Inlet: As directed, Bottom, Front, Bottom or front, punched louver or extruded-aluminum bar grille.
b. Air Outlet: As directed, Front, Top, Front or top, quad louver, punched louver or extruded-aluminum bar grille.

8. Horizontal, Fully Recessed:

a. Air Inlet: As directed, Front, Duct connection, punched louver or extruded-aluminum bar grille.
b. Air Outlet: As directed, Front, Duct connection, quad louver, punched louver or extruded-aluminum bar grille.

B. Concealed Unit Heater:

1. Vertical: As directed, Upflow or Downflow.

a. Air Inlet: As directed, Open bottom, Front, punched louver or Front, extruded-aluminum bar grille.
b. Air Outlet: As directed, Front, Top, Front or top, quad louver, punched louver or extruded-aluminum bar grille.

2. Horizontal: Upflow.

a. Air Inlet: As directed, Open bottom, Front, punched louver or Front, extruded-aluminum bar grille.

b. Air Outlet: As directed, Front, Top, Front or top, quad louver, punched louver or extruded-aluminum bar grille.

C. Fan:

1. Airflow: As directed.
2. External Static Pressure: As directed.
3. Fan Speed: As directed.
4. Motor Horsepower: As directed.

D. Heating Capacity:

1. Output: As directed.
2. Entering-Air Temperature: As directed.
3. Air-Temperature Rise: As directed.

E. Hot-Water Heating Coil:

1. Water Flow: As directed.
2. Water-Side Pressure Loss: As directed.
3. Entering-Water Temperature: As directed.

F. Filters:

1. Face Area: As directed.
2. Thickness: As directed, 1/2 inch (13 mm) or 1 inch (25 mm).

G. Electrical Characteristics for Single-Point Connection:

1. Volts: As directed.
2. Phase: As directed.
3. Hertz: As directed.
4. Full-Load Amperes: As directed.
5. Minimum Circuit Ampacity: As directed.
6. Maximum Overcurrent Protection: As directed.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive cabinet unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping and electrical connections to verify actual locations before unit-heater installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install wall boxes in finished wall assembly; seal and weatherproof. Joint-sealant materials and applications are specified in Section 079200 "Joint Sealants."

B. Install cabinet unit heaters to comply with NFPA 90A.

C. Suspend cabinet unit heaters from structure with elastomeric hangers. Vibration isolators are specified in Section 230548 "Vibration and Seismic Controls for HVAC" or Section 230548.13 "Vibration Controls for HVAC" As directed.

D. Install wall-mounted thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.

E. Install new filters in each fan-coil unit within two weeks of Substantial Completion.

3.3 CONNECTIONS

A. Piping installation requirements are specified in Section 232113 "Hydronic Piping," Section 232116 "Hydronic Piping Specialties," Section 232213 "Steam and Condensate Heating Piping," and Section 232216 "Steam and Condensate Heating Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Connect piping to cabinet unit heater's factory, hot-water piping package. Install the piping package if shipped loose.

D. Connect supply and return ducts to cabinet unit heaters with flexible duct connectors specified in Section 233300 "Air Duct Accessories."

E. Comply with safety requirements in UL 1995.

F. Unless otherwise indicated, install union and gate or ball valve on supply-water connection and union and calibrated balancing valve on return-water connection of cabinet unit heater. Hydronic specialties are specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."

G. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

H. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

B. Units will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 238239.13

SECTION 238239.16 - PROPELLER UNIT HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes propeller unit heaters with hot-water coils.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings:

1. Include plans, elevations, sections, and details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include location and size of each field connection.
4. Include details of anchorages and attachments to structure and to supported equipment.
5. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
6. Indicate location and arrangement of piping valves and specialties.
7. Indicate location and arrangement of integral controls.
8. Wiring Diagrams: Power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which propeller unit heaters will be attached.
3. Method of attaching hangers to building structure.
4. Size and location of initial access modules for acoustical tile.
5. Items penetrating finished ceiling, including the following:

a. Lighting fixtures.
b. Air outlets and inlets.
c. Speakers.
d. Sprinklers.
e. Access panels.

B. Seismic Qualification Data: Submit certification that propeller unit heaters, accessories, and components will withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC."

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 DESCRIPTION

A. Assembly including casing, coil, fan, and motor in vertical and horizontal discharge configuration with adjustable discharge louvers.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 PERFORMANCE REQUIREMENTS

A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

B. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

C. Seismic Performance: Propeller unit heaters shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.4 HOUSINGS

A. Finish: As directed, Manufacturer's standard or custom baked enamel applied to factory-assembled and -tested propeller unit heaters before shipping.

B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Discharge Louver: Adjustable fin diffuser for horizontal units and conical diffuser for vertical units.

2.5 COILS

A. General Coil Requirements: Test and rate hot-water propeller unit-heater coils according to ASHRAE 33.

B. Hot-Water Coil: Copper tube, minimum 0.025-inch (0.635-mm) wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of 200 psig (1380 kPa) and a maximum entering-water temperature of 325 deg F (163 deg C), with manual air vent. Test for leaks to 350 psig (2413 kPa) underwater.

C. Hot-Water Coil: Vertical steel tube, minimum 0.065-inch (1.65-mm) wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of 400 psig (2760 kPa) and a maximum entering-water temperature of 450 deg F (232 deg C), with steel headers at top and bottom. Test for leaks to 600 psig (4137 kPa) underwater.

2.6 FAN AND MOTOR

A. Fan: Propeller type with aluminum wheel directly mounted on motor shaft in the fan venturi.

B. Motor: As directed, permanently lubricated, explosion proof, multispeed or variable speed. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

2.7 CONTROLS

A. Control Devices:

1. As directed, Unit, Wall-mounted, variable fan-speed switch.
2. As directed, Unit or Wall-mounted thermostat.

2.8 CAPACITIES AND CHARACTERISTICS

A. Heating Capacity:

1. Heat Output: As directed.
2. Length of Throw: As directed.
3. Mounting Height: As directed.

B. Water Coil:

1. Entering-Water Temperature: As directed.
2. Temperature Difference: As directed.
3. Water Flow: As directed.

4. Water-Side Pressure Drop: As directed.

C. Supply Air:

1. Airflow: As directed.
2. Leaving-Air Temperature: As directed.
3. Entering-Air Temperature: As directed.

D. Fan Motor:

1. High Speed: As directed.
2. Motor Size: As directed.

E. Electrical Characteristics for Single-Point Connection:

1. Volts: As directed.
2. Phase: As directed.
3. Hertz: As directed.
4. Full-Load Amperes: As directed.
5. Minimum Circuit Amperes: As directed.
6. Maximum Overcurrent Protection: As directed.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive propeller unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping and electrical connections to verify actual locations before unit-heater installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install propeller unit heaters to comply with NFPA 90A.

B. Install propeller unit heaters level and plumb.

C. As directed, Suspend propeller unit heaters from structure with all-thread hanger rods and elastomeric hangers, spring hangers or spring hangers with vertical-limit stop. Hanger rods and attachments to structure are specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment." Vibration hangers are specified in Section 230548 "Vibration and Seismic Controls for HVAC" or Section 230548.13 "Vibration Controls for HVAC" As directed

D. Install wall-mounted thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.

3.3 CONNECTIONS

A. Piping installation requirements are specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Connect piping to propeller unit heater's factory, hot-water piping package. Install the piping package if shipped loose.

D. Comply with safety requirements in UL 1995.

E. Unless otherwise indicated, install union and gate or ball valve on supply-water connection and union and calibrated balancing valve on return-water connection of propeller unit heater. Hydronic specialties are specified in Section 232116 "Hydronic Piping Specialties."

F. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

G. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

B. Units will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 238239.16

SECTION 238239.19 - WALL AND CEILING UNIT HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes wall and ceiling heaters with propeller fans and electric-resistance heating coils.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings:

1. Include plans, elevations, sections, and details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include details of anchorages and attachments to structure and to supported equipment.
4. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
5. Wiring Diagrams: Power, signal, and control wiring.

C. Samples: For each exposed product and for each color and texture specified.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 DESCRIPTION

A. Assembly including chassis, electric heating coil, fan, motor, and controls. Comply with UL 2021.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 CABINET

A. Front Panel: As directed, stamped-steel louver or Extruded-aluminum bar grille, with removable panels fastened with tamperproof fasteners.

B. Finish: As directed, baked enamel over baked-on primer with manufacturer's standard or custom color selected by Architect, applied to factory-assembled and -tested wall and ceiling heaters before shipping.

C. Surface-Mounted Cabinet Enclosure: Steel with finish to match cabinet.

2.4 COIL

A. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in corrosion-resistant metallic sheath. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware, and limit controls for high-temperature protection. Provide integral circuit breaker for overcurrent protection.

2.5 FAN AND MOTOR

A. Fan: Aluminum propeller directly connected to motor.

B. Motor: Permanently lubricated, multispeed. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

2.6 CONTROLS

A. Controls: Unit-mounted thermostat. Low-voltage relay with transformer kit.

B. Electrical Connection: Factory wire motors and controls for a single field connection with disconnect switch.

2.7 CAPACITIES AND CHARACTERISTICS

A. Airflow: As directed.

B. Fan Speed: As directed.

C. Heating Coil: As directed.

D. Electrical Characteristics for Single-Point Connection:

1. Volts: As directed.
2. Phase: As directed.
3. Hertz: As directed.
4. Full-Load Amperes: As directed.
5. Minimum Circuit Ampacity: As directed.

6. Maximum Overcurrent Protection: As directed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install wall and ceiling unit heaters to comply with NFPA 90A.

B. Install wall and ceiling unit heaters level and plumb.

C. Install wall-mounted thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.

D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

END OF SECTION 238239.19

SECTION 238313 - RADIANT-HEATING ELECTRIC CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes electric heating cables for ceiling or floor radiant heating, snow and ice melting on pavement, and freezer-floor frost-heave prevention with the following electric heating cables:

1. Plastic insulated, series resistance.
2. Self-regulating, parallel resistance.

B. Related Requirements:

1. Section 210533 "Heat Tracing for Fire-Suppression Piping."
2. Section 220533 "Heat Tracing for Plumbing Piping."
3. Section 230533 "Heat Tracing for HVAC Piping."
4. Section 238213 "Valance Heating and Cooling Units" for factory-fabricated electric heating panels for ceiling and wall applications.
5. Section 238323 "Radiant-Heating Electric Panels."

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For electric heating cable. Include plans, sections, details, and attachments to other work.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, and coordinated with each other, using input from installers of the items involved.

B. Field quality-control reports.

C. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace electric heating cable that fails in materials or workmanship within specified warranty period.

1. Warranty Period: As directed, 10 or 15 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR ELECTRIC HEATING CABLES

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 PLASTIC-INSULATED, SERIES-RESISTANCE HEATING CABLES

A. Comply with UL 1673.

B. Heating Element: Single resistor wire. Terminate with waterproof, factory-assembled, non-heating leads with connectors at both ends.

C. Electrical Insulating Jacket: Minimum 4.0-mil (0.10-mm) Kapton with silicone or Tefzel.

D. Cable Cover: As directed, Aluminum, Stainless-steel or Nickel braid with silicone or Hylar outer jacket.

E. Maximum Operating Temperature: 300 deg F (150 deg C).

F. Cable-Heated Mats: As directed, Factory-fabricated cable and fiberglass or plastic mesh with uniform 1-1/2-inch (38-mm) or 3-inch (76-mm) cable spacing, in 18-inch (457-mm) or 36-inch (914-mm) widths.

G. Capacities and Characteristics:

1. Maximum Heat Output (Cable): As directed, 6 W/ft. (19.7 W/m) or 7.5 W/ft. (24.6 W/m).
2. Maximum Heat Output (Mat): As directed, 12 W/sq. ft. (129 W/sq. m) or 16 W/sq. ft. (172 W/sq. m).
3. Spacing: As directed.
4. Electrical Characteristics for Single-Circuit Connection:

a. Volts: As directed, 120, 208, 240, 277 or 480.
b. Phase: As directed.
c. Hertz: As directed.
d. Full-Load Amperes: As directed.
e. Minimum Circuit Ampacity: As directed.
f. Maximum Overcurrent Protection: As directed.

2.3 SELF-REGULATING, PARALLEL-RESISTANCE HEATING CABLES

A. As directed, Comply with UL 1673.

B. Heating Element: As directed, Pair of parallel No. 16 or No. 18 AWG, tinned or nickel-coated, stranded copper bus wires embedded in crosslinked conductive polymer core, which varies heat output in response to temperature along its length. Terminate with waterproof, factory-assembled, non-heating leads with connectors at one end, and seal the opposite end watertight. Cable shall be capable of crossing over itself once without overheating.

C. Electrical Insulating Jacket: Flame-retardant polyolefin.

D. Cable Cover: As directed, Tinned-copper or Stainless-steel braid with polyolefin outer jacket with ultraviolet inhibitor.

E. Maximum Operating Temperature: 300 deg F (150 deg C).

F. Cable-Heated Mats: As directed, Factory-fabricated cable and fiberglass or plastic mesh with uniform 1-1/2-inch (38-mm) or 3-inch (76-mm) cable spacing, in 18-inch (457-mm) or 36-inch (914-mm) widths.

G. Capacities and Characteristics:

1. Maximum Heat Output (Cable): As directed, 3 W/ft. (9.8 W/m), 5 W/ft. (16.4 W/m), 8 W/ft. (26 W/m), 10 W/ft. (32.8 W/m) or 12 W/ft. (39.4 W/m).
2. Maximum Heat Output (Mat): As directed, 6 W/sq. ft. (65 W/sq. m), 12 W/sq. ft. (129 W/sq. m), 16 W/sq. ft. (172 W/sq. m) or 24 W/sq. ft. (260 W/sq. m).
3. Spacing: As directed.
4. Electrical Characteristics for Single-Circuit Connection:

    a. Volts: As directed, 120, 208, 240, 277 or 480.
    b. Phase: As directed.
    c. Hertz: As directed.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed.
    f. Maximum Overcurrent Protection: As directed.

2.4 CONTROLS

A. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC" for control devices and sequence of operations for radiant-heating electric cables.

B. Wall-Mounted Thermostats for Ceiling and Floor Heating Cables:

1. Minimum temperature range from 50 to 90 deg F (10 to 32 deg C).
2. Manually operated with on-off switch.

C. Precipitation and Temperature Sensor for Snow Melting on Pavement:

1. As directed, Microprocessor-based or Automatic control with manual on, automatic, and standby/reset switch.
2. Precipitation and temperature sensors shall sense the surface conditions of pavement and shall be programmed to energize the cable as follows:

    a. Temperature Span: 34 to 44 deg F (1 to 7 deg C).
    b. Adjustable Delay-Off Span: 30 to 90 minutes.
    c. Energize Cables: Following two-minute delay if ambient temperature is below set point and precipitation is detected.
    d. De-Energize Cables: On detection of a dry surface plus time delay.

3. Corrosion-proof and waterproof enclosure suitable for outdoor mounting, for controls and precipitation and temperature sensors.
4. Minimum 30-A contactor to energize cable or close other contactors.
5. Provide relay with contacts to indicate operational status, on or off, for interface with central HVAC control-system workstation.

2.5 ACCESSORIES

A. Cable Installation Accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer.

B. Embedded Heating-Cable Identification:

1. Flush-mounted cast-iron boxes with identification on lid according to NFPA 70.
2. As directed, mechanically fastened metal or plastic signage with identification according to NFPA 70 and complying with requirements in Section 101416"Plaques," Section 101419 "Dimensional Letter Signage" or Section 101423 "Panel Signage."
3. As directed, mechanically fastened metal, plastic or concrete post-mounted signage with identification according to NFPA 70 and complying with requirements in Section 101416 "Plaques," Section 101419 "Dimensional Letter Signage" or Section 101423 "Panel Signage."

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Install the following types of electric heating cable for the applications described:

1. Ceiling Radiant Heating: As directed, Plastic-insulated, series-resistance or Self-regulating, parallel-resistance heating cable.
2. Floor Radiant Heating: As directed, Plastic-insulated, series-resistance or Self-regulating, parallel-resistance heating cable.
3. Snow and Ice Melting on Pavement: As directed, Plastic-insulated, series-resistance or Self-regulating, parallel-resistance heating cable.
4. Freezer-Floor Frost-Heave Prevention: As directed, Plastic-insulated, series-resistance or Self-regulating, parallel-resistance heating cable.

3.2 INSTALLATION

A. Install electric heating cable or cable-heated mats across expansion, construction, and control joints according to manufacturer's written instructions; use cable-protection conduit and slack cable to allow movement without damage to cable.

B. Do not energize cables embedded in concrete or plaster until those assemblies are cured.

C. Electric Heating-Cable Installation for Ceiling Radiant Heating: Install heating cable or cable-heated mat with heat-conductive fill materials such as plaster to ensure direct contact with finished radiant surfaces.

D. Electric Heating-Cable Installation for Floor Radiant Heating: Install heating cable or cable-heated mat with heat-conductive fill materials such as concrete to ensure direct contact with finished radiant surfaces.

E. Electric Heating-Cable or Cable-Heated-Mat Installation for Snow and Ice Melting in Pavement:

1. Install heating cable or cable-heated mat with heat-conductive fill materials such as asphalt or concrete to ensure direct contact with finished radiant surfaces.
2. Install cables or cable-heated mats after applying bituminous binder course to lower base; ensure that second bituminous binder course is applied to cables or mats before pouring finish topping.
3. Install embedded electric heating-cable or cable-heated-mat identification box where indicated in pavement before pavement work is completed.
4. Stamp concrete with embedded electric heating-cable or cable-heated-mat identification according to NFPA 70 and complying with requirements in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete."
5. Mount precipitation sensor in pavement.

F. Electric Heating-Cable Installation for Freezer-Floor Frost-Heave Prevention: Install electric heating cable or cable-heated mat below insulation in subsoil.

1. Install embedded electric heating-cable or cable-heated-mat identification box where indicated.
2. Install embedded electric heating-cable or cable-heated-mat identification according to NFPA 70 on adjacent structure and complying with requirements in Section 101416 "Plaques," Section 101419 "Dimensional Letter Signage" or Section 101423 "Panel Signage" As directed.
3. As directed, install embedded electric heating-cable or cable-heated-mat identification according to NFPA 70 on metal, wood or concrete post and complying with requirements in Section 101416 "Plaques", Section 101419 "Dimensional Letter Signage" or Section 101423 "Panel Signage."
4. Stamp concrete with embedded electric heating-cable or cable-heated-mat identification according to NFPA 70 and complying with requirements in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" As directed

G. Set field-adjustable switches and circuit-breaker trip ranges.

H. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

I. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. As directed, Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform tests after cable installation but before application of coverings such as insulation, wall or ceiling construction, or concrete.
2. Test cables for electrical continuity and insulation integrity before energizing.
3. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.

B. Repeat tests for continuity, insulation resistance, and input power after applying finished surface on heating cables.

C. Radiant-heating electric cables will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

E. Remove and replace damaged radiant-heating electric cables and cable-heated mats.

END OF SECTION 238313

SECTION 238316 - RADIANT-HEATING HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes radiant-heating piping, including the following:

1. PEX pipe and fittings
2. PEX-AL-PEX pipe and fittings
3. Distribution manifolds
4. Piping specialties
5. Controls

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include data for piping, fittings, manifolds, specialties, and controls; include pressure and temperature ratings, oxygen-barrier performance, fire-performance characteristics, and water-flow and pressure-drop characteristics.

B. Shop Drawings: Show piping layout and details drawn to scale, including valves, manifolds, controls, and support assemblies, and their attachments to building structure.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PEX PIPE AND FITTINGS

A. Pipe Material: PEX plastic according to ASTM F876.

B. Oxygen Barrier: Limit oxygen diffusion through the tube to maximum 0.10 mg per cu. m/day at 104 deg F (40 deg C) according to DIN 4726.

C. Fittings: As directed, ASTM F1807, metal insert and copper crimp rings or ASTM F1960, cold expansion fittings and reinforcing rings.

D. Pressure/Temperature Rating: Minimum 100 psig (690 kPa) and 180 deg F (82 deg C).

2.2 PEX-AL-PEX PIPE AND FITTINGS

A. Pipe Material: PEX plastic bonded to the inside and outside of a welded aluminum tube according to ASTM F1281.

B. Oxygen Barrier: Limit oxygen diffusion through the pipe to maximum 0.10 mg per cu. m/day at 104 deg F (40 deg C) according to DIN 4726.

C. Fittings: ASTM F1974, metal insert fittings with split ring and compression nut (compression joint) or metal insert fittings with copper crimp rings (crimp joint).

D. Flame-Spread and Smoke-Developed Indices: 25 and 50 or less, respectively, tested according to ASTM E84.

E. Pressure/Temperature Rating: Minimum 100 psig (690 kPa) and 210 deg F (99 deg C).

2.3 DISTRIBUTION MANIFOLDS

A. Manifold: As directed, Minimum NPS 1 (DN 25), brass, copper, modular plastic or stainless steel.

B. Main Shutoff Valves:

1. Factory installed on supply and return connections.
2. As directed, Two or Three-piece body.
3. Body: Brass or bronze.
4. Ball: Chrome-plated bronze.
5. Seals: PTFE.
6. CWP Rating: 150 psig (1035 kPa).
7. Maximum Operating Temperature: 225 deg F (107 deg C).

C. Manual Air Vents:

1. Body: Bronze.
2. Internal Parts: Nonferrous.
3. Operator: Key furnished with valve, or screwdriver bit.
4. Inlet Connection: NPS 1/2 (DN 15).
5. Discharge Connection: NPS 1/8 (DN 6).
6. CWP Rating: 150 psig (1035 kPa).
7. Maximum Operating Temperature: 225 deg F (107 deg C).

D. Balancing Valves:

1. Body: Plastic or bronze, ball or plug, or globe cartridge type.
2. Ball or Plug: Brass or stainless steel.
3. Globe Cartridge and Washer: Brass with EPDM composition washer.
4. Seat: PTFE.
5. Visual Flow Indicator: Flowmeter with visible indication in a clear plastic cap at top of valve.

6. Differential Pressure Gage Connections: Integral seals for portable meter to measure loss across calibrated orifice.
7. Handle Style: Lever or knob, with memory stop to retain set position if used for shutoff.
8. CWP Rating: Minimum 125 psig (860 kPa).
9. Maximum Operating Temperature: 250 deg F (121 deg C).

E. Zone Control Valves:

1. Body: Plastic or bronze, ball or plug, or globe cartridge type.
2. Ball or Plug: Brass or stainless steel.
3. Globe Cartridge and Washer: Brass with EPDM composition washer.
4. Seat: PTFE.
5. Actuator: Replaceable electric motor.
6. CWP Rating: Minimum 125 psig (860 kPa).
7. Maximum Operating Temperature: 250 deg F (121 deg C).

F. Thermometers:

1. Mount on supply and return connections.
2. Case: Dry type, metal or plastic, 2-inch (50-mm) diameter.
3. Element: Bourdon tube or other type of pressure element.
4. Movement: Mechanical, connecting element and pointer.
5. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
6. Pointer: Black metal.
7. Window: Plastic.
8. Connector: Rigid, back type.
9. Thermal System: Liquid- or mercury-filled bulb in copper-plated steel, aluminum, or brass stem.
10. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

G. Mounting Brackets: Copper, or plastic- or copper-clad steel, where in contact with manifold.

2.4 PIPING SPECIALTIES

A. Cable Ties:

1. Fungus-inert, self-extinguishing, one-piece, self-locking, Type 6/6 nylon cable ties.
2. Minimum Width: 1/8 inch (3 mm).
3. Tensile Strength: 20 lb (9 kg), minimum.
4. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).

B. Floor Mounting Staples:

1. Steel, with corrosion-resistant coating and smooth finish without sharp edges.
2. Minimum Thickness: 3/32 inch (2.4 mm).
3. Width: Minimum, wider than tubing.

C. Floor Mounting Clamps:

1. Two bolts, steel, with corrosion-resistant coating and smooth finish without sharp edges.
2. Minimum Thickness: 3/32 inch (2.4 mm).
3. Width: Minimum, wider than tubing.

D. Floor Mounting Tracks:

1. Aluminum or plastic channel track with smooth finish and no sharp edges.
2. Minimum Thickness: 1/16 inch (1.6 mm).
3. Slot Width: Snap fit to hold tubing.
4. Slot Spacing: As directed, 2-inch (50-mm) or 3-inch (75-mm) intervals.

E. Channeled Subfloor:

1. Plywood, APA-rated subfloor panel, composed of premium, tongue-and-groove, seven-layer, Douglas fir structural subfloor panels.
2. Particleboard manufactured to comply with Federal Housing Authority standards of less than 0.3-ppm formaldehyde.
3. Clad panel with minimum 0.025-inch- (0.635-mm-) thick aluminum recessed in the grooves sized to maintain contact with radiant piping.

F. Modular Interlocking Blocks:

1. Polypropylene snap-together blocks with grooves to support piping.
2. Galvanized sheet metal or aluminum emission plates.
3. Natural mineralboard cover panel.

G. Heat-Emission Plates:

1. Formed aluminum suitable for radiant-heating piping.
2. Minimum Thickness: 1/16 inch (1.6 mm).
3. Slot Width: Snap fit to maintain pressure fit on tubing.

2.5 CONTROLS

A. Wall-Mounted Thermostat:

1. Minimum temperature range from 50 to 90 deg F (10 to 32 deg C).
2. Manually operated with on-off switch.
3. Day and night setback and clock program with minimum four periods per day.
4. Operate pumps or open zone control valves if room temperature falls below the thermostat setting and stop pumps or close zone control valves when room temperature rises above the thermostat setting.

B. Precipitation and Temperature Sensor:

1. As directed, Microprocessor-based or Automatic control with manual on, automatic, and standby/reset switch.
2. Precipitation and temperature sensors shall sense the surface conditions of pavement and shall be programmed to operate pump and zone control valves as follows:

a. Temperature Span: 34 to 44 deg F (1 to 7 deg C).
b. Adjustable Delay Off Span: 30 to 90 minutes.
c. Start Pump or Open Zone Control Valves: Following two-minute delay if ambient temperature is below set point and precipitation is detected.
d. Stop Pump or Close Zone Control Valves: On detection of a dry surface plus time delay.

3. Corrosion-proof and waterproof enclosure suitable for outdoor mounting, for controls and precipitation and temperature sensors.
4. Minimum 30-A contactor to start pump and open valves.
5. Precipitation sensor shall be mounted in pavement.
6. Provide relay with contacts to indicate operational status, on or off, for interface with central HVAC control-system workstation.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Install the following types of radiant-heating piping for the applications described:

1. Piping in Exterior Pavement: As directed, PEX or PEX/AL/PEX.
2. Piping in Interior Reinforced-Concrete Floors: As directed, PEX or PEX/AL/PEX.
3. Piping in Level Fill Concrete Floors (Not Reinforced): As directed, PEX or PEX/AL/PEX.
4. Piping in Ceilings: As directed, PEX or PEX/AL/PEX.
5. Piping in Subfloors: As directed, PEX or PEX/AL/PEX.
6. Piping below Wood Floors: As directed, PEX or PEX/AL/PEX.

3.2 INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings or coordination drawings.

B. Install radiant-heating piping continuous from the manifold through the heated panel and back to the manifold without piping joints in heated panels.

C. Connect radiant piping to manifold in a reverse-return arrangement.

D. Do not bend pipes in radii smaller than manufacturer's minimum bend radius dimensions.

E. Install manifolds in accessible locations or install access panels to provide maintenance access as required in Section 083113 "Access Doors and Frames."

F. See Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties" for pipes and connections to hydronic systems and for glycol-solution fill requirements.

G. Fire- and Smoke-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials according to Section 078413 "Penetration Firestopping."

H. Piping in Exterior Pavement:

1. Secure piping in concrete floors by attaching pipes to reinforcement using cable ties.
2. Space cable ties a maximum of 18 inches (457 mm) o.c. and at center of turns or bends.
3. Maintain 3-inch (75-mm) minimum cover.
4. Install a sleeve of 3/8-inch- (9.5-mm-) thick, foam-type insulation or PE pipe around tubing and extending for a minimum of 10 inches (250 mm) on each side of slab joints to protect the tubing passing through expansion or control joints. Anchor sleeve to slab form at control joints to provide maximum clearance for saw cut.
5. Maintain minimum 40-psig (275-kPa) pressure in piping during concrete placement and continue for 24 hours after placement.

I. Piping in Interior Reinforced-Concrete Floors:

1. Secure piping in concrete floors by attaching pipes to reinforcement using cable ties.
2. Space cable ties a maximum of 18 inches (457 mm) o.c. and at center of turns or bends.
3. Maintain 2-inch (50-mm) minimum cover.
4. Install a sleeve of 3/8-inch- (9.5-mm-) thick, foam-type insulation or PE pipe around tubing and extending for a minimum of 10 inches (250 mm) on each side of slab joints to protect the tubing passing through expansion or control joints. Anchor sleeve to slab form at control joints to provide maximum clearance for saw cut.
5. Maintain minimum 40-psig (275-kPa) pressure in piping during concrete placement and continue for 24 hours after placement.

J. Piping in Level Fill Concrete Floors (Not Reinforced):

1. Secure piping in concrete floors by attaching pipes to subfloor using tracks, clamps, or staples.
2. Space tracks, clamps, or staples a maximum of 18 inches (457 mm) o.c. and at center of turns or bends.
3. Maintain 3/4-inch (19-mm) minimum cover.
4. Install a sleeve of 3/8-inch- (9.5-mm-) thick, foam-type insulation or PE pipe around tubing and extending for a minimum of 10 inches (250 mm) on each side of slab joints to protect the tubing passing through expansion or control joints. Anchor sleeve to slab form at control joints to provide maximum clearance for saw cut.
5. Maintain minimum 40-psig (275-kPa) pressure in piping during the concrete pour and continue for 24 hours during curing.

K. Piping in Ceiling:

1. Secure piping by attaching pipes to ceiling substrate using clamps or staples.
2. Space clamps or staples a maximum of 18 inches (457 mm) o.c. and at center of turns or bends.
3. Maintain 1-1/2-inch (38-mm) minimum plaster cover.
4. Maintain minimum 40-psig (275-kPa) pressure in piping during the plaster application and continue for 24 hours during curing.

L. Piping in Subfloor:

1. Secure piping by laying in subfloor channels or modular interlocking blocks.
2. Use straight channel panels or blocks in the center and curved channel panels or blocks at the ends.
3. Finish floor with mineralboard panel cover or finished floor surface.

M. Piping below Wood Floor:

1. Secure piping by attaching pipes to subfloor using heat-emission plates, clamps, or staples.
2. Space heat-emission plates, clamps, or staples a maximum of 4 inches (100 mm) o.c. and at center of turns or bends.
3. Install heat-emission plates on underside of wood subfloor with maximum space between plates, as noted above, to maintain pipe contact with floor.

N. Revise locations and elevations from those indicated as required to suit field conditions and ensure integrity of piping and as approved by Architect.

O. After system balancing has been completed, mark balancing valves to permanently indicate final position.

P. Perform the following adjustments before operating the system:

1. Open valves to fully open position.
2. Check operation of automatic valves.
3. Set temperature controls so all zones call for full flow.
4. Purge air from piping.

Q. After concrete or plaster heating panel has cured as recommended by concrete or plaster supplier, operate radiant-heating system as follows:

1. Start system heating at a maximum of 10 deg F (6 deg C) above the ambient radiant-panel temperature and increase 10 deg F (6 deg C) each following day until design temperature is achieved.
2. For freeze protection, operate at a minimum of 60 deg F (16 deg C) supply-water temperature.

3.3 FIELD QUALITY CONTROL

A. Prepare radiant-heating piping for testing as follows:

1. Open all isolation valves and close bypass valves.
2. Open and verify operation of zone control valves.
3. Flush with clean water and clean strainers.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Leak Test: After installation, charge system and test for leaks. Subject piping to hydrostatic test pressure that is not less than 1.5 times the design pressure but not more than 100 psig (690 kPa). Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Radiant-heating piping will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. Protect hydronic piping system from damage during construction.

END OF SECTION 238316

SECTION 238323 - RADIANT-HEATING ELECTRIC PANELS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes prefabricated radiant-heating electric panels.

B. Related Requirements:

1. Section 238213 "Valance Heating and Cooling Units" for factory-fabricated electric heating panels for ceiling and wall applications.
2. Section 238313 "Radiant-Heating Electric Cables."

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For electric heating panels. Include plans, sections, details, and attachments to other work.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, and coordinated with each other, using input from installers of the items involved.

B. Field quality-control reports.

C. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace electric heating panels that fail in materials or workmanship within specified warranty period.

1. Warranty Period: As directed, Three or Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR RADIANT-HEATING ELECTRIC PANELS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 PREFABRICATED RADIANT-HEATING ELECTRIC PANELS

A. Description: As directed, Sheet-metal-enclosed panel with heating element suitable for lay-in installation flush with T-bar ceiling grid, surface mounting or recessed mounting. Comply with UL 2021.

1. Panel: Minimum 0.0276-inch- (0.7-mm-) thick, galvanized sheet steel back panel riveted to minimum 0.0396-inch- (1.0-mm-) thick, galvanized sheet steel front panel with fused-on crystalline surface.
2. Heating Element: Powdered graphite sandwiched between sheets of electric insulation.
3. Heating Element: Insulated resistive wires.
4. Electrical Connections: Nonheating, high-temperature, insulated-copper leads, factory connected to heating element.
5. Exposed-Side Panel Finish: Apply silk-screened finish to match appearance of Architect-selected acoustical ceiling tiles.
6. Exposed-Side Panel Finish: Factory prime coated, ready for field painting.
7. Exposed-Side Panel Finish: As directed, Baked-enamel finish in manufacturer's standard or custom paint color as selected by Architect.
8. Surface-Mounted Trim: As directed, Sheet metal with baked-enamel finish in manufacturer's standard or custom paint color as selected by Architect.

B. Wall Thermostat: As directed, Bimetal, sensing elements calibrated from 55 to 90 deg F (13 to 32 deg C); with contacts suitable for low or line-voltage circuit, and manually operated on-off switch with contactors, relays, and control transformers.

C. Capacities and Characteristics:

1. Nominal Panel Size: As directed, 24 by 24 inches (600 by 600 mm), 24 by 36 inches (600 by 900 mm), 24 by 48 inches (600 by 1200 mm) or 24 by 60 inches (600 by 1500 mm).
2. Heating Capacity: As directed, 250, 375, 500, 570, 625, 750 or 950 W.
3. Electrical Characteristics for Single-Point Connection:

    a. Volts: As directed.
    b. Phase: As directed.
    c. Hertz: As directed.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed.
    f. Maximum Overcurrent Protection: As directed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install radiant-heating panels level and plumb.

B. Support for Radiant-Heating Panels in or on Grid-Type Suspended Ceilings: Use grid as a support element.

1. Install a minimum of four ceiling-support-system rods or wires for each panel. Locate not more than 6 inches (150 mm) from panel corners.
2. Support Clips: Fasten to panel and to ceiling grid members at or near each panel corner with clips designed for the application.
3. Panels of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support panels independently with at least two 3/4-inch (19-mm) metal channels spanning and secured to ceiling tees.
4. Install at least one independent support rod or wire from structure to a tab on panel. Wire or rod shall have breaking strength of the weight of the panel at a safety factor of 3.

C. Verify locations of thermostats with Drawings and room details before installation. As directed, Install devices 48 inches (1220 mm) or 60 inches (1525 mm) above finished floor.

D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operate electric-heating elements through each stage to verify proper operation and electrical connections.
2. Test and adjust controls and safeties.

B. Radiant-heating electric panels will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

D. Remove and replace damaged radiant-heating electric panels.

END OF SECTION 238323

SECTION 238413.16 - WETTED-ELEMENT HUMIDIFIERS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes wetted-element humidifiers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

C. Shop Drawings: Detail fabrication and installation of humidifiers. Include piping details, plans, elevations, sections, details of components, manifolds, attachments to other work, and wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Detail humidifiers and adjacent equipment. Show support locations, type of support, weight on each support, required clearances, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

B. Seismic Qualification Data: Certificates, for humidifiers, accessories, and components from manufacturer.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with AHRI 640.

C. Comply with UL 900, Class I or Class II.

D. Comply with standard as directed.

E. Seismic Performance: Wetted-element humidifiers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means the "unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: As directed, 1.5 or 1.0.

F. Capacities and Characteristics:

1. Humidification Rate: As directed.
2. Entering Dry-Bulb Air Temperature: As directed.
3. Entering Wet-Bulb Air Temperature: As directed.
4. Leaving Dry-Bulb Air Temperature: As directed.
5. Leaving Wet-Bulb Air Temperature: As directed.
6. Duct/Plenum Height: As directed.
7. Duct/Plenum Width: As directed.
8. Number of Media Control Stages: As directed.
9. Maximum Absorption Distance: As directed.
10. Cooling Efficiency Required: Percent As directed.
11. Media Water Pump:

    a. Number of Pumps: As directed.
    b. Motor Horsepower (Each): As directed.

12. Drain Pump:

    a. Number of Pumps: As directed.
    b. Motor Horsepower: As directed.

13. Electrical Characteristics: Single point of connection.

    a. Volts: As directed.
    b. Phase: As directed, Single or Three phase.
    c. Hertz: As directed, Hz.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed
    f. Maximum Overcurrent Protection: As directed.

G. Water Type: As directed, Suitable for use with tap or softened water.

2.2 WETTED-ELEMENT HUMIDIFIER MANUFACTURERS

2.3 WETTED-ELEMENT HUMIDIFIERS

A. Piping and Fittings: As directed, ASTM A269 (ASTM A269M), Stainless-steel or Stainless-steel, type 304 pipe and fittings.

B. Piping and Fittings: ASTM B88 (ASTM B88M), type L copper pipe and wrought-copper fittings with brazed joints.

C. Media Water Pump:

1. As directed, Stainless-steel or Bronze pump body and single or variable-speed motor.
2. As directed, One pump, One solenoid valve or One pump or solenoid valve for each media stage.

D. Drain Pump: As directed, Stainless-steel or Bronze pump body and single-speed motor.

E. Media:

1. Inorganic and inflammable.

F. Reservoir, Header, and Frame:

1. Stainless steel.
2. Reservoir designed, so it drains and dries completely.

G. Water Treatment:

1. Silver-ion antibacterial cartridge.
2. 5-micron pre-filter.

H. Control Panel:

1. As directed, NEMA 250, type 3R or type 4X, to comply with environmental conditions at installed location.
2. Material: As directed, Galvanized, Powder-coated or Stainless steel.

I. Controls:

1. As directed, Cycle or Vary speed of motor and sequence solenoid valve stages to satisfy humidistat.
2. Multilevel probe and supply solenoid to maintain tank water level.

J. Accessories:

1. As directed, Humidistat or Humidity Sensor: As directed, Wall or Return duct mounted.
2. As directed, High-Limit Humidistat or Humidity Sensor: Supply duct mounted.
3. Airflow switch prevents humidifier operation without airflow.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Examine roughing-in for piping systems to verify actual locations of piping connections before humidifier installation.

B. Install humidifiers with required clearance for service and maintenance. Maintain path, downstream from humidifiers, clear of obstructions as required by ASHRAE 62.1.

C. Seal all duct and plenum penetrations with flange.

D. Install humidifier manifolds in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

E. As directed, Install galvanized or stainless-steel drain pan under each manifold.

1. Construct drain pans with connection for drain; insulated and complying with ASHRAE 62.1.
2. Connect to condensate trap and drainage piping.
3. Extend drain pan upstream and downstream from manifold a minimum distance recommended by manufacturer but not less than that required by ASHRAE 62.1.

F. Equipment Mounting:

1. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

G. Install all manufacturer-furnished accessories in accordance with manufacturer's written installation instructions.

3.2 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

1. Install piping adjacent to humidifiers to allow service and maintenance.

B. Install devices and piping specialties furnished by manufacturer but not factory mounted.

3.3 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between humidity sensors, high-limit humidity sensors, and DDC control system.

C. Connect control wiring between humidistats and controlled devices.

D. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: As directed, Owner will engage or Engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Humidifier will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.6 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain humidifiers.

END OF SECTION 238413.16

SECTION 238413.19 – ATOMIZING HUMIDIFIERS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes water-pressure atomizing humidifiers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Sustainable Design Submittals:

C. Shop Drawings: Detail fabrication and installation of humidifiers. Include piping details, plans, elevations, sections, details of components, manifolds, and attachments to other work.

1. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Detail humidifiers and adjacent equipment. Show support locations, type of support, weight on each support, required clearances, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

B. Seismic Qualification Data: Certificates, for humidifiers, accessories, and components from manufacturer.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with AHRI 640.

C. Comply with standard as directed.

D. Seismic Performance: Wetted-element humidifiers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: As directed, 1.5 or 1.0.

2.2 WATER-PRESSURE ATOMIZING HUMIDIFIERS

A. Capacities and Characteristics:

1. Humidification Rate: As directed.
2. Dry-Bulb Air Temperature at Discharge: As directed.
3. Wet-Bulb Air Temperature at Discharge: As directed.
4. Number of Nozzles: As directed.
5. Nozzle Spacing: As directed.
6. Maximum Absorption Distance: As directed.
7. Minimum Makeup Water Supply Pressure: As directed.
8. Water Pump:
    a. Discharge Pressure: As directed, 1000 psig (6894 kPa), 1200 psig (13 790 kPa) or 1000 psig (6895 kPa) to 1200 psig (8274 kPa).
    b. Motor Horsepower: As directed.
9. Final Water Filter:
    a. Efficiency: Percent As directed.
    b. Maximum Size of Particles Retained: Number microns as directed.
    c. Pressure Drop, Clean: As directed.
    d. Pressure Drop, Dirty: As directed.
10. Electrical Characteristics: Single point of connection.
    a. Volts: As directed.
    b. Phase: As directed, Single or Three phase.
    c. Hertz: Hz as directed.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed.
    f. Maximum Overcurrent Protection: As directed.

B. Water Type: As directed, Suitable for use with tap, softened, reverse osmosis or deionized water.

C. Atomizing Nozzles: As directed, Stainless-steel, Stainless-steel, type 304 or Stainless-steel, type 316 anti-drip.

D. Manifold: As directed, Stainless-steel, Stainless-steel, type 304 or Stainless-steel, type 316 piping.

E. Piping and Fittings: As directed, ASTM A269 (ASTM A269M), Stainless-steel, Stainless-steel, type 304 or Stainless-steel, type 316 pipe and fittings.

F. Piping and Fittings: ASTM B88 (ASTM B88M), type L copper pipe and wrought-copper fittings with brazed joints.

G. Droplet Separator: Located downstream from manifolds to eliminate nonevaporated droplets.

H. Water Pump:

1. As directed, Enclosed belt-drive or Direct-drive high-pressure stainless-steel, brass or ceramic piston pump.
2. As directed, Single or Variable-speed, totally enclosed, fan-cooled motor.
3. Mounting: As directed, Skid or Wall.

I. Control Panel:

1. As directed, NEMA 250, type 3R or type 4X, to comply with environmental conditions at installed location.
2. Material: As directed, Galvanized, Powder-coated or Stainless steel.

J. Controls:

1. As directed, Cycle or Vary speed of pump motor to satisfy humidity sensor or humidistat.
2. Provide a high-pressure, normally closed solenoid valve for each control zone shown on Drawings.
3. Flushing: Automatic flushing of piping upon system shutdown and upon no humidification demand for an extended time.

K. System Discharge Type:

1. Direct-area dispersion system.
2. Duct/plenum dispersion system.

L. Accessories:

1. As directed, Humidistat or Humidity Sensor: As directed, Wall or Return duct mounted.
2. As directed, Duct or Space-mounted, high-limit humidistat or humidity sensor.
3. Airflow switch for preventing humidifier operation without airflow.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Examine roughing-in for piping systems to verify actual locations of piping connections before humidifier installation.

B. Install humidifiers with required clearance for service and maintenance. Maintain path, downstream from humidifiers, clear of obstructions as required by ASHRAE 62.1.

C. Seal all duct and plenum penetrations with flange.

D. Install humidifier assemblies in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

E. As directed, Install galvanized or stainless-steel drain pan under each manifold.

1. Construct drain pans with connection for drain; insulated and complying with ASHRAE 62.1.
2. Connect to condensate trap and drainage piping.
3. Extend drain pan upstream and downstream from manifold a minimum distance recommended by manufacturer but not less than required by ASHRAE 62.1.

F. Equipment Mounting:

1. Install floor-mounted humidifier pumping and air compressor component systems on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" As directed.
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

G. Install all manufacturer-furnished accessories in accordance with manufacturer's written installation instructions.

3.2 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

1. Install piping adjacent to humidifiers to allow service and maintenance.

B. Install devices and piping specialties furnished by manufacturer but not factory mounted.

3.3 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

3.4 CONTROLS CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between control devices.

C. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: As directed, Owner will engage or Engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Humidifier will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.6 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain humidifiers.

END OF SECTION 238413.19

SECTION 238413.23 - DIRECT-STEAM-INJECTION HUMIDIFIERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Direct-steam-injection distributer tube humidifiers.
2. Direct-steam-injection panel distribution manifold humidifiers.
3. Direct-steam-injection area humidifiers.
4. Condensate drain coolers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: Detail fabrication and installation of humidifiers. Include piping details, plans, elevations, sections, details of components, distributer tubes/manifolds, and attachments to other work.

1. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Detail humidifiers and adjacent equipment. Show support locations, type of support, weight on each support, required clearances, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

B. Seismic Qualification Certificates: For humidifiers, accessories, and components, from manufacturer.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with AHRI 640.

C. Seismic Performance: Direct-steam-injection humidifiers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: As directed, 1.5 or 1.0.

D. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

2.2 DIRECT-STEAM-INJECTION DISTRIBUTER TUBE HUMIDIFIERS

A. Capacities and Characteristics:

1. Humidification Rate: As directed.
2. Steam Supply Pressure: As directed.
3. Dry-Bulb Air Temperature at Discharge: As directed.
4. Wet-Bulb Air Temperature at Discharge: As directed.
5. Maximum Absorption Distance: As directed.
6. Number of Distributer Tubes: As directed.

B. Steam Distributer Tube(s): Single or multiple, steam-jacketed tubes suitable for pressurized steam applications.

C. Material: As directed, Stainless steel or Stainless steel, type 304.

D. Insulation: As directed, Uninsulated or Insulated.

E. Steam Separator: As directed, Cast iron or Stainless steel, type 304.

F. Humidifier Control Valve:

1. Actuator: As directed, Pneumatic or Electric modulating with spring return.
2. Actuator: As specified in Section 230923.11 "Control Valves."
3. Body: As directed, Bronze, Stainless steel or Stainless steel, type 304.

G. Steam Trap:

1. Material: As directed, Cast iron, Stainless steel or Stainless steel, type 304.
2. Type: Inverted-bucket or Float and thermostatic.
3. Capacity: Sized for a minimum of 3 times the maximum rated condensate flow of humidifier at 1/2-psig (3.4-kPa) differential pressure.

H. Accessories:

1. As directed, Humidistat or Humidity sensor: As directed, Wall or Return-duct mounted.
2. Duct-mounted high-limit humidistat or humidity sensor as directed.
3. As directed, Aquastat or Temperature sensor mounted on steam condensate return piping to prevent cold operation of humidifier.
4. In-Line Strainer, Y-Pattern: As directed, Stainless steel, Stainless steel, type 304 or Cast iron body with 20-mesh type 304 stainless-steel screen.
5. Airflow switch for preventing humidifier operation without airflow.
6. Humidifier Controller:

    a. Digital, with keypad and display.

2.3 DIRECT-STEAM-INJECTION PANEL DISTRIBUTION MANIFOLD HUMIDIFIERS

A. Capacities and Characteristics:

1. Humidification Rate: As directed.
2. Steam Supply Pressure: As directed.
3. Dry-Bulb Air Temperature at Discharge: As directed.
4. Wet-Bulb Air Temperature at Discharge: As directed.
5. Maximum Absorption Distance: As directed.
6. Number of Distribution Tubes: As directed.

B. Panel Distribution Manifold:

1. Pre-fabricated panel distribution manifold, steam dispersion grid assembly.
2. Designed for short absorption distance.
3. Suitable for pressurized steam applications.
4. Extending the full width and height of duct or plenum.
5. Horizontal or vertical header with multiple vertical or horizontal, nonsteam-jacketed or steam-jacketed tubes as directed, designed for dry-steam injection, within short absorption distance.
6. Nozzles/metered orifices in conjunction with nonsteam-jacketed manifolds or punched orifices/nozzles in conjunction with steam-jacketed manifolds spaced evenly along manifold tubes and providing dry and uniform steam distribution.
7. Headers and Distribution Tubes:

    a. Material: As directed, Stainless steel or Stainless steel, type 304.
    b. Insulation: As directed, Uninsulated or Insulated.

C. Steam Separator: External separator, or separator/baffles integral to header, to provide condensate-free steam to the distribution tubes.

1. Material: As directed, Stainless steel or Stainless steel, type 304.

D. Humidifier Control Valve:

1. Actuator: As directed, Pneumatic or Electric modulating with spring return.
2. Actuator: As specified in Section 230923.11 "Control Valves."
3. Body: As directed, Bronze, Stainless steel or Stainless steel, type 304.

E. Steam Trap:

1. Material: As directed, Cast iron, Stainless steel or Stainless steel, type 304.
2. Type: As directed, Inverted-bucket or Float and thermostatic
3. Capacity: Sized for a minimum of 3 times the maximum rated condensate flow of humidifier at 1/2-psig (3.4-kPa) differential pressure.

F. Accessories:

1. As directed, Humidistat or Humidity Sensor: As directed, Wall or Return-duct mounted.
2. Duct-mounted, high-limit humidistat or humidity sensor as directed.
3. As directed, Aquastat or Temperature sensor mounted on steam condensate return piping to prevent cold operation of humidifier.
4. In-Line Strainer, Y-Pattern: As directed, Stainless steel, Stainless steel, type 304 or Cast iron body with 20-mesh stainless steel or stainless steel, type 304 screen.
5. Airflow switch for preventing humidifier operation without airflow.
6. Humidifier Controller:

    a. Digital, with keypad and display.

2.4 DIRECT-STEAM-INJECTION AREA HUMIDIFIERS

A. Capacities and Characteristics:

1. Humidification Rate: As directed.
2. Steam Supply Pressure: As directed.
3. Dry-Bulb Air Temperature at Discharge: As directed.
4. Wet-Bulb Air Temperature at Discharge: As directed.
5. Maximum Absorption Distance: As directed.
6. Dispersion Fan:

    a. Airflow: As directed.
    b. Motor Horsepower: As directed.

7. Electrical Characteristics: Single point of connection.

    a. Volts: As directed.
    b. Phase: As directed, Single or Three phase.
    c. Hertz: 60 Hz.
    d. Full-Load Amperes: As directed.
    e. Minimum Circuit Ampacity: As directed.
    f. Maximum Overcurrent Protection: As directed.

B. Discharge Nozzle and Dispersion Fan:

1. Steam-jacketed discharge nozzle, aluminum blade propeller fan with finger guard, and motor interlocked to operate with humidifier.
2. Fan Mounting: Above and behind discharge outlet on bracket integral to discharge outlet.
3. Steam Separator: External separator, or separator/baffles integral to the nozzle assembly, to provide condensate-free steam to the discharge nozzle.
4. Dispersion Nozzle Material: As directed, Stainless steel or type 304.

C. Humidifier Control Valve:

1. Actuator: As directed, Pneumatic or Electric modulating with spring return.
2. Actuator: As specified in Section 230923.11 "Control Valves."
3. Body: As directed, Bronze, Stainless steel or Stainless steel, type 304.

D. Accessories:

1. As directed, Humidistat or Humidity Sensor: Wall mounted.
2. In-Line Strainer, Y-Pattern: As directed, Stainless steel, Stainless steel, type 304 or Cast iron body with 20-mesh stainless steel or stainless steel, type 304 screen.
3. Humidifier Controller:

    a. Digital, with keypad and display.

2.5 CONDENSATE DRAIN COOLERS

A. Capacities and Characteristics:

1. Hot Condensate in: As directed.
2. Hot Condensate Temperature: As directed.
3. Cold Water in as directed.
4. Cold Water Temperature: As directed.
5. Tempered Water out as directed.
6. Tempered Water Temperature: as directed.

B. Description: Mixes hot condensate with a cold water supply to reduce the drain temperature, as required by state and local codes.

C. Cold Water Tempering Valve: As directed, Bronze body, thermostatic self-actuated with aquastat or 24 V ac electric actuated with temperature sensor.

D. Drain Temperature Set Point Range: Field adjustable between 115 deg F (46 deg C) and 140 deg F (60 deg C).

E. Reservoir Body Material: As directed, Stainless steel, Stainless steel, type 304 or Cast iron or carbon steel.

F. Mounting: As directed, Suitable for wall, floor or suspended mounting.

G. Vacuum breaker or air vent connection.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for piping systems to verify actual locations of piping connections before humidifier installation.

3.2 INSTALLATION

A. Install humidifiers with required clearance for service and maintenance. Maintain path, downstream from humidifiers, clear of obstructions as required by ASHRAE 62.1.

B. Seal all penetrations of duct or plenum with flange.

C. Install humidifier assemblies in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

D. As directed, Install galvanized or stainless-steel drain pan under each manifold mounted in duct.

1. Construct drain pans with connection for drain; insulated and complying with ASHRAE 62.1.
2. Connect to condensate trap and drainage piping.
3. Extend drain pan upstream and downstream from humidifier tube(s)/manifold a minimum distance recommended by manufacturer but not less than that required by ASHRAE 62.1.

E. Install drip leg upstream from steam trap a minimum of 12 inches (300 mm) tall for proper operation of trap.

F. Equipment Mounting:

1. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

G. Install all manufacturer-furnished accessories in accordance with manufacturer's written installation instructions.

3.3 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

1. Install piping adjacent to humidifiers to allow service and maintenance.
2. Where condensate drain cooler is used, install shutoff valve, strainer, backflow preventer, and union in tempering water makeup piping.

B. Install piping specialties furnished by manufacturer but not factory mounted.

3.4 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

3.5 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between humidity sensors, high-limit humidity sensors, condensate temperature sensors and DDC control system.

C. Connect control wiring between humidistats, thermostats, and control devices.

D. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.6 FIELD QUALITY CONTROL

A. Testing Agency: As directed, owner will engage or Engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Humidifier will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.7 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain humidifiers.

END OF SECTION 238413.23

SECTION 238413.29 - SELF-CONTAINED STEAM HUMIDIFIERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Self-contained electric-resistance humidifiers.
2. Self-contained electrode humidifiers.
3. Condensate drain coolers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: Detail fabrication and installation of humidifiers. Include piping details, plans, elevations, sections, details of components, distributer tubes/manifolds, and attachments to other work.

1. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Detail humidifiers and adjacent equipment. Show support locations, type of support, weight on each support, required clearances, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

B. Seismic Qualification Data: Certificates, for humidifiers, accessories, and components from manufacturer.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An NRTL.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with AHRI 640.

C. Comply with UL 998.

D. Listed and labeled by CE, ETL, CSA, or as complying with applicable AGA/CGA standards.

E. Listed and labeled by ETL.

F. Seismic Performance: Self-contained steam humidifiers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: As directed, 1.5 or 1.0.

G. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

2.2 SELF-CONTAINED ELECTRIC-RESISTANCE HUMIDIFIERS

A. Capacities and Characteristics:

1. Humidification Rate: As directed.
2. Dry-Bulb Air Temperature at Discharge: As directed.
3. Wet-Bulb Air Temperature at Discharge: As directed.
4. Maximum Absorption Distance: As directed.
5. Minimum Makeup Water Supply Pressure: As directed.
6. Electric-Resistance Evaporation Chamber:

    a. Power Input per Chamber: kW.
    b. Number of Chambers: As directed.

7. Steam Distribution Method - Atmospheric Distributer Tube:

    a. Number of Distributer Tubes: As directed.

8. Steam Distribution Method - Atmospheric Panel Distribution Manifold:

    a. Number of Distribution Manifolds: As directed.

9. Steam Distribution Method - Area Dispersion:

    a. Number of Distributer Tubes: As directed.
    b. Fan Airflow: As directed.
    c. Fan Motor Horsepower: As directed.
    d. Fan Electrical Characteristics:

        1) Volts: As directed.
        2) Phase: As directed, Single or Three phase.
        3) Hertz: 60 Hz.
        4) Full-Load Amperes: As directed.
        5) Minimum Circuit Ampacity: As directed.
        6) Maximum Overcurrent Protection: As directed.

B. Water Type: As directed, Suitable for use with tap or softened water.

C. Immersion Heating:

1. Evaporation Chamber: Cleanable, stainless steel or stainless steel, type 304.
2. Elements: Incoloy-sheathed, stainless-steel sheathed, or alloy-sheathed aluminum.

D. Cabinet:

1. As directed, Stainless-steel or painted-steel enclosure, factory-insulated for safe operating surface temperature, for housing heater cylinder, electrical wiring, components, controls, and control panel.
2. Hinged or removable cover, keyed to restrict unauthorized access.
3. Plumbing and electrical components housed in separate parts of the cabinet.
4. Threaded outlet in bottom of cabinet for drain piping.

E. Weatherproof Outdoor Enclosure: Insulated, with automatically controlled heating and ventilating system to maintain minimum operating conditions within the enclosure.

F. Control Panel:

1. As directed, Microprocessor-based control system for modulating or cycling control.
2. Factory-wired disconnect switch.
3. Liquid-crystal display.
4. Programmable keypad.
5. Low-voltage control circuit, with fused transformer.
6. Diagnostic, maintenance, alarm, and status features.
7. Safety switch interlocked to shut off heaters when cabinet is open.
8. Internal electrical controls prewired to appropriately marked terminals for field connection.
9. Electrical terminals for connection to each controlling device and alarm.
10. NEMA 250, type 3R, type 4, type 4X or type 12, to comply with environmental conditions at installed locations.
11. Material: As directed, Galvanized, Powder-coated or Stainless steel.

G. Controls:

1. Solenoid Fill Valve Maintains Water Level: As directed, Stainless steel or Bronze, including fill tee with built-in air gap to prevent back siphoning. Include stainless-steel or bronze inlet strainer.
2. As directed, Field-adjustable timer or conductivity controller to control drain cycle for flush duration and interval.
3. Controls shall drain tanks if no demand for humidification for more than 72 hours.
4. Set-point adjustment.
5. Tri-conductivity sensor probes for water-level control.
6. Low-water switch shuts down heater to protect elements.
7. Over-temperature switch shuts down heater.
8. Aquastat maintains minimum water temperature in tank during short periods of no demand.

H. Area Dispersion Accessory: Stainless-steel tube, with integral fan that discharges vapor directly into occupied space. As directed, Designed for remote mounting or integral mounting onto humidifier cabinet.

I. Atmospheric Steam Distributer Tube(s): Single or multiple, atmospheric steam distributer tube extending across entire width of duct or plenum and equipped with mounting brackets on ends. Nozzles/metered orifices are spaced evenly along distributer tubes and provide dry and uniform steam distribution.

1. Material: As directed, Stainless steel or Stainless steel, type 304.
2. Insulation: As directed, Uninsulated or Insulated.

J. Atmospheric Steam Panel Distribution Manifold:

1. Prefabricated steam dispersion grid assembly.
2. Designed for short absorption distance.
3. Suitable for atmospheric steam applications.
4. Extending the full width and height of duct or plenum.
5. Horizontal or Vertical header with multiple vertical or horizontal tubes designed for dry steam injection within short absorption distance.
6. Nozzles/metered orifices, spaced evenly along distribution tubes, provide dry and uniform steam distribution.
7. Distribution panel extending the full width and height of duct or plenum.
8. Headers and Distribution Tubes:

    a. Material: As directed, Stainless steel or Stainless steel, type 304.
    b. Insulation: As directed, Uninsulated or Insulated.

9. Steam Separator: Separators/baffles, integral to the header, provide condensate-free steam to distribution tubes.

K. Accessories:

1. As directed, Humidistat or Humidity Sensor: As directed, Wall or Return-duct mounted.
2. As directed, Duct-mounted, high-limit humidistat or humidity sensor.
3. Airflow switch prevents humidifier operation without airflow.
4. Steam and Condensate Hoses: For interconnection of humidifier to distributer tube(s)/manifold.

2.3 SELF-CONTAINED ELECTRODE HUMIDIFIERS

A. Capacities and Characteristics:

1. Humidification Rate: As directed.
2. Dry-Bulb Air Temperature at Discharge: As directed.
3. Wet-Bulb Air Temperature at Discharge: As directed.
4. Maximum Absorption Distance: As directed.
5. Minimum Makeup Water Supply Pressure: As directed.
6. Electrode Cylinder:

    a. Power Input Cylinder: As directed, kW.
    b. Number of Cylinders: As directed.

7. Steam Distribution Method - Atmospheric Distributer Tube:

    a. Number of Distributer Tubes: As directed.

8. Steam Distribution Method - Atmospheric Panel Distribution Manifold:

    a. Number of Distribution Manifolds: As directed.

9. Steam Distribution Method - Area Dispersion:

    a. Number of Distributer Tubes: As directed.
    b. Fan Airflow: As directed.
    c. Fan Motor Horsepower: As directed.
    d. Fan Electrical Characteristics:

        1) Volts: As directed.
        2) Phase: As directed, Single or Three phase.
        3) Hertz: 60 Hz.
        4) Full-Load Amperes: As directed.
        5) Minimum Circuit Ampacity: As directed.
        6) Maximum Overcurrent Protection: As directed.

B. Water Type: Suitable for use with tap water.

C. Cylinders: Replaceable or Cleanable plastic humidifier water reservoir, steel electrode assembly, suitable for use with tap water.

D. Cabinet:

1. Baked-enamel, Powder-coated-steel, or stainless-steel enclosure houses heater cylinder, electrical wiring, components, controls, and control panel. Cabinet is factory insulated for safe operating surface temperature.
2. Hinged or removable cover, keyed to restrict unauthorized access.
3. Plumbing and electrical components housed in separate compartments of the cabinet.
4. Threaded outlet in bottom of cabinet for drain piping.

E. Weatherproof Outdoor Enclosure: Insulated, with automatically controlled heating and ventilating system to maintain minimum operating conditions within the enclosure.

F. Control Panel:

1. As directed, Microprocessor-based control system for modulating or cycling control.
2. Factory-wired disconnect switch.
3. Liquid-crystal display.
4. Programmable keypad.
5. Low-voltage control circuit.
6. Diagnostic, maintenance, alarm, and status features.
7. Safety switch interlocked to shut off heaters when cabinet is open.
8. Internal electrical controls prewired to appropriately marked terminals for field connection.
9. Electrical terminals for connection to each controlling device and alarm.
10. As directed, NEMA 250, type 3R, type 4, type 4X or type 12, to comply with environmental conditions at installed locations.

G. Controls:

1. Solenoid fill valve and automatic drain valve or drain pump maintain water level. Include bronze inlet strainer, bronze solenoid fill valve with flow regulator, bronze solenoid drain valve or drain pump, and fill tee with built-in air gap to prevent back siphoning.
2. Controls shall drain tanks if no demand for humidification for more than 72 hours.
3. Set-point adjustment.
4. Electrode current shutdown upon sensing unsafe condition (e.g., drain system malfunction, fill system malfunction, or overcurrent malfunction).
5. Tri-conductivity sensor probes for water-level control.

H. Area Dispersion Accessory: Stainless-steel tube, with integral fan that discharges vapor directly into occupied space. As directed, Designed for remote mounting or integral mounting onto humidifier cabinet.

I. Atmospheric Steam Distributer Tube(s): Single or multiple, atmospheric steam distributer tube extending across entire width of duct or plenum and equipped with mounting brackets on ends. Nozzles/metered orifices are spaced evenly along distributer tubes and provide dry and uniform steam distribution.

1. Material: As directed, Stainless steel or Stainless steel, type 304.
2. Insulation: As directed, Uninsulated or Insulated.

J. Atmospheric Steam Panel Distribution Manifold:

1. Prefabricated steam dispersion grid assembly.
2. Designed for short absorption distance.
3. Suitable for atmospheric steam applications
4. Extending the full width and height of duct or plenum.
5. Horizontal or Vertical header with multiple vertical or horizontal tubes designed for dry steam injection within short absorption distance.

6. Nozzles/metered orifices, spaced evenly along distribution tubes, provide dry and uniform steam distribution.
7. Distribution panel extending the full width and height of duct or plenum.
8. Headers and Distribution Tubes:

    a. Material: As directed, Stainless steel or Stainless steel, type 304.
    b. Insulation: As directed, Uninsulated or Insulated.

9. Steam Separator: Separators/baffles, integral to the header, provide condensate-free steam to distribution tubes.

K. Accessories:

1. As directed, Humidistat or Humidity Sensor: As directed, Wall or Return-duct mounted.
2. As directed, Duct-mounted, high-limit humidistat or humidity sensor.
3. Airflow switch prevents humidifier operation without airflow.
4. Steam and Condensate Hoses: For interconnection of humidifier to distributer tube(s)/manifold.
5. Diagnostic, maintenance, alarm, and status features.

2.4 CONDENSATE DRAIN COOLERS

A. Capacities and Characteristics:

1. Hot Condensate in: As directed.
2. Hot Condensate Temperature: As directed.
3. Cold Water in as directed.
4. Cold Water Temperature: As directed.
5. Tempered Water out As directed.
6. Tempered Water Temperature: As directed.

B. Description: Mixes hot condensate with a cold water supply to reduce the drain temperature as required by state and local codes.

C. Cold Water Tempering Valve: Bronze body, thermostatic self-actuated with aquastat or 24 VAC electric-actuated with temperature sensor.

D. Drain Temperature Set-Point Range: Field adjustable between 115 deg F (46 deg C.)and 140 deg F. (60 deg C.). Drain sensor to control cold water tempering valve to limit drain discharge temperature to set point.

E. Reservoir Body Material: As directed, Stainless steel, Cast iron or carbon steel or Stainless steel, type 304.

F. Mounting: As directed, Suitable for wall, floor or suspended mounting.

G. Vacuum breaker or air vent connection.

H. Condensate drain cooler built into the humidifier cabinet and offered as the humidifier manufacturer's standard product is acceptable in lieu of a separate product by the listed manufacturers.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Examine roughing-in for piping systems to verify actual locations of piping connections before humidifier installation.

B. Install humidifiers with required clearance for service and maintenance. Maintain path, downstream from humidifiers, clear of obstructions as required by ASHRAE 62.1.

C. Seal all duct and plenum penetrations with flange.

D. Install humidifier assemblies in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

E. As directed, install galvanized or stainless-steel drain pan under each manifold mounted in duct.

1. Construct drain pans with connection for drain; insulated and complying with ASHRAE 62.1.
2. Connect to condensate trap and drainage piping.
3. Extend drain pan upstream and downstream from tube(s)/manifold a minimum distance recommended by manufacturer but not less than required by ASHRAE 62.1.

F. Install tube(s)/manifold supply piping pitched to drain condensate back to humidifier or as recommended by manufacturer.

G. Equipment Mounting:

1. Install floor-mounted humidifiers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" As directed.
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

H. Install all manufacturer-furnished accessories in accordance with manufacturer's written installation instructions.

3.2 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

1. Install piping adjacent to humidifiers to allow service and maintenance.
2. Install shutoff valve, strainer, backflow preventer, and union in humidifier makeup line.

B. Install piping specialties furnished by manufacturer but not factory mounted.

3.3 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between control devices.

C. Connect control wiring according to Section 260523 "Control Voltage Electrical Power Cables."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: As directed, Owner will engage or Engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests and inspection with the assistance of a factory-authorized service agent:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Humidifier will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.6 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain humidifiers.

END OF SECTION 238413.29

SECTION 238413.36 - HEAT EXCHANGER HUMIDIFIERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Heat-exchanger humidifiers.
2. Condensate drain coolers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: Detail fabrication and installation of humidifiers. Include piping details, plans, elevations, sections, details of components, manifolds, and attachments to other work.

1. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Detail humidifiers and adjacent equipment. Show support locations, type of support, weight on each support, required clearances, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

B. Seismic Qualification Data: Certificates, for humidifiers, accessories, and components from manufacturer.

C. Product Test Reports: For each humidifier, for tests performed by a qualified testing agency.

D. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An NRTL.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with AHRI 640.

C. Listed and labeled by an NRTL for intended location and use.

D. Listed and labeled by ETL.

E. Seismic Performance: Heat-exchanger humidifiers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: As directed, 1.5 or 1.0.

F. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

2.2 HEAT-EXCHANGER HUMIDIFIERS

A. As directed.

B. Capacities and Characteristics:

1. Humidification Rate: As directed.
2. Dry-Bulb Air Temperature at Discharge: As directed.
3. Wet-Bulb Air Temperature at Discharge: As directed.
4. Distributer Tube/Manifold Steam Supply Pressure: As directed.
5. Maximum Absorption Distance: As directed.
6. Minimum Makeup Water Supply Pressure: As directed.
7. Steam to Heat Exchanger:
    a. Supply Pressure at Control Valve Inlet: As directed.
    b. Condensing Rate: As directed.
8. Steam Distribution Method - Atmospheric Steam Distributer Tube:
    a. Number of Distributer Tubes: As directed.
9. Steam Distribution Method - Atmospheric Steam Panel Distribution Manifold:

a. Number of Distribution Manifolds: As directed.

10. Steam Distribution Method -Area Dispersion:

a. Number of Distributer Tubes: As directed.
b. Fan Airflow: As directed.
c. Fan Motor Horsepower: As directed.
d. Fan Electrical Characteristics:

1) Volts: As directed.
2) Phase: As directed, Single or Three Phase.
3) Hertz: 60 Hz.
4) Full-Load Amperes: As directed.
5) Minimum Circuit Ampacity: As directed.
6) Maximum Overcurrent Protection: As directed.

C. Water Type: As directed, Suitable for use with tap or softened water.

1. Evaporation Chamber:

a. Designed for atmospheric steam output.
b. As directed, Chamber and lid constructed of stainless steel, stainless steel, type 304, factory insulated for safe operating surface temperature.
c. Removable lid for access to clean.
d. Provide overflow and drain fittings.

2. Heat Exchanger:

a. Material: Stainless steel, Stainless steel, type 304, Copper or Nickel-plated copper.
b. Pressure: Designed for maximum incoming steam pressure of 15 psig (103 kPa).

3. Hinged or removable cover, keyed to restrict unauthorized access.
4. Weatherproof Outdoor Enclosure. Insulated and with automatically controlled heating and ventilating system to maintain minimum operating conditions within the enclosure.

D. Control Panel:

1. As directed, Shipped loose or Factory mounted.
2. As directed, Microprocessor-based control system for modulating or cycling control.
3. Liquid-crystal display.
4. Programmable keypad.
5. Low-voltage control circuit, with fused transformer.
6. Diagnostic, maintenance, alarm, and status features.
7. Key-locked access doors to prevent unauthorized access.
8. Electrical terminals for connection to each controlling device and alarm.
9. As directed, NEMA 250, type 3R, type 4, type 4X or type 12, to comply with environmental conditions at installed locations.
10. As directed, Material: Galvanized, Powder-coated or Stainless steel.

E. Controls:

1. Solenoid Fill Valve to Maintain Water Level: Bronze, including fill tee with built-in air gap to prevent back siphoning.
2. Inlet Strainer, Y-Pattern: Bronze body with 20-mesh stainless-steel screen.
3. As directed, field-adjustable timer or conductivity controller to control drain cycle for flush duration and interval.
4. Controls shall drain tanks if no demand for humidification for more than 72 hours.
5. Set-point adjustment.
6. Tri-conductivity sensor probes for water-level control and to shut down heat exchanger upon low water condition.
7. Aquastat maintains minimum water temperature in tank during short periods of no demand.

F. Area Dispersion Accessory: Stainless-steel tube, with integral fan that discharges vapor directly into occupied space. Designed for remote mounting from humidifier.

G. Atmospheric Steam Distributer Tube(s): Single or multiple, atmospheric steam distributer tube extending across entire width of duct or plenum and equipped with mounting brackets on ends. Nozzles/metered orifices are spaced evenly along distributer tubes and provide dry and uniform steam distribution.

1. Material: As directed, Stainless steel or Stainless steel, type 304.
2. Insulation: As directed, Uninsulated or Insulated.

H. Atmospheric Steam Panel Distribution Manifold:

1. Prefabricated steam dispersion grid assembly.
2. Designed for short absorption distance.
3. Suitable for atmospheric steam applications.
4. Extending the full width and height of duct or plenum.
5. Horizontal or Vertical header with multiple vertical or horizontal tubes designed for dry steam injection within short absorption distance.
6. Nozzles/metered orifices, spaced evenly along distribution tubes, provide dry and uniform steam distribution.
7. Distribution panel extending the full width and height of duct or plenum.
8. Headers and Distribution Tubes:

    a. Material: As directed, Stainless steel or Stainless steel, type 304.
    b. Insulation: As directed, Uninsulated or Insulated.

9. Steam Separator: Separators/baffles, integral to the header, to provide condensate-free steam to the distribution tubes.

I. Humidifier Control Valve:

1. Actuator: As directed, Pneumatic or Electric modulating with spring return.
2. Actuator: As specified in Section 230923.11 "Control Valves."
3. Body: As directed, Bronze, Stainless steel or Stainless steel, type 304.

J. Steam Trap:

1. Material: As directed, Cast iron, Stainless steel or Stainless steel, type 304.

2. Type: Inverted-bucket type or float and thermostatic type.
3. Sized for a minimum of 3 times the maximum rated condensate flow of humidifier at 1/2-psig (3.4-kPa) differential pressure.

K. Accessories:

1. As directed, Humidistat or Humidity Sensor: As directed, Wall or Return-duct mounted.
2. As directed, Duct-mounted, high-limit humidistat or humidity sensor.
3. In-Line Strainer, Y-Pattern: As directed, Cast-iron, Stainless-steel or Stainless-steel, type 304 body with 20-mesh type 304 stainless-steel screen.
4. Airflow switch for preventing humidifier operation without airflow.
5. Steam and Condensate Hoses: For interconnection of humidifier to distributer tube(s)/manifold.

2.3 CONDENSATE DRAIN COOLERS

A. Capacities and Characteristics:

1. Hot Condensate in: As directed.
2. Hot Condensate Temperature: As directed.
3. Cold Water in As directed.
4. Cold Water Temperature: As directed.
5. Tempered Water out As directed.
6. Tempered Water Temperature: As directed.

B. Description: Mixes hot condensate with a cold water supply to reduce the drain temperature as required by state and local codes.

C. Cold Water Tempering Valve: As directed, Bronze body, thermostatic self-actuated with aquastat or 24-VAC electric-actuated with temperature sensor.

D. Drain Temperature Set-Point Range: Field adjustable between 115 deg F (46 deg C) and 140 deg F (60 deg C). Drain sensor to control cold water tempering valve to limit drain discharge temperature to set point.

E. Reservoir Body Material: As directed, Cast iron or carbon steel, Stainless steel or stainless steel, type 304.

F. Mounting: As directed, Suitable for wall, floor or suspended mounting.

G. Vacuum breaker or air vent connection.

H. Condensate drain cooler built into the humidifier cabinet and offered as the humidifier manufacturer's standard product is acceptable in lieu of a separate product by the listed manufacturers.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Examine roughing-in for piping systems to verify actual locations of piping connections before humidifier installation.

B. Install humidifiers with required clearance for service and maintenance. Maintain path, downstream from humidifiers, clear of obstructions as required by ASHRAE 62.1.

C. Seal all penetrations of duct or plenum with flange.

D. Install humidifier assemblies in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

E. As directed, Install galvanized or stainless-steel drain pan under each manifold mounted in duct.

1. Construct drain pans with connection for drain; insulated and complying with ASHRAE 62.1.
2. Connect to condensate trap and drainage piping.
3. Extend drain pan upstream and downstream from humidifier tube(s)/manifold a minimum distance recommended by manufacturer but not less than required by ASHRAE 62.1.

F. Install drip leg upstream from steam trap a minimum of 12 inches (300 mm) tall for proper operation of trap.

G. Equipment Mounting:

1. Install floor-mounted humidifiers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" As directed.
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

H. Install all manufacturer-provided accessories in accordance with manufacturer's written installation instructions.

3.2 PIPING CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

1. Install piping adjacent to humidifiers to allow service and maintenance.
2. Install shutoff valve, strainer, backflow preventer, and union in humidifier makeup line.

B. Install piping specialties furnished by manufacturer but not factory mounted.

3.3 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install electrical devices furnished by manufacturer but not factory mounted.

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between control devices.

C. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.5 FIELD QUALITY CONTROL

A. Testing Agency: As directed, Owner will engage or Engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Humidifier will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.6 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain humidifiers.

END OF SECTION 238413.36

SECTION 238416.13 - OUTDOOR, MECHANICAL DEHUMIDIFICATION UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes packaged, factory-assembled and -tested, refrigerant-type, outdoor, mechanical dehumidification units designed for outdoor installation.

B. Related Requirements:

1. Section 237223 "Air-to-Air Energy Recovery Equipment."

1.2 ACTION SUBMITTALS

A. Product Data: For each type of outdoor, mechanical dehumidification unit.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: For each outdoor, mechanical dehumidification unit.

D. Delegated-Design Submittal: For outdoor, mechanical dehumidification units.

1. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
2. Include design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: For outdoor, mechanical dehumidification units, accessories, and components, from manufacturer.

B. Product test reports.

C. Field quality-control reports.

D. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An NRTL.

1.6 COORDINATION

A. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of outdoor, mechanical dehumidification units that fail in materials or workmanship within specified warranty period.

1. As directed, Warranty Period for Compressors: Manufacturer's standard, but not less than two or five years from date of Substantial Completion.
2. Warranty Period for Refrigerant Coils: Manufacturer's standard, but not less than five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 OUTDOOR, MECHANICAL DEHUMIDIFICATION UNIT MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Seismic Performance: Dehumidification units shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: As directed, 1.5 or 1.0.

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.

D. ASHRAE 62.1 Compliance: Section 5, "Systems and Equipment" and Section 7, "Construction and System Start-up."

E. ASHRAE 15 Compliance: "Safety Standard for Refrigeration Systems."

F. Capacities and Characteristics:

1. Airflow through Unit:

a. Supply Air: As directed.
b. Outside Air: As directed.
c. Exhaust/Return Air: As directed.

2. Supply Fan:

a. Speed: rpm As directed.
b. External Static Pressure: As directed.
c. Motor Size: hp As directed.

3. As directed, Exhaust or Return Fan:

a. External Static Pressure: As directed.
b. Speed: rpm As directed.
c. Motor Size: hp As directed.

4. Refrigeration System:

a. Sensible Heat-Transfer Rate: As directed.
b. Total Heat-Transfer Rate: As directed.
c. Energy-Efficiency Ratio: As directed.
d. Dehumidification Capacity: As directed.
e. Evaporator Coil Conditions:

1) Entering-Air, Dry-Bulb Temperature:.
2) Entering-Air, Wet-Bulb Temperature: As directed.
3) Entering-Air, Dew-Point Temperature: As directed.
4) Leaving-Air, Dry-Bulb Temperature: As directed.
5) Leaving-Air, Wet-Bulb Temperature: As directed.
6) Leaving-Air, Dew-Point Temperature: As directed.

5. Energy Recovery Heat Exchanger (Pool Heater):

a. Water Flow Rate: As directed.
b. Water Pressure Loss: As directed.
c. Entering-Water Temperature: As directed.
d. Leaving-Water Temperature: As directed.

6. Filters:

a. Thickness or Depth: As directed.

7. Hydronic Heating Coil:

a. Heat-Transfer Rate: As directed.
b. Entering-Air Temperature: As directed.
c. Leaving-Air Temperature: As directed.
d. Water:

1) Water Flow: As directed.
2) Maximum Water Pressure Drop: As directed.

3) Entering-Water Temperature: As directed.
4) Leaving-Water Temperature: As directed.

8. Electric Heating Coil:

a. kW: As directed.
b. Volts: As directed, 120, 208 or 230 V ac.
c. Phase: As directed, Single or Three Ph.
d. Hertz: 60 Hz.
e. Full-Load Amperes: As directed.
f. Number of Steps: As directed.

9. Assembly Power Requirements:

a. Volts: As directed, 120, 208 or 230 V ac.
b. Phase: As directed, Single or Three phase.
c. Hertz: 60 Hz.
d. Full-Load Amperes: As directed.
e. Minimum Circuit Ampacity: As directed.
f. Maximum Overcurrent Protection: As directed.

2.3 CASINGS

A. Casing: As directed, Single or Double-wall construction with interior corrosion-resistant coating and exterior baked-enamel or powder-coated steel or aluminum, stainless-steel fasteners, knockouts for electrical and piping connections, condensate drain connection, and lifting lugs.

1. Access: Hinged access doors with neoprene compression gaskets and cam latches.
2. Insulation: Minimum 2-inch- (50-mm-) thick, glass-fiber-insulation fill or closed cell foam, with thermal breaks.
3. Fully weatherproof with cross-broken roof for drainage, rain hood or louver for outside air, and relief/exhaust air openings.
4. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. Drain Pan and Connection: Stainless steel; insulated and complying with ASHRAE 62.1.

2.4 FANS

A. Supply Fans:

1. Blades: As directed, Forward curved or Backward inclined.
2. Type: As directed, Housed or Unhoused plenum type, centrifugal.
3. Blade and Housing Material: Galvanized steel with baked-enamel or powder-coated finish.
4. Drive: As directed, Direct-driven with keyed motor shaft or Belt-driven with adjustable sheaves and self-aligning, grease-lubricated ball bearings, with extended grease fittings easily accessible inside the casing of the dehumidification unit.

B. As directed, Exhaust or Return Fans:

1. Blades: As directed, Forward curved or Backward inclined.
2. Type: As directed, Housed or Unhoused plenum type, centrifugal.
3. Blade and Housing Material: As directed, Galvanized steel with baked-enamel or powder-coated finish.
4. Drive: As directed, Direct-driven with keyed motor shaft or Belt-driven with adjustable sheaves and self-aligning, grease-lubricated ball bearings, with extended grease fittings easily accessible inside the casing of the dehumidification unit.

C. Fan Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Enclosure Type: Totally enclosed, fan cooled.

D. Variable-Frequency Motor Controller: Comply with Section 262923 "Variable-Frequency Motor Controllers."

E. Variable-Frequency Motor Controller:

1. Manufactured Units: Pulse-width modulated; constant torque and variable torque for Design A and Design B motors or inverter-duty motors As directed.
2. Output Rating: Three phase; As directed, 10 to 60 Hz, with voltage proportional to frequency throughout voltage range or 66 Hz, with torque constant as speed changes; maximum voltage equals input voltage.
3. Unit Operating Requirements:

a. Internal Adjustability:

1) Minimum Speed: 5 to 25 percent of maximum rpm.
2) Maximum Speed: 80 to 100 percent of maximum rpm.
3) Acceleration: 0.1 to 999.9 seconds.
4) Deceleration: 0.1 to 999.9 seconds.
5) Current Limit: 30 to minimum of 150 percent of maximum rating.

b. Self-Protection and Reliability Features:

1) Surge suppression.
2) Loss of input signal protection.
3) Under- and overvoltage trips.
4) Variable-frequency controller and motor-overload/overtemperature protection.
5) Critical frequency rejection.
6) Loss-of-phase protection.
7) Reverse-phase protection.
8) Motor-overtemperature fault.

c. Bidirectional autospeed search.
d. Torque boost.
e. Motor temperature compensation at slow speeds.

1) Panel-mounted operator station.
2) Historical logging information and displays.
3) Digital indicating devices.

f. Control Signal Interfaces: As directed, Electric or Pneumatic.
g. Proportional-integral-derivative control interface.
h. DDC system for HVAC Protocols for Network Communications: ASHRAE 135.

4. Line Conditioning:

a. Input line conditioning.
b. Output filtering.
c. EMI/RFI filtering.

5. Bypass Systems:

a. Bypass Mode: As directed, Manual operation only or Field-selectable automatic or manual.
b. Bypass Controller: Two-contactor style, with bypass and output isolating contactors and isolating switch.
c. Bypass Controller: Three-contactor style, with bypass and input and output isolating contactors and isolating switch.
d. Bypass Contactor Configuration: As directed, Full-voltage (across the line) or Reduced-voltage (autotransformer) type.

2.5 FILTERS

A. Pleated:

1. Thickness: As directed, 1 inch (25 mm), 2 inches (50 mm) or 4 inches (100 mm).
2. MERV Rating: As directed, MERV 6 or MERV 13, according to ASHRAE 52.2.

2.6 REFRIGERATION SYSTEM

A. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IES 90.1.

B. Refrigerant Coils with Multiple Refrigerant Circuits:

1. Tubes: Copper.
2. Fins:

a. Material: As directed, Aluminum or Copper.
b. Fin Spacing: Maximum As directed, 12, 10 or 8 fins per inch (mm).

3. Fin and Tube Joints: Mechanical bond.
4. Headers: Seamless-copper headers with brazed connections.
5. Frames: As directed, Galvanized-steel or Stainless-steel frame.
6. Coatings: As directed, None or Corrosion-resistant coating.
7. Ratings: Designed, tested, and rated according to ASHRAE 33 and AHRI 410.

8. Source Quality Control: Factory test to minimum 450-psig (3105-kPa) internal pressure and to minimum 300-psig (2070-kPa) internal pressure while underwater.

C. Compressors: Hermetic, scroll compressors with integral vibration isolators and crankcase heaters that de-energize during compressor operation; with thermal-expansion valves, filter-dryers, sight glasses, compressor service valves, and liquid- and suction-line service valves.

1. Minimum Number of Refrigerant Circuits: Two for compressor capacities of more than 7-1/2 tons (26.4 kW).
2. Refrigerant: As directed, R-134a, R-407C, R-410A or R-134a, R-407C, or R-401A.
3. Capacity Control:

    a. Hot-gas bypass valve and piping on one compressor.
    b. Cycle compressor.

4. Low-Pressure Cutout: Manual reset after three automatic-reset failures.
5. High-Pressure Cutout: Manual reset.
6. Compressor Motor Overload Protection: Manual reset.
7. Antirecycling Timing Device: Prevent compressor restart for five minutes after shutdown.
8. Defrost Cycle: Adjustable timer shuts off supply fan. Compressor cycles until suction-line temperature confirms thawed evaporator coil. Timer limits defrost time to 10 minutes.

D. Energy Recovery Heat Exchanger (Pool Heater): Cupronickel, coaxial, vented, double-wall construction for potable-water service.

2.7 INTEGRAL, AIR-COOLED CONDENSER

A. Description: Mounted on same framing skid as outdoor, mechanical dehumidification unit.

B. Casing: Steel, baked-enamel finish, with access doors or removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.

C. Refrigerant Coil:

1. Copper tube with mechanically bonded aluminum fins; with liquid subcooler.
2. Coating: As directed, None or Corrosion-resistant coating.

D. Fan: Aluminum-propeller type, directly connected to permanently lubricated motor with integral thermal-overload protection.

E. Adjustable, Low Ambient Head-Pressure Control: Designed to operate at temperatures as low as 0 deg F (minus 18 deg C) by cycling condenser fans and controlling speed of last fan of each circuit.

F. Mounting Base: Same material as unit base.

2.8 REMOTE-MOUNTED, AIR-COOLED CONDENSER UNIT

A. Casing: Steel, baked-enamel finish; with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.

B. Refrigerant Coil:

1. Copper tube with mechanically bonded aluminum fins; with liquid subcooler.
2. Coating: As directed, None or Corrosion-resistant coating.

C. Fan: Aluminum-propeller type, directly connected to permanently lubricated motor with integral thermal-overload protection.

D. Adjustable, Low Ambient Head-Pressure Control: Designed to operate at temperatures as low as 0 deg F (minus 18 deg C) by cycling condenser fans and controlling speed of last fan of each circuit.

E. Mounting Base: As directed, Polyethylene or Same material as unit base.

2.9 HEATING COILS

A. Hot-Water Coil: Continuous circuit coil.

1. Tubes: Copper.
2. Fins:

    a. Material: As directed, Aluminum or Copper.
    b. Fin Spacing: Maximum As directed, 12, 10 or 8 fins per inch (mm).

3. Fin and Tube Joints: Mechanical bond.
4. Headers: Cast iron with drain and air vent tappings.
5. Frames: Galvanized-steel channel, minimum 0.052 inch (1.3 mm).
6. Coatings: As directed, None or Corrosion-resistant coating.
7. Ratings: Designed, tested, and rated according to ASHRAE 33 and AHRI 410.

    a. Working-Pressure Ratings: 200 psig (1380 kPa), 325 deg F (163 deg C).

8. Source Quality Control: Test to 300 psig (2070 kPa).

B. Electric-Resistance Heating Coil: Comply with UL 1995.

1. Heating Element: Coiled resistance wire of 80 percent nickel and 20 percent chromium; surrounded by compacted magnesium oxide powder in tubular-steel sheath; with spiral-wound, copper-plated steel fins continuously brazed to sheath.
2. Heating Element: Open-coil resistance wire of 80 percent nickel and 20 percent chromium; supported and insulated by floating ceramic bushings recessed into casing openings; fastened to supporting brackets and mounted in galvanized-steel frame.
3. Coatings: As directed, None or Corrosion-resistant coating.
4. Overtemperature Protection: Disk-type, automatic-reset, thermal-cutout safety device; serviceable through terminal box without removing heater from unit.

5. Thermal Cutouts: Load carrying, manual reset or replaceable, and factory wired in series with each heater stage.
6. Control: Disconnecting means, overcurrent protection, and airflow proving switch.

2.10 DAMPERS

A. Outdoor-Air Dampers: As directed, Opposed-blade, galvanized-steel, aluminum or extruded-aluminum dampers with zinc-plated-steel operating rod rotating in sintered bronze or nylon bearings. Provide blade gaskets and edge seals, and mechanically fasten blades to operating rod. As directed, Size for 0 to 25 percent outdoor air, with manual or motorized operator and filter.

B. As directed, Outdoor- and Return-Air or Outdoor-, Return-, and Exhaust-Air Dampers:

1. As directed, Parallel-blade, galvanized-steel, aluminum or extruded-aluminum dampers.
2. Mechanically fastened to zinc-plated-steel operating rod in reinforced cabinet.
3. Connect operating rods with common linkage and interconnect linkages, so dampers operate simultaneously.

C. As directed, Outdoor- and Return-Air or Outdoor-, Return-, and Exhaust-Air Dampers:

1. As directed, Low-leakage, double-skin, airfoil-blade, galvanized-steel, aluminum or extruded-aluminum dampers.
2. As directed, Compressible jamb seals and extruded-vinyl blade edge seals in opposed or parallel-blade arrangement.
3. Zinc-plated-steel operating rods rotating in stainless-steel sleeve or sintered bronze or nylon bearings mounted in a single galvanized-steel, aluminum or extruded-aluminum frame As directed.
4. Operating rods connected with a common linkage.
5. Leakage rate shall not exceed 5 cfm/sq. ft. (0.22 L/s per sq. m) at 1-inch wg (250 Pa) and 9 cfm/sq. ft. (0.4 L/s per sq. m) at 4-inch wg (1.0 MPa).

D. Damper Operator: As directed, 115 or 24 V ac, close coupled, with gear train sealed in oil and with spring return.

2.11 CONTROLS

A. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC" for control equipment and in Section 230993.11 "Sequence of Operations for HVAC DDC."

B. Control Panel: Integral service compartment containing fan-motor thermal and overload cutouts, compressor thermal and overload cutouts, 115-V control transformer if required, magnetic contactors for fan and compressor motors, and a nonfused factory-mounted and -wired disconnect switch for single external electrical power connection.

C. Operating Control: Space humidistat cycles the compressor. Humidistat shall incorporate fan on-off-auto switch.

D. Operating Control: Factory-installed microprocessor controller, capable of being remotely mounted.

1. Display the following on the face of controller:

   a. System on.
   b. System dehumidifying mode.
   c. System air-conditioning mode.
   d. System outdoor-air (economizer) mode.
   e. System heating pool water.
   f. Auxiliary space heat is operating.
   g. Unit requires service.
   h. Return-air (space) temperature.
   i. Return-air (space) humidity.
   j. Pool-water temperature.
   k. Outdoor-air temperature.

2. Indicate the following sensor failures on panel:

   a. Airflow: Dirty air filter, blocked airflow, and fan failure.
   b. Refrigerant high and low pressure.
   c. High water temperature.
   d. High and low evaporator temperature.
   e. Low water flow.
   f. Communication fault.
   g. System off.
   h. Antishort cycle delay.
   i. Power failure.

3. Provide access to the following set points on panel:

   a. Space temperature.
   b. Space relative humidity.
   c. Outdoor ventilation/air-conditioning changeover temperature.
   d. Airflow alarm.

4. Provide the following displays on panel:

   a. Space temperature.
   b. Space relative humidity.
   c. Outdoor-air temperature.
   d. Supply-air temperature.
   e. Return-air temperature.
   f. Airflow rating.
   g. Air-off evaporator temperature.
   h. Return-air relative humidity.
   i. Service codes.

5. Provide the following controls on panel:

   a. System on-off, fan continues to run.

b. Fan on-off.
c. Service code access.
d. System dehumidifying mode.
e. System air-conditioning mode.
f. System outdoor-air (economizer) mode.
g. Auxiliary space heat is operating.
h. Outdoor-air-temperature, conditioned-space-temperature, and control set-point-temperature digital display.
i. Outdoor enthalpy digital display.
j. Filter pressure drop digital display.
k. Status: Airflow, fans, system, unit operation, and operating mode.
l. Alarm digital display.

2.12 ACCESSORIES

A. Water-Cooling Heat Exchanger: Coaxial, vented, double-wall construction; with three-way refrigerant control valve.

B. Smoke Detectors: Photoelectric detector located in return-air plenum, to de-energize unit.

1. Operating Voltage: 24 V dc, nominal.
2. Self-Restoring: Detectors do not require resetting or readjusting after actuation to restore them to normal operation.
3. Plug-in Arrangement: Detector and associated electronic components mounted in module with tamper-resistant connection to fixed base with twist-locking plug. Terminals in fixed base accept building wiring.
4. Integral Visual-Indicating Light: Digital-display type indicating detector operation.
5. Sensitivity can be tested and adjusted in place after installation.
6. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the fire-alarm control panel.
7. Sensor: Digital display or infrared light source with matching silicon-cell receiver.
8. Detector Sensitivity: Between 2.5 and 3.5 percent/foot (0.008 and 0.011 percent/mm) of smoke obscuration when tested according to UL 268A.
9. Integral Thermal Detector: Fixed-temperature type with 135 deg F (57 deg C) setting.

C. Electrical Convenience Outlet: 125 V ac, duplex, straight-blade receptacles, separately fused and located inside control panel.

2.13 ROOF CURBS

A. Roof Curbs: Vibration isolation and wind or seismic restraint roof curbs are specified in Section 230548 "Vibration and Seismic Controls for HVAC."

B. Roof Curbs: Vibration isolation with no wind or seismic restraint roof curbs are specified in Section 230548.13 "Vibration Controls for HVAC."

C. Roof Curbs:

1. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.
2. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.

    a. Materials: ASTM C1071, Type I or II.
    b. Thickness: As directed, 1 inch (25 mm), 1-1/2 inches (38 mm) or 2 inches (50 mm).
    c. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
    d. Liner Adhesive: Comply with ASTM C916, Type I.
    e. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
    f. Liner materials applied in this location shall have airstream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric, depending on service-air velocity.
    g. Provide sheet metal liner to separate insulation from contact with the airstream.

D. Curb Height: As directed, 14 inches (355 mm), 24 inches (610 mm) or 36 inches (910 mm).

E. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match dehumidification unit; used to anchor unit to the curb and designed for loads at Project site. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for wind-load requirements.

2.14 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for sheet steel.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A240/240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

D. Aluminum: ASTM B209.

E. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding a 3,000-hour salt-spray test according to ASTM B117.

1. Standards:

    a. ASTM B117 for salt spray.
    b. ASTM D2794 for minimum impact resistance of 100 in/lb (11.3 N/m).

c. ASTM B3359 for cross hatch adhesion of 5B.

2. Application: As directed, Immersion or Spray.
3. Thickness: 1 mil (0.025 mm).
4. Gloss: Minimum gloss of 60 on a 60-degree meter.

2.15 SOURCE QUALITY CONTROL

A. Verification of Performance: Factory test and rate dehumidification units according to AHRI 910.

B. Sound-Power-Level Ratings: Factory test and rate dehumidification units according to AHRI 575.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. As directed, examine roughing-in for hot-water or refrigerant piping systems to verify actual locations of piping connections before equipment installation.

3.2 INSTALLATION

A. Equipment Mounting:

1. Install dehumidification units on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" As directed
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

3.3 PIPING CONNECTIONS

A. Where piping is installed adjacent to dehumidification units, allow space for service and maintenance of dehumidification units.

B. Connect piping to dehumidification units mounted on vibration isolators with flexible connectors.

C. Connect condensate drain pans using minimum NPS 1-1/4 (DN 32) copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanout at changes in direction.

D. Refrigerant Piping: Comply with requirements in Section 232300 "Refrigerant Piping." Connect to supply and return coil tappings with shutoff valve and union or flange at each connection.

E. Hot-Water Piping: Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties." Connect to supply coil tappings with shutoff valve, return coil tappings with balancing valve, and union or flange at each connection.

F. Duct installation requirements are specified in Section 233113 "Metal Ducts" or Section 233116" Nonmetal Ducts. Section 233113 "Metal Ducts" and Section 233116 "Nonmetal Ducts" As directed, Drawings indicate the general arrangement of ducts. The following are specific connection requirements:

1. Install ducts to termination in roof-mounted frames. Where indicated, terminate return-air duct through roof structure, and insulate the space between roof and bottom of dehumidification unit.

3.4 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.
3. Locate nameplate where easily visible.

3.5 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between control devices.

C. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

D. Connect smoke detector to fire alarm system.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative.

1. Leak Test: After installation, fill water coils with water, and test coils and connections for leaks. Repair leaks and retest until no leaks exist.
2. Charge refrigerant coils with refrigerant and test for leaks. Repair leaks and retest until no leaks exist.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Dehumidification unit will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.7 CLEANING

A. Clean dehumidification units internally, on completion of installation, according to manufacturer's written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils' entering-air face.

B. After completing system installation, testing, and startup service of dehumidification units, clean filter housings and install new filters.

3.8 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust initial temperature and humidity set points.

3.9 STARTUP SERVICE

A. As directed, Engage a factory-authorized service representative to perform or Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

B. Perform the following final checks before startup:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Perform cleaning and adjusting specified in this Section.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify free fan wheel rotation and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.

5. Check lubrication of bearings, pulleys, belts, and other moving parts.
6. Set outside- and return-air mixing dampers to minimum outside-air setting.
7. Install clean filters.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

C. Starting procedures for dehumidification units include the following:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace malfunctioning motors, bearings, and fan wheels.
2. Measure and record motor's electrical values for voltage and amperage.
3. Manually operate dampers from fully closed to fully open position and record fan performance.

D. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing of dehumidification unit.

E. Startup Report: Report findings during startup. Identify startup steps, corrective measures taken, and final results.

3.10 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain dehumidification units.

END OF SECTION 238416.13

SECTION 238416.16 - INDOOR, MECHANICAL DEHUMIDIFICATION UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes packaged, factory-assembled and -tested, refrigerant-type, indoor, mechanical dehumidification units designed for indoor installation.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of indoor, mechanical dehumidification unit.

B. Sustainable Design Submittals:

C. Shop Drawings: For each indoor, mechanical dehumidification unit.

D. Delegated-Design Submittal: For indoor, mechanical dehumidification units.

1. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
2. Include design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates for indoor, mechanical dehumidification units, accessories, and components, from manufacturer.

B. Product test reports.

C. Field quality-control reports.

D. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An NRTL.

1.6 COORDINATION

A. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of indoor, mechanical dehumidification units that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: As directed, Manufacturer's standard, but not less than two or five years from date of Substantial Completion.
2. Warranty Period for Refrigerant Coils: Manufacturer's standard, but not less than five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 INDOOR, MECHANICAL DEHUMIDIFICATION UNIT MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Seismic Performance: Dehumidification units shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: As directed, 1.5 or 1.0.

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.

D. ASHRAE 62.1 Compliance: Section 5, "Systems and Equipment" and Section 7, "Construction and System Start-up."

E. ASHRAE 15 Compliance: "Safety Standard for Refrigeration Systems."

F. Capacities and Characteristics:

1. Airflow through Unit:

a. Supply Air: As directed.
b. Outside Air: As directed.
c. Exhaust/Return Air: As directed.

2. Supply Fan:

    a. Speed: As directed, rpm.
    b. External Static Pressure: As directed.
    c. Motor Size: As directed, hp.

3. As directed, Exhaust or Return Fan:

    a. External Static Pressure: As directed.
    b. Speed: As directed, rpm.
    c. Motor Size: As directed, hp.

4. Refrigeration System:

    a. Sensible Heat-Transfer Rate: As directed.
    b. Total Heat-Transfer Rate: As directed.
    c. Energy-Efficiency Ratio: As directed.
    d. Dehumidification Capacity: As directed.
    e. Evaporator Coil Conditions:

        1) Entering-Air, Dry-Bulb Temperature: As directed.
        2) Entering-Air, Wet-Bulb Temperature: As directed.
        3) Entering-Air, Dew-Point Temperature: As directed.
        4) Leaving-Air, Dry-Bulb Temperature: As directed.
        5) Leaving-Air, Wet-Bulb Temperature: As directed.
        6) Leaving-Air, Dew-Point Temperature: As directed.

5. Energy Recovery Heat Exchanger (Pool Heater):

    a. Water Flow Rate: As directed.
    b. Water Pressure Loss: As directed.
    c. Entering-Water Temperature: As directed.
    d. Leaving-Water Temperature: As directed.

6. Filters:

    a. Thickness or Depth: As directed.

7. Hydronic Heating Coil:

    a. Heat-Transfer Rate: As directed.
    b. Entering-Air Temperature: As directed.
    c. Leaving-Air Temperature: As directed.
    d. Water:

        1) Water Flow: As directed.
        2) Maximum Water Pressure Drop: As directed.
        3) Entering-Water Temperature: As directed.
        4) Leaving-Water Temperature: As directed.

8. Electric Heating Coil:

a. kW: As directed, kW.
b. Volts: As directed, 120, 208 or 230 V ac.
c. Phase: As directed, Single or Three Ph.
d. Hertz: 60 Hz.
e. Full-Load Amperes: As directed.
f. Number of Steps: As directed.

9. Electrical Characteristics:

a. Volts: As directed, 120, 208 or 230 V ac.
b. Phase: As directed, Single or Three phase.
c. Hertz: 60 Hz.
d. Full-Load Amperes: As directed.
e. Minimum Circuit Ampacity: As directed.
f. Maximum Overcurrent Protection: As directed.

2.3 CASINGS

A. Casing: As directed, Single or Double-wall construction with interior corrosion-resistant coating and exterior baked-enamel or powder-coated steel or aluminum, stainless-steel fasteners, knockouts for electrical and piping connections, condensate drain connection, and lifting lugs.

1. Access: As directed, Removable panels or Hinged access doors with neoprene compression gaskets and cam latches.
2. Insulation: Minimum 2-inch- (50-mm-) thick, glass-fiber-insulation fill or closed cell foam, with thermal breaks.
3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

B. Drain Pan and Connection: Stainless steel; insulated and complying with ASHRAE 62.1.

2.4 FANS

A. Supply Fans:

1. Blades: As directed, Forward curved or Backward inclined.
2. Type: As directed, Housed or Unhoused plenum type, centrifugal.
3. Blade and Housing Material: V Galvanized steel with baked-enamel or powder-coated finish.
4. Drive: As directed, Direct-driven with keyed motor shaft or Belt-driven with adjustable sheaves and self-aligning, grease-lubricated ball bearings, with extended grease fittings easily accessible inside the casing of the dehumidification unit.

B. As directed, Exhaust or Return Fans:

1. Blades: As directed, Forward curved or Backward inclined.
2. Type: As directed, Housed or Unhoused plenum type, centrifugal.
3. Blade and Housing Material: As directed, Galvanized steel with baked-enamel or powder-coated finish.

4. Drive: Direct-driven with keyed motor shaft or Belt-driven with adjustable sheaves and self-aligning, grease-lubricated ball bearings, with extended grease fittings easily accessible inside the casing of the dehumidification unit.

C. Fan Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Enclosure Type: Totally enclosed, fan cooled.

D. Variable-Frequency Motor Controller: Comply with Section 262923 "Variable-Frequency Motor Controllers."

E. Variable-Frequency Motor Controller:

1. Manufactured Units: Pulse-width modulated; constant torque and variable torque for Design A and Design B motors or inverter-duty motors.
2. Output Rating: Three phase; As directed, 10 to 60 Hz, with voltage proportional to frequency throughout voltage range or 66 Hz, with torque constant as speed changes; maximum voltage equals input voltage.
3. Unit Operating Requirements:

a. Internal Adjustability:

1) Minimum Speed: 5 to 25 percent of maximum rpm.
2) Maximum Speed: 80 to 100 percent of maximum rpm.
3) Acceleration: 0.1 to 999.9 seconds.
4) Deceleration: 0.1 to 999.9 seconds.
5) Current Limit: 30 to minimum of 150 percent of maximum rating.

b. Self-Protection and Reliability Features:

1) Surge suppression.
2) Loss of input signal protection.
3) Under- and overvoltage trips.
4) Variable-frequency controller and motor-overload/overtemperature protection.
5) Critical frequency rejection.
6) Loss-of-phase protection.
7) Reverse-phase protection.
8) Motor-overtemperature fault.

c. Bidirectional autospeed search.
d. Torque boost.
e. Motor temperature compensation at slow speeds.

1) Panel-mounted operator station.
2) Historical logging information and displays.
3) Digital indicating devices.

f. Control Signal Interfaces: As directed, Electric or Pneumatic.

g. Proportional-integral-derivative control interface.
h. DDC system for HVAC Protocols for Network Communications: ASHRAE 135.

4. Line Conditioning:

a. Input line conditioning.
b. Output filtering.
c. EMI/RFI filtering.

5. Bypass Systems:

a. Bypass Mode: As directed, Manual operation only or Field-selectable automatic or manual.
b. Bypass Controller: Two-contactor style, with bypass and output isolating contactors and isolating switch.
c. Bypass Controller: Three-contactor style, with bypass and input and output isolating contactors and isolating switch.
d. Bypass Contactor Configuration: As directed, Full-voltage (across the line) or Reduced-voltage (autotransformer) type.

2.5 FILTERS

A. Pleated:

1. Thickness: As directed, 1 inch (25 mm), 2 inches (50 mm), 4 inches (100 mm) or Manufacturer's standard depth.
2. MERV Rating: As directed, MERV 6 or MERV 13, according to ASHRAE 52.2.

2.6 REFRIGERATION SYSTEM

A. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IES 90.1.

B. Refrigerant Coils with Multiple Refrigerant Circuits:

1. Tubes: Copper.
2. Fins:

a. Material: As directed, Aluminum or Copper.
b. Fin Spacing: Maximum As directed, 12, 10 or 8 fins per inch (mm).

3. Fin and Tube Joints: Mechanical bond.
4. Headers: Seamless-copper headers with brazed connections.
5. Frames: As directed, Galvanized-steel or Stainless-steel frame.
6. Coatings: As directed, None or Corrosion-resistant coating.
7. Ratings: Designed, tested, and rated according to ASHRAE 33 and AHRI 410.
8. Source Quality Control: Factory test to minimum 450-psig (3105-kPa) internal pressure and to minimum 300-psig (2070-kPa) internal pressure while underwater.

C. Compressors: Hermetic, scroll compressors with integral vibration isolators and crankcase heaters that de-energize during compressor operation; with thermal-expansion valves, filter-dryers, sight glasses, compressor service valves, and liquid- and suction-line service valves.

1. Minimum Number of Refrigerant Circuits: Two for compressor capacities of more than 7-1/2 tons (26.4 kW).
2. Refrigerant: As directed, R-134a, R-407C, R-410A or R-134a, R-407C, or R-401A.
3. Capacity Control:

    a. Hot-gas bypass valve and piping on one compressor.
    b. Cycle compressor.

4. Low-Pressure Cutout: Manual reset after three automatic-reset failures.
5. High-Pressure Cutout: Manual reset.
6. Compressor Motor Overload Protection: Manual reset.
7. Antirecycling Timing Device: Prevent compressor restart for five minutes after shutdown.
8. Defrost Cycle: Adjustable timer shuts off supply fan. Compressor cycles until suction-line temperature confirms thawed evaporator coil. Timer limits defrost time to 10 minutes.

D. Energy Recovery Heat Exchanger (Pool Heater): Cupronickel, coaxial, vented, double-wall construction for potable-water service.

2.7 REMOTE-MOUNTED, AIR-COOLED CONDENSER UNIT

A. Casing: Steel, baked-enamel finish; with access doors or removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.

B. Refrigerant Coil:

1. Copper tube with mechanically bonded aluminum fins; with liquid subcooler.
2. Coating: As directed, None or corrosion-resistant coating.

C. Fan: Aluminum-propeller type, directly connected to permanently lubricated motor with integral thermal-overload protection.

D. Adjustable, Low Ambient Head-Pressure Control: Designed to operate at temperatures as low as 0 deg F (minus 18 deg C) by cycling condenser fans and controlling speed of last fan of each circuit.

E. Mounting Base: Same material as unit base.

2.8 HEATING COILS

A. Hot-Water Coil: Continuous circuit coil.

1. Tubes: Copper.

2. Fins:

   a. Material: As directed, Aluminum or Copper.
   b. Fin Spacing: Maximum As directed, 12, 10 or 8 fins per inch (mm).

3. Fin and Tube Joints: Mechanical bond.
4. Headers: Cast iron with drain and air vent tappings.
5. Frames: Galvanized-steel channel, minimum 0.052 inch (1.3 mm).
6. Coatings: As directed, None or Corrosion-resistant coating.
7. Ratings: Designed, tested, and rated according to ASHRAE 33 and AHRI 410.

   a. Working-Pressure Ratings: Minimum 200 psig (1380 kPa), 325 deg F (163 deg C).

8. Source Quality Control: Test to minimum 300 psig (2070 kPa) internal pressure.

B. Electric-Resistance Heating Coil: Comply with UL 1995.

1. Heating Element: Coiled resistance wire of 80 percent nickel and 20 percent chromium; surrounded by compacted magnesium oxide powder in tubular-steel sheath; with spiral-wound, copper-plated steel fins continuously brazed to sheath.
2. Heating Element: Open-coil resistance wire of 80 percent nickel and 20 percent chromium; supported and insulated by floating ceramic bushings recessed into casing openings; fastened to supporting brackets and mounted in galvanized-steel frame.
3. Coatings: As directed, None or Corrosion-resistant coating.
4. Overtemperature Protection: Disk-type, automatic-reset, thermal-cutout safety device; serviceable through terminal box without removing heater from unit.
5. Thermal Cutouts: Load carrying, manual reset or replaceable, and factory wired in series with each heater stage.
6. Control: Disconnecting means, overcurrent protection, and airflow proving switch.

2.9 DAMPERS

A. Outdoor-Air Dampers: As directed, Opposed-blade, galvanized-steel, aluminum or extruded-aluminum dampers with zinc-plated-steel operating rod rotating in sintered bronze or nylon bearings. Provide blade gaskets and edge seals, and mechanically fasten blades to operating rod. As directed, Size for 0 to 25 percent outdoor air, with manual or motorized operator and filter.

B. As directed, Outdoor- and Return-Air or Outdoor-, Return-, and Exhaust-Air Dampers:

1. As directed, Parallel-blade, galvanized-steel, aluminum or extruded-aluminum dampers.
2. Mechanically fastened to zinc-plated-steel operating rod in reinforced cabinet.
3. Connect operating rods with common linkage and interconnect linkages, so dampers operate simultaneously.

C. As directed, Outdoor- and Return-Air or Outdoor-, Return-, and Exhaust-Air Dampers:

1. Low-leakage, double-skin, airfoil-blade, galvanized-steel, aluminum or extruded-aluminum dampers.
2. As directed, Compressible jamb seals and extruded-vinyl blade edge seals in opposed or parallel-blade arrangement.

3. As directed, Zinc-plated-steel operating rods rotating in stainless-steel sleeve or sintered bronze or nylon bearings mounted in a single galvanized-steel, aluminum or extruded-aluminum frame.
4. Operating rods connected with a common linkage.
5. Leakage rate shall not exceed 5 cfm/sq. ft. (0.22 L/s per sq. m) at 1-inch wg (250 Pa) and 9 cfm/sq. ft. (0.4 L/s per sq. m) at 4-inch wg (1.0 MPa).

D. Damper Operator: As directed, 115 or 24 V ac, close coupled, with gear train sealed in oil and with spring return.

2.10 CONTROLS

A. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC" for control equipment and in Section 230993.11 "Sequence of Operations for HVAC DDC."

B. Control Panel: Integral service compartment containing fan-motor thermal and overload cutouts, compressor thermal and overload cutouts, 115-V control transformer if required, magnetic contactors for fan and compressor motors, and a nonfused factory-mounted and -wired disconnect switch for single external electrical power connection.

C. Operating Control: Space humidistat cycles the compressor. Humidistat shall incorporate fan on-off-auto switch.

D. Operating Control: Factory-installed microprocessor controller, capable of being remotely mounted.

1. Display the following on the face of controller:

   a. System on.
   b. System dehumidifying mode.
   c. System air-conditioning mode.
   d. System outdoor-air (economizer) mode.
   e. System heating pool water.
   f. Auxiliary space heat is operating.
   g. Unit requires service.
   h. Return-air (space) temperature.
   i. Return-air (space) humidity.
   j. Pool-water temperature.
   k. Outdoor-air temperature.

2. Indicate the following sensor failures on panel:

   a. Airflow: Dirty air filter, blocked airflow, and fan failure.
   b. Refrigerant high and low pressure.
   c. High water temperature.
   d. High and low evaporator temperature.
   e. Low water flow.
   f. Communication fault.
   g. System off.

h. Antishort cycle delay.
i. Power failure.

3. Provide access to the following set points on panel:

a. Space temperature.
b. Space relative humidity.
c. Outdoor ventilation/air-conditioning changeover temperature.
d. Airflow alarm.

4. Provide the following displays on panel:

a. Space temperature.
b. Space relative humidity.
c. Outdoor-air temperature.
d. Supply-air temperature.
e. Return-air temperature.
f. Airflow rating.
g. Air-off evaporator temperature.
h. Return-air relative humidity.
i. Service codes.

5. Provide the following controls on panel:

a. System on-off, fan continues to run.
b. Fan on-off.
c. Service code access.
d. System dehumidifying mode.
e. System air-conditioning mode.
f. System outdoor-air (economizer) mode.
g. Auxiliary space heat is operating.
h. Outdoor-air-temperature, conditioned-space-temperature, and control set-point-temperature digital display.
i. Outdoor enthalpy digital display.
j. Filter pressure drop digital display.
k. Status: Airflow, fans, system, unit operation, and operating mode.
l. Alarm digital display.

2.11 ACCESSORIES

A. Water-Cooling Heat Exchanger: Coaxial, vented, double-wall construction; with three-way refrigerant control valve.

B. Smoke Detectors: Photoelectric detector located in return-air plenum, to de-energize unit.

1. Operating Voltage: 24 V dc, nominal.
2. Self-Restoring: Detectors do not require resetting or readjusting after actuation to restore them to normal operation.

3. Plug-in Arrangement: Detector and associated electronic components mounted in module with tamper-resistant connection to fixed base with twist-locking plug. Terminals in fixed base accept building wiring.
4. Integral Visual-Indicating Light: Digital-display type indicating detector operation.
5. Sensitivity can be tested and adjusted in-place after installation.
6. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the fire-alarm control panel.
7. Sensor: Digital display or infrared light source with matching silicon-cell receiver.
8. Detector Sensitivity: Between 2.5 and 3.5 percent/foot (0.008 and 0.011 percent/mm) of smoke obscuration when tested according to UL 268A.
9. Integral Thermal Detector: Fixed-temperature type with 135 deg F (57 deg C) setting.

C. Electrical Convenience Outlet: 115 V ac fused, duplex, straight-blade receptacles, separately fused and located inside control panel.

2.12 MATERIALS

A. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A240/240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

D. Aluminum: ASTM B209.

E. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding a 3,000-hour salt-spray test according to ASTM B117.

1. Standards:

a. ASTM B117 for salt spray.
b. ASTM D2794 for minimum impact resistance of 100 in/lb (11.3 N/m).
c. ASTM B3359 for cross hatch adhesion of 5B.

2. Application: As directed, Immersion or Spray.
3. Thickness: 1 mil (0.025 mm).
4. Gloss: Minimum gloss of 60 on a 60-degree meter.

2.13 SOURCE QUALITY CONTROL

A. Verification of Performance: Factory test and rate dehumidification units according to AHRI 910.

B. Sound-Power-Level Ratings: Factory test and rate dehumidification units according to AHRI 575.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. As directed, examine roughing-in for hot-water or refrigerant piping systems to verify actual locations of piping connections before equipment installation.

C. Examine walls, floors, and roofs for suitable conditions where dehumidification units will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Equipment Mounting:

1. Install dehumidification units on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" As directed.
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

3.3 PIPING CONNECTIONS

A. Where piping is installed adjacent to dehumidification units, allow space for service and maintenance of dehumidification units.

B. Connect piping to dehumidification units mounted on vibration isolators with flexible connectors.

C. Connect condensate drain pans using minimum NPS 1-1/4 (DN 32) copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan, and install cleanout at changes in direction.

D. Refrigerant Piping: Comply with requirements in Section 232300 "Refrigerant Piping." Connect to supply and return coil tappings with shutoff valve and union or flange at each connection.

E. Hot-Water Piping: Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties." Connect to supply coil tappings with shutoff valve, return coil tappings with balancing valve, and union or flange at each connection.

F. Duct installation requirements are specified in Section 233113 "Metal Ducts," Section 233113 "Nonmetal Ducts, Section 233113 "Metal Ducts" and Section 233116 "Nonmetal Ducts" As directed. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:

1. Install ducts to termination in roof-mounted frames. Where indicated, terminate return-air duct through roof structure, and insulate the space between roof and bottom of dehumidification unit.

3.4 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems".

C. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems".
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.
3. Locate nameplate where easily visible.

3.5 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between control devices.

C. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

D. Connect smoke detector to fire alarm system.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Leak Test: After installation, fill water coils with water, and test coils and connections for leaks. Repair leaks and retest until no leaks exist.

2. Charge refrigerant coils with refrigerant and test for leaks. Repair leaks and retest until no leaks exist.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Dehumidification unit will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.7 CLEANING

A. Clean dehumidification units internally, on completion of installation, according to manufacturer's written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils' entering-air face.

B. After completing system installation, testing, and startup service of dehumidification units, clean filter housings and install new filters.

3.8 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust initial temperature and humidity set points.

3.9 STARTUP SERVICE

A. As directed, engage a factory-authorized service representative to perform or Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

B. Perform the following final checks before startup:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Perform cleaning and adjusting specified in this Section.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify free fan wheel rotation and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
5. Check lubrication of bearings, pulleys, belts, and other moving parts.
6. Set outside- and return-air mixing dampers to minimum outside-air setting.
7. Install clean filters.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

C. Starting procedures for dehumidification units include the following:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace malfunctioning motors, bearings, and fan wheels.
2. Measure and record motor's electrical values for voltage and amperage.
3. Manually operate dampers from fully closed to fully open position and record fan performance.

D. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing of dehumidification unit.

E. Startup Report: Report findings during startup. Identify startup steps, corrective measures taken, and final results.

3.10 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain dehumidification units.

END OF SECTION 238416.16

SECTION 260513 - MEDIUM-VOLTAGE CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes cables and related cable splices, terminations, and accessories for medium-voltage (2001 to 35,000 V) electrical distribution systems.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of cable. Include splices and terminations for cables and cable accessories.

B. Samples: 16-inch (400-mm) lengths for each type of cable specified.

C. Sustainable Design Submittals: As directed.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with IEEE C2 and NFPA 70.

C. Source Limitations: Obtain cables and accessories from single source from single manufacturer.

2.2 CABLES

A. Cable Type: Type MV 90 or Type MV 105.

B. Conductor Insulation: Crosslinked polyethylene or Ethylene-propylene rubber.

1. Voltage Rating: 5, 8, 15, 25 or 35 kV as directed.
2. Insulation Thickness: 100 or 133 percent insulation level.

C. Conductor: Copper or Aluminum as directed.

D. Comply with UL 1072, AEIC CS8, ICEA S-93-639/NEMA WC 74, and ICEA S-97-682, and ICEA S-94-649 as directed.

E. Conductor Stranding: Compact round, concentric lay, Class B or Concentric lay, Class B.

F. Strand Filling: Conductor interstices are filled with impermeable compound.

G. Shielding: As directed, Copper tape or Solid copper wires, helically applied over semiconducting insulation shield.

H. Shielding and Jacket: Corrugated copper drain wires embedded in extruded, chlorinated, polyethylene jacket.

I. Three-Conductor Cable Assembly: Three insulated, shielded conductors cabled together with ground conductors.

J. Cable Jacket: Sunlight-resistant PVC or Chlorosulfonated polyethylene as directed.

2.3 CONNECTORS

A. Comply with ANSI C119.4 for connectors between aluminum conductors or for connections between aluminum to copper conductors.

B. Copper-Conductor Connectors: Copper barrel crimped, Aluminum barrel crimped or Copper shear bolt connectors as directed.

2.4 SOLID TERMINATIONS

A. Multiconductor Cable Sheath Seals: Type recommended by seal manufacturer for type of cable and installation conditions, including orientation.

1. Cold-shrink sheath seal kit with preformed sleeve openings sized for cable and insulated conductors.
2. Heat-shrink sheath seal kit with phase- and ground-conductor rejacketing tubes, cable-end sealing boot, and sealing plugs for unused ground-wire openings in boot.

B. Shielded-Cable Terminations: Comply with the following classes of IEEE 48. Insulation class shall be equivalent to that of cable. Include shield ground strap for shielded cable terminations.

1. Class 1 Terminations: Modular type, furnished as a kit, with stress-relief tube; multiple, molded-silicone-rubber, insulator modules; shield ground strap; and compression-type connector.
2. Class 2 Terminations, Indoors: Kit with stress-relief tube, non-tracking insulator tube, shield ground strap, and compression-type connector. Include cold-shrink-rubber sleeve moisture seal for end of insulation whether or not supplied with kits.

2.5 SEPARABLE INSULATED CONNECTORS

A. Description: Modular system with disconnecting, single-pole, cable terminators and with matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.

B. Standard: Comply with IEEE 386.

C. Terminations at Distribution Points: Modular type, consisting of terminators installed on cables and modular, dead-front, terminal junctions for interconnecting cables.

D. Load-Break Cable Terminators: Elbow-type units with 200-A-load make/break and continuous-current rating; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.

E. Dead-Break Cable Terminators: As directed, Elbow-type unit with 200 or 600-A continuous-current rating; designed for de-energized disconnecting and connecting; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.

F. Dead-Front Terminal Junctions: Modular bracket-mounted groups of dead-front stationary terminals that mate and match with above cable terminators. Two-, three-, or four-terminal units as indicated, with fully rated, insulated, watertight conductor connection between terminals and complete with grounding lug, manufacturer's standard accessory stands, stainless-steel mounting brackets, and attaching hardware.

1. Protective Cap: Insulating, electrostatic-shielding, water-sealing cap with drain wire.
2. Portable Feed-Through Accessory: Two-terminal, dead-front junction arranged for removable mounting on accessory stand of stationary terminal junction.
3. Grounding Kit: Jumpered elbows, portable feed-through accessory units, protective caps, test rods suitable for concurrently grounding three phases of feeders and carrying case.
4. Standoff Insulator: Portable, single dead-front terminal for removable mounting on accessory stand of stationary terminal junction. Insulators suitable for fully insulated isolation of energized cable-elbow terminator.

G. Test-Point Fault Indicators: Applicable current-trip ratings and arranged for installation in test points of load-break separable connectors, and complete with self-resetting indicators capable of being installed with shotgun hot stick and tested with test tool.

H. Tool Set: Shotgun hot stick with energized terminal indicator, fault-indicator test tool, and carrying case.

2.6 SPLICE KITS

A. Description: For splicing medium voltage cables; type as recommended by cable or splicing kit manufacturer for the application.

B. Standard: Comply with IEEE 404.

C. Splicing Products: As recommended, in writing, by splicing kit manufacturer for specific sizes, materials, ratings, and configurations of cable conductors. Include all components required for complete splice, with detailed instructions.

2.7 MEDIUM-VOLTAGE TAPES

A. Description: Electrical grade, insulating tape for medium voltage application.

B. Ethylene/propylene rubber-based, 30-mil (0.76-mm) splicing tape, rated for 130 deg C operation. Minimum 3/4 inch (20 mm) wide.

C. Silicone rubber-based, 12-mil (0.30-mm) self-fusing tape, rated for 130 deg C operation. Minimum 1-1/2 inches (38 mm) wide.

D. Insulating-putty, 125-mil (3.175-mm) elastic filler tape. Minimum 1-1/2 inches (38 mm) wide.

2.8 ARC-PROOFING MATERIALS

A. Tape for First Course on Metal Objects: 10-mil (250-micrometer) thick, corrosion-protective, moisture-resistant, PVC pipe-wrapping tape.

B. Arc-Proofing Tape: Fireproof tape, flexible, conformable, intumescent to 0.3 inch (8 mm) thick, and compatible with cable jacket.

C. Glass-Cloth Tape: Pressure-sensitive adhesive type, 1 inch (25 mm) wide.

2.9 FAULT INDICATORS

A. Indicators: As directed, Automatically or Manually reset fault indicator with inrush restraint feature, arranged to clamp to cable sheath and provide a display after a fault has occurred in cable. Instrument shall not be affected by heat, moisture, and corrosive conditions and shall be recommended by manufacturer for installation conditions.

B. Resetting Tool: Designed for use with fault indicators, with moisture-resistant storage and carrying case.

2.10 SOURCE QUALITY CONTROL

A. Test and inspect cables according to ICEA S-97-682 or ICEA S-94-649 before shipping as directed.

B. Test strand-filled cables for water-penetration resistance according to ICEA T-31-610, using a test pressure of 5 psig (35 kPa).

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install cables according to IEEE 576.

B. Proof conduits prior to conductor installation by passing a wire brush mandrel and then a rubber duct swab through the conduit. Separate the wire brush and the rubber swab by 48 to 72 inches (1200 to 1800 mm) on the pull rope.

1. Wire Brush Mandrel: Consists of a length of brush approximately the size of the conduit inner diameter with stiff steel bristles and an eye on each end for attaching the pull ropes. If an obstruction is felt, pull the brush back and forth repeatedly to break up the obstruction.
2. Rubber Duct Swab: Consists of a series of rubber discs approximately the size of the conduit inner diameter on a length of steel cable with an eye on each end for attaching the pull ropes. Pull the rubber duct swab through the duct to extract loose debris from the duct.

C. Pull Conductors: Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

1. Where necessary, use manufacturer-approved pulling compound or lubricant that does not deteriorate conductor or insulation.
2. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips, that do not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.
3. Use pull-in guides, cable feeders, and draw-in protectors as required to protect cables during installation.
4. Do not pull cables with ends unsealed. Seal cable ends with rubber tape.

D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.

E. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

F. Install direct-buried cables on leveled and tamped bed of 3-inch- (75-mm-) thick, clean sand. Separate cables crossing other cables or piping by a minimum of 2 inches (50 mm) of tamped earth, plus an additional 2 inches (50 mm) of sand. Install permanent markers at ends of cable runs, changes in direction, and buried splices.

G. Install "buried-cable" warning tape 12 inches (305 mm) above cables.

H. In manholes, handholes, pull boxes, junction boxes, and cable vaults, train cables around walls by the longest route from entry to exit; support cables at intervals adequate to prevent sag.

I. Install sufficient cable length to remove cable ends under pulling grips. Remove length of conductor damaged during pulling.

J. Install cable splices at pull points and elsewhere as indicated; use standard kits. Use dead-front separable watertight connectors in manholes and other locations subject to water infiltration.

K. Install terminations at ends of conductors, and seal multiconductor cable ends with standard kits.

L. Install separable insulated-connector components as follows:

1. Protective Cap: At each terminal junction, with one on each terminal to which no feeder is indicated to be connected.
2. Portable Feed-Through Accessory: At each terminal junction, with one on each terminal.
3. Standoff Insulator: At each terminal junction, with one on each terminal.

M. Arc Proofing: Unless otherwise indicated, arc proof medium-voltage cable at locations not protected by conduit, cable tray, direct burial, or termination materials. In addition to arc-proofing tape manufacturer's written instructions, apply arc proofing as follows:

1. Clean cable sheath.
2. Wrap metallic cable components with 10-mil (250-micrometer) pipe-wrapping tape.
3. Smooth surface contours with electrical insulation putty.
4. Apply arc-proofing tape in one half-lapped layer with coated side toward cable.
5. Band arc-proofing tape with two layers of 1-inch (25-mm) wide half-lapped, adhesive, glass-cloth tape at each end of the arc-proof tape.

N. Seal around cables passing through fire-rated elements according to Section 078413 "Penetration Firestopping."

O. Install fault indicators on each phase where indicated.

P. Ground shields of shielded cable at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated-connector fittings, and hardware.

Q. Ground shields of shielded cable at one point only. Maintain shield continuity and connections to metal connection hardware at all connection points.

R. Identify cables according to Section 260553 "Identification for Electrical Systems." Identify phase and circuit number of each conductor at each splice, termination, pull point, and junction box. Arrange identification so that it is unnecessary to move the cable or conductor to read the identification.

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
2. After installing medium-voltage cables and before electrical circuitry has been energized, test for compliance with requirements.
3. Perform Partial Discharge test of each new conductor according to NETA ATS, Ch. 7.3.3 and to test equipment manufacturer's recommendations.

4. Perform Dissipation Factor test of each new conductor according to NETA ATS, Ch. 7.3.3 and to test equipment manufacturer's recommendations.

B. Prepare test and inspection reports.

END OF SECTION 260513

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Copper building wire rated 600 V or less.
2. Aluminum building wire rated 600 V or less.
3. Metal-clad cable, Type MC, rated 600 V or less.
4. Fire-alarm wire and cable.
5. Connectors, splices, and terminations rated 600 V and less.

B. Related Requirements:

1. Section 260513 "Medium-Voltage Cables" for single-conductor and multiconductor cables, cable splices, and terminations for electrical distribution systems with 601 to 35,000 V.
2. Section 260523 "Control-Voltage Electrical Power Cables" for control systems communications cables and Classes 1, 2, and 3 control cables.
3. Section 271500 "Communications Horizontal Cabling" for cabling used for voice and data circuits.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Product Schedule: Indicate type, use, location, and termination locations.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 COPPER BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

B. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. RoHS compliant.
3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

C. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 or ASTM B496 for stranded conductors as directed.

D. Conductor Insulation:

1. Type NM: Comply with UL 83 and UL 719.
2. Type RHH and Type RHW-2: Comply with UL 44.
3. Type USE-2 and Type SE: Comply with UL 854.
4. Type THHN and Type THWN-2: Comply with UL 83.
5. Type THW and Type THW-2: Comply with NEMA WC-70/ICEA S-95-658 and UL 83.
6. Type XHHW-2: Comply with UL 44.

2.2 ALUMINUM BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn aluminum current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

B. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. RoHS compliant.
3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

C. Conductors: Aluminum, complying with ASTM B800 and ASTM B801.

D. Conductor Insulation:

1. Type NM: Comply with UL 83 and UL 719.
2. Type RHH and Type RHW-2: Comply with UL 44.
3. Type USE-2 and Type SE: Comply with UL 854.
4. Type THHN and Type THWN-2: Comply with UL 83.
5. Type THW and Type THW-2: Comply with NEMA WC-70/ICEA S-95-658 and UL 83.
6. Type XHHW-2: Comply with UL 44.

2.3 METAL-CLAD CABLE, TYPE MC

A. Description: A factory assembly of one or more current-carrying insulated conductors in an overall metallic sheath.

B. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. Comply with UL 1569.
3. RoHS compliant.
4. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

C. Circuits:

1. Single circuit and multicircuit with color-coded conductors.
2. Power-Limited Fire-Alarm Circuits: Comply with UL 1424.

D. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors or Aluminum, complying with ASTM B800 and ASTM B801 as directed.

E. Ground Conductor: Bare, Insulated or None as directed.

F. Conductor Insulation:

1. Type TFN/THHN/THWN-2: Comply with UL 83.
2. Type XHHW-2: Comply with UL 44.

G. Armor: As directed Steel or Aluminum, interlocked.

H. Jacket: PVC applied over armor.

2.4 FIRE-ALARM WIRE AND CABLE

A. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.

B. Signaling Line Circuits: Twisted, shielded pair, not less than, No. 18 AWG or size as recommended by system manufacturer as directed.

1. Circuit Integrity Cable: Twisted shielded pair, NFPA 70, Article 760, Classification CI, for power-limited fire-alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a two-hour rating.

C. Non-Power-Limited Circuits: Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation, and complying with requirements in UL 2196 for a two-hour rating.

1. Low-Voltage Circuits: No. 16 AWG, minimum, in pathway.
2. Line-Voltage Circuits: No. 12 AWG, minimum, in pathway.
3. Multiconductor Armored Cable: NFPA 70, Type MC, copper conductors, Type TFN/THHN conductor insulation, copper drain wire, copper armor with outer jacket with red identifier stripe, NTRL listed for fire-alarm and cable tray installation, plenum rated.

2.5 CONNECTORS AND SPLICES

A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.

C. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.

1. Material: Copper, Aluminum or Bronze.
2. Type: One or Two hole with standard or long barrels as directed.
3. Termination: Compression or Crimp as directed.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper; solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Feeders: Copper for feeders smaller than No. 4 AWG; copper or aluminum for feeders No. 4 AWG and larger. Conductors shall be solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

C. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

D. Branch Circuits: Copper. Solid for No. 12 AWG and smaller; stranded for No. 10 AWG and larger.

E. Power-Limited Fire Alarm and Control: Solid for No. 12 AWG and smaller.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN/THWN-2, single conductors in raceway, Type XHHW-2, single conductors in raceway, Type USE, single conductor in raceway or Multiconductor cable, Type SE as directed.

B. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway, Type XHHW-2, single conductors in raceway, Metal-clad cable, Type MC or Nonmetallic-sheathed cable, Type NM as directed.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN/THWN-2, single conductors in raceway, Metal-clad cable, Type MC or Nonmetallic-sheathed cable, Type NM as directed.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway, Type XHHW-2, single conductors in raceway or Underground feeder cable, Type UF as directed.

E. Feeders in Cable Tray: Type THHN/THWN-2, single conductors in raceway, Type XHHW-2, single conductors larger than No. 1/0 AWG, Metal-clad cable, Type MC or Nonmetallic-sheathed cable, Type NM as directed.

F. Exposed Branch Circuits, Including in Crawlspaces: Type THHN/THWN-2, single conductors in raceway, Metal-clad cable, Type MC or Nonmetallic-sheathed cable, Type NM as directed.

G. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway, Metal-clad cable, Type MC or Nonmetallic-sheathed cable, Type NM as directed.

H. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway, Type XHHW-2, single conductors in raceway or Underground branch-circuit cable, Type UF as directed.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.

F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

3.4 INSTALLATION OF FIRE-ALARM WIRING

A. Comply with NECA 1 and NFPA 72.

B. Wiring Method: Install wiring in metal pathway according to Section 280528 "Pathways for Electronic Safety and Security."

1. Install plenum cable in environmental airspaces, including plenum ceilings.
2. Fire-alarm circuits and equipment control wiring associated with fire-alarm system shall be installed in a dedicated pathway system. This system shall not be used for any other wire or cable.

C. Wiring Method:

1. Cables and pathways used for fire-alarm circuits, and equipment control wiring associated with fire-alarm system, may not contain any other wire or cable.
2. Fire-Rated Cables: Use of two-hour, fire-rated fire-alarm cables, NFPA 70, Types MI and CI, is not permitted.
3. Signaling Line Circuits: Power-limited fire-alarm cables may or shall not be installed in the same cable or pathway as signaling line circuits.

D. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with fire-alarm system to terminal blocks. Mark each terminal according to system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

E. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.

F. Color-Coding: Color-code fire-alarm conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and another for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire-alarm system junction boxes and covers red.

G. Risers: Install at least two vertical cable risers to serve the fire-alarm system. Separate risers in close proximity to each other with a minimum one-hour-rated wall, so the loss of one riser does not prevent receipt or transmission of signals from other floors or zones.

H. Wiring to Remote Alarm Transmitting Device: 1-inch (25-mm) conduit between the fire-alarm control panel and the transmitter. Install number of conductors and electrical supervision for connecting wiring as needed to suit monitoring function.

3.5 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

1. Use oxide inhibitor in each splice, termination, and tap for aluminum conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches (150 mm) or 12 inches (300 mm) of slack as directed.

D. Comply with requirements in Section 283111 "Digital, Addressable Fire-Alarm System" or Section 283112 "Zoned (DC Loop) Fire-Alarm System" for connecting, terminating, and identifying wires and cables as directed.

3.6 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor and identify as spare conductor.

3.7 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.8 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping."

END OF SECTION 260519

SECTION 260523 - CONTROL-VOLTAGE ELECTRICAL POWER CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Backboards.
2. Category 5e balanced twisted pair cable.
3. Balanced twisted pair cabling hardware.
4. RS-485 cabling.
5. Low-voltage control cabling.
6. Control-circuit conductors.

1.2 DEFINITIONS

A. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency, RCDD, layout technician, installation supervisor, and field inspector.

B. Source quality-control reports.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Flame Travel and Smoke Density in Plenums: As determined by testing identical products according to NFPA 262, by a qualified testing agency. Identify products for installation in plenums with appropriate markings of applicable testing agency.

1. Flame Travel Distance: 60 inches (1520 mm) or less.
2. Peak Optical Smoke Density: 0.5 or less.
3. Average Optical Smoke Density: 0.15 or less.

C. Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As determined by testing identical products according to UL 1666.

D. Flame Travel and Smoke Density for Cables in Non-Riser Applications and Non-Plenum Building Spaces: As determined by testing identical products according to UL 1685.

E. RoHS compliant.

2.2 BACKBOARDS

A. Description: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm). Comply with requirements for plywood backing panels in Section 061000 "Rough Carpentry."

B. Painting: Paint plywood on all sides and edges with flat, eggshell, black, latex or alkyd paint as directed. Comply with requirements in Section 099123 "Interior Painting."

2.3 CATEGORY 5e BALANCED TWISTED PAIR CABLE

A. Description: Four-pair, balanced-twisted pair cable, certified to meet transmission characteristics of Category 5e cable at frequencies up to 100 MHz.

B. Standard: Comply with ICEA S-90-661, NEMA WC 63.1, and TIA-568-C.2 for Category 5e cables.

C. Conductors: 100-ohm, 24 AWG solid copper.

D. Shielding/Screening: Unshielded twisted pairs (UTP), Shielded twisted pairs (FTP), Screened twisted pairs (F/UTP) or Screened and shielded twisted pairs (F/FTP) as directed.

E. Cable Rating: Riser or Plenum as directed.

F. Jacket: White or Gray thermoplastic as directed.

2.4 BALANCED TWISTED PAIR CABLE HARDWARE

A. Description: Hardware designed to connect, splice, and terminate balanced twisted pair copper communications cable.

B. General Requirements for Balanced Twisted Pair Cable Hardware:

1. Comply with the performance requirements of Category 5e, Category 6, Category 6a or Category 7 as directed.
2. Comply with TIA-568-C.2, IDC type, with modules designed for punch-down caps or tools.
3. Cables shall be terminated with connecting hardware of same category or higher.

C. Source Limitations: Obtain balanced twisted pair cable hardware from single source from single manufacturer or Obtain balanced twisted pair cable hardware from same manufacturer as balanced twisted pair cable, from single source as directed.

D. Connecting Blocks: 110-style IDC for Category 5e, 110-style IDC for Category 6 or 66-style IDC for Category 5e as directed. Provide blocks for the number of cables terminated on the block, plus 25 percent spare, integral with connector bodies, including plugs and jacks where indicated.

E. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.

1. Number of Terminals per Field: One for each conductor in assigned cables.

F. Patch Panel: Modular panels housing numbered jack units with IDC-type connectors at each jack location for permanent termination of pair groups of installed cables.

1. Features:

a. Universal T568A and T568B wiring labels.
b. Labeling areas adjacent to conductors.
c. Replaceable connectors.
d. 24 or 48 ports.

2. Construction: 16-gauge steel and mountable on 19-inch (483 mm) equipment racks.
3. Number of Jacks per Field: One for each four-pair cable indicated or conductor group of indicated cables, plus spares and blank positions adequate to suit specified expansion criteria as directed.

G. Patch Cords: Factory-made, four-pair cables in 36-inch (900-mm) or 48-inch (1200-mm) lengths as directed; terminated with an eight-position modular plug at each end.

1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure performance. Patch cords shall have latch guards to protect against snagging.
2. Patch cords shall have color-coded boots for circuit identification.

H. Plugs and Plug Assemblies:

1. Male; eight position; color-coded modular telecommunications connector designed for termination of a single four-pair 100-ohm unshielded or shielded balanced twisted pair cable.
2. Comply with IEC 60603-7-1, IEC 60603-7-2, IEC 60603-7-3, IEC 60603-7-4, and IEC 60603-7.5.
3. Marked to indicate transmission performance.

I. Jacks and Jack Assemblies:

1. Female; eight position; modular; fixed telecommunications connector designed for termination of a single four-pair 100-ohm unshielded or shielded balanced twisted pair cable.
2. Designed to snap-in to a patch panel or faceplate.
3. Standards.

    a. Category 5e, unshielded balanced twisted pair cable shall comply with IEC 60603-7-2.
    b. Category 5e, shielded balanced twisted pair cable shall comply with IEC 60603-7-3.
    c. Category 6, unshielded balanced twisted pair cable shall comply with IEC 60603-7-4.
    d. Category 6, shielded balanced twisted pair cable shall comply with IEC 60603-7.5.
    e. Category 6a, unshielded balanced twisted pair cable shall comply with IEC 60603-7-41.
    f. Category 6a, shielded balanced twisted pair cable shall comply with IEC 60603-7.51.

4. Marked to indicate transmission performance.

J. Faceplate:

1. Two, Four or Six port as directed, vertical single gang faceplates designed to mount to single gang wall boxes.
2. Eight, Ten or Twelve port as directed, vertical double gang faceplates designed to mount to double gang wall boxes.
3. Plastic Faceplate: High-impact plastic. Coordinate color with Section 262726 "Wiring Devices."
4. Metal Faceplate: Stainless steel or Brass as directed, complying with requirements in Section 262726 "Wiring Devices."
5. For use with snap-in jacks accommodating any combination of balanced twisted pair, optical fiber, and coaxial work area cords.

    a. Flush mounting jacks, positioning the cord at a 45-degree angle.

K. Legend:

1. Machine printed, in the field, using adhesive-tape label.
2. Snap-in, clear-label covers and machine-printed paper inserts.

2.5 TWIN-AXIAL DATA HIGHWAY CABLE

A. Plenum-Rated Cable: NFPA 70, Type CMP.

1. Paired, number of pairs as directed, No. 20, No. 22 or No. 24 AWG, stranded (7x28), (7x30) or (7x32) tinned-copper conductors.
2. Plastic insulation.
3. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
4. Plastic jacket.
5. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned-copper drain wire.
6. Flame Resistance: Comply with NFPA 262.

2.6 RS-232 CABLE

A. PVC-Jacketed, TIA 232-F:

1. Three or Nine as directed, No. 22 AWG, stranded (7x30) tinned copper conductors.
2. Polypropylene insulation.
3. Aluminum foil-polyester tape shield with 100 percent shield coverage.
4. PVC jacket.
5. Conductors are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
6. NFPA 70 Type: Type CM.
7. Flame Resistance: Comply with UL 1581.

B. Plenum-Type, TIA 232-F:

1. Three or Nine, No. 22 AWG, stranded (7x30) tinned copper conductors.
2. PE insulation.
3. Aluminum foil-polyester tape shield with 100 percent shield coverage.
4. Fluorinated ethylene propylene jacket.
5. Conductors are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
6. Flame Resistance: Comply with NFPA 262.

2.7 RS-485 CABLE

A. Plenum-Rated Cable: NFPA 70, Type CMP.

1. Paired, one pair or two pairs as directed, No. 22 AWG, stranded (7x30) tinned-copper conductors.
2. Fluorinated ethylene propylene insulation.
3. Unshielded.
4. Fluorinated ethylene propylene jacket.
5. Flame Resistance: NFPA 262.

2.8 LOW-VOLTAGE CONTROL CABLE

A. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.

1. One or Multi-pair, twisted, No. 16 AWG, stranded (19x29) or No. 18 AWG, stranded (19x30) tinned-copper conductors as directed.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with NFPA 262.

2.9 CONTROL-CIRCUIT CONDUCTORS

A. Class 1 Control Circuits: Stranded copper, Type THHN/THWN-2, complying with UL 83 in raceway.

B. Class 2 Control Circuits: Stranded copper, Type THHN/THWN-2, complying with UL 83 in raceway.

C. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type THHN/THWN-2, complying with UL 83 in raceway.

D. Class 2 Control Circuits and Class 3 Remote-Control and Signal Circuits That Supply Critical Circuits: Circuit Integrity (CI) cable.

1. Smoke control signaling and control circuits.

2.10 FIRE-ALARM WIRE AND CABLE

A. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.

B. Signaling Line Circuits: Twisted, shielded pair, not less than, No. 18 AWG or size as recommended by system manufacturer.

1. Circuit Integrity Cable: Twisted shielded pair, NFPA 70, Article 760, Classification CI, for power-limited fire-alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a two-hour rating.

C. Non-Power-Limited Circuits: Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation, and complying with requirements in UL 2196 for a two-hour rating.

1. Low-Voltage Circuits: No. 16 AWG, minimum, in pathway.
2. Line-Voltage Circuits: No. 12 AWG, minimum, in pathway.
3. Multiconductor Armored Cable: NFPA 70, Type MC, copper conductors, Type TFN/THHN conductor insulation, copper drain wire, copper armor with outer jacket with red identifier stripe, NTRL listed for fire-alarm and cable tray installation, plenum rated.

2.11 SOURCE QUALITY CONTROL

A. Factory test balanced twisted pair cables according to TIA-568-C.2.

B. Cable will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Test cables on receipt at Project site.

1. Test each pair of twisted pair cable for open and short circuits.

3.2 INSTALLATION OF RACEWAYS AND BOXES

A. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for raceway selection and installation requirements for boxes, conduits, and wireways as supplemented or modified in this Section.

1. Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.
2. Outlet boxes shall be no smaller than 4 inches (102 mm) square by 1-1/2 inches (38 mm) or 2-1/8 inches (53 mm) deep as directed, with extension ring sized to bring edge of ring to within 1/8 inch (3.1 mm) of the finished wall surface.
3. Flexible metal conduit shall not be used.

B. Comply with TIA-569-D for pull-box sizing and length of conduit and number of bends between pull points.

C. Install manufactured conduit sweeps and long-radius elbows if possible.

D. Raceway Installation in Equipment Rooms:

1. Position conduit ends adjacent to a corner on backboard if a single piece of plywood is installed, or in the corner of the room if multiple sheets of plywood are installed around perimeter walls of the room.
2. Install cable trays to route cables if conduits cannot be located in these positions.
3. Secure conduits to backboard if entering the room from overhead.
4. Extend conduits 3 inches (75 mm) above finished floor.
5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

E. Backboards: Install backboards with 96-inch (2440-mm) dimension vertical. Butt adjacent sheets tightly and form smooth gap-free corners and joints.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:

1. Comply with TIA-568-C Series of standards.
2. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems."
3. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
4. Cables may not be spliced and shall be continuous from terminal to terminal. Do not splice cable between termination, tap, or junction points.
5. Cables serving a common system may be grouped in a common raceway. Install network cabling and control wiring and cable in separate raceway from power wiring. Do not group conductors from different systems or different voltages.
6. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
7. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Install lacing bars and distribution spools.
8. Do not install bruised, kinked, scored, deformed, or abraded cable. Remove and discard cable if damaged during installation and replace it with new cable.
9. Cold-Weather Installation: Bring cable to room temperature before dereeling. Do not use heat lamps for heating.
10. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Monitor cable pull tensions.
11. Support: Do not allow cables to lay on removable ceiling tiles.
12. Secure: Fasten securely in place with hardware specifically designed and installed so as to not damage cables.
13. Provide strain relief.
14. Keep runs short. Allow extra length for connecting to terminals. Do not bend cables in a radius less than 10 times the cable OD. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners and through penetrations.
15. Ground wire shall be copper, and grounding methods shall comply with IEEE C2. Demonstrate ground resistance.

C. Balanced Twisted Pair Cable Installation:

1. Comply with TIA-568-C.2.
2. Install termination hardware as specified in Section 271513 "Communications Copper Horizontal Cabling" unless otherwise indicated.
3. Do not untwist UTP cables more than 1/2 inch (12 mm) at the point of termination to maintain cable geometry.

D. Installation of Control-Circuit Conductors:

1. Install wiring in raceways. Comply with requirements specified in Section 260533 "Raceways and Boxes for Electrical Systems."

E. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend copper cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceilings by cable supports not more than 30 inches (760 mm) apart.
3. Cable shall not be run through or on structural members or in contact with pipes, ducts, or other potentially damaging items. Do not run cables between structural members and corrugated panels.

F. Installation of Cable Routed Exposed under Raised Floors:

1. Install plenum-rated cable only.
2. Install cabling after the flooring system has been installed in raised floor areas.
3. Below each feed point, neatly coil a minimum of 72 inches (1830 mm) of cable in a coil not less than 12 inches (305 mm) in diameter.

3.4 REMOVAL OF CONDUCTORS AND CABLES

A. Remove abandoned conductors and cables. Abandoned conductors and cables are those installed that are not terminated at equipment and are not identified with a tag for future use.

3.5 CONTROL-CIRCUIT CONDUCTORS

A. Minimum Conductor Sizes:

1. Class 1 remote-control and signal circuits; No 14 AWG.
2. Class 2 low-energy, remote-control, and signal circuits; No. 16 AWG.
3. Class 3 low-energy, remote-control, alarm, and signal circuits; No 12 AWG.

3.6 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-D, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping" Chapter.

3.7 GROUNDING

A. For data communication wiring, comply with TIA-607-B and with BICSI TDMM, "Bonding and Grounding (Earthing)" Chapter.

B. For low-voltage control wiring and cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.8 IDENTIFICATION

A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Identify data and communications system components, wiring, and cabling according to TIA-606-B; label printers shall use label stocks, laminating adhesives, and inks complying with UL 969.

C. Identify each wire on each end and at each terminal with a number-coded identification tag. Each wire shall have a unique tag.

3.9 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. Tests and Inspections:

1. Visually inspect cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments and inspect cabling connections to confirm compliance with TIA-568-C.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.

C. End-to-end cabling will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION 260523

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes grounding and bonding systems and equipment.

B. Section includes grounding and bonding systems and equipment, plus the following special applications:

1. Underground distribution grounding.
2. Ground bonding common with lightning protection system.
3. Foundation steel electrodes.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article.

B. Qualification Data: For testing agency and testing agency's field supervisor.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1. Plans showing as-built, dimensioned locations of system described in "Field Quality Control" Article, including the following:

a. Test wells.
b. Ground rods.
c. Ground rings.
d. Grounding arrangements and connections for separately derived systems.

2. As directed, Instructions for periodic testing and inspection of grounding features at test wells, ground rings or grounding connections for separately derived systems based on NETA MTS or NFPA 70B.

a. Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
b. Include recommended testing intervals.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Certified by NETA.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with UL 467 for grounding and bonding materials and equipment.

2.2 MANUFACTURERS

2.3 CONDUCTORS

A. Insulated Conductors: Copper or tinned-copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

1. Solid Conductors: ASTM B3.
2. Stranded Conductors: ASTM B8.
3. Tinned Conductors: ASTM B33.
4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches (6.3 by 100 mm) in cross section, with 9/32-inch (7.14-mm) holes spaced 1-1/8 inches (28 mm) apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

2.4 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

C. Bus-Bar Connectors: As directed, Mechanical type, cast silicon bronze, solderless compression or exothermic-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

D. Bus-Bar Connectors: Compression type, copper or copper alloy, with two wire terminals.

E. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.

F. Cable-to-Cable Connectors: Compression type, copper or copper alloy.

G. Cable Tray Ground Clamp: Mechanical type, zinc-plated malleable iron.

H. Conduit Hubs: Mechanical type, terminal with threaded hub.

I. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt or socket set screw as directed.

J. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.

K. Lay-in Lug Connector: Mechanical type, aluminum or copper rated for direct burial terminal with set screw as directed.

L. Service Post Connectors: Mechanical type, bronze alloy terminal, in short- and long-stud lengths, capable of single and double conductor connections.

M. Signal Reference Grid Clamp: Mechanical type, stamped-steel terminal with hex head screw.

N. Straps: Solid copper, cast-bronze clamp or copper lugs as directed. Rated for 600 A.

O. Tower Ground Clamps: Mechanical type, copper or copper alloy, terminal one or two-piece clamp as directed.

P. U-Bolt Clamps: Mechanical type, copper or copper alloy, terminal listed for direct burial.

Q. Water Pipe Clamps:

1. Mechanical type, two pieces with zinc-plated or stainless-steel bolts as directed.

    a. Material: Tin-plated aluminum or Die-cast zinc alloy as directed.
    b. Listed for direct burial.

2. U-bolt type with malleable-iron clamp and copper ground connector or copper ground connector rated for direct burial as directed.

2.5 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel, sectional type; 3/4 inch by 10 feet (19 mm by 3 m) or 5/8 by 96 inches (16 by 2400 mm) as directed.

B. Ground Plates: 1/4 inch (6 mm) thick, hot-dip galvanized.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 2/0 AWG minimum.

1. Bury at least 30 inches (750 mm) below grade.

C. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

1. Install bus horizontally, on insulated spacers 2 inches (50 mm) minimum from wall, 6 inches (150 mm) above finished floor unless otherwise indicated.
2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.

D. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING AT THE SERVICE

A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

3.3 GROUNDING SEPARATELY DERIVED SYSTEMS

A. Generator: Install grounding electrode(s) at the generator location. The electrode shall be connected to the equipment grounding conductor and to the frame of the generator.

3.4 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches (100 mm) will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches (50 mm) above to 6 inches (150 mm) below concrete. Seal floor opening with waterproof, non-shrink grout.

C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

D. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches (150 mm) from the foundation.

3.5 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1. Feeders and branch circuits.
2. Lighting circuits.
3. Receptacle circuits.
4. Single-phase motor and appliance branch circuits.
5. Three-phase motor and appliance branch circuits.
6. Flexible raceway runs.
7. Armored and metal-clad cable runs.
8. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
9. X-Ray Equipment Circuits: Install insulated equipment grounding conductor in circuits supplying x-ray equipment.

C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

D. Water Heater, Heat-Tracing, and Anti-frost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

E. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.6 FENCE GROUNDING

A. Fence Grounding: Install at maximum intervals of 1500 feet (450 m) except as follows:

1. Fences within 100 Feet (30 m) of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of 750 feet (225 m).

    a. Gates and Other Fence Openings: Ground fence on each side of opening.

B. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a maximum distance of 150 feet (45 m) on each side of crossing.

C. Fences Enclosing Electrical Power Distribution Equipment: Ground as required by IEEE C2 unless otherwise indicated.

3.7 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor and install in conduit.

C. Ground Rods: Drive rods until tops are 2 inches (50 mm) below finished floor or final grade unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.

D. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.

3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

E. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before any conductors are connected.

    a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
    b. Perform tests by fall-of-potential method according to IEEE 81.

4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

C. Grounding system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
4. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 or 3 ohm(s).
5. Substations and Pad-Mounted Equipment: 5 ohms.
6. Manhole Grounds: 10 ohms.

F. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526

SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Steel slotted support systems.
2. Conduit and cable support devices.
3. Support for conductors in vertical conduit.
4. Structural steel for fabricated supports and restraints.
5. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
6. Fabricated metal equipment support assemblies.

B. Related Requirements:

1. Section 260548.16 "Seismic Controls for Electrical Systems" for products and installation requirements necessary for compliance with seismic criteria.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. For fabrication and installation details for electrical hangers and support systems.

1. Hangers. Include product data for components.
2. Slotted support systems.
3. Equipment supports.
4. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated-Design Submittal: For hangers and supports for electrical systems.

1. Include design calculations and details of hangers.
2. Include design calculations for seismic restraints.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, and coordinated with each other, using input from installers of the items involved.

B. Seismic Qualification Data: Certificates, for hangers and supports for electrical equipment and systems, accessories, and components, from manufacturer.

C. Welding certificates.

1.4 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M or AWS D1.2/D1.2M as directed.

B. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M.
2. AWS D1.2/D1.2M.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design hanger and support system.

B. Seismic Performance: Hangers and supports shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the supported equipment and systems will remain in place without separation of any parts when subjected to the seismic forces specified and the supported equipment and systems will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 or 1.0 as directed.

C. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame Rating: Class 1.
2. Self-extinguishing according to ASTM D635.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32-inch (10-mm) diameter holes at a maximum of 8 inches (200 mm) o.c. in at least one surface.
1. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
2. Material for Channel, Fittings, and Accessories: Galvanized steel, Plain steel, Stainless steel, Type 304 or Stainless steel, Type 316 as directed.
3. Channel Width: Selected for applicable load criteria, 1-5/8 inches (41.25 mm), 1-1/4 inches (31.75 mm) or 13/16 inches (20.64 mm) as directed.
4. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.

5. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
6. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
7. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Conduit and Cable Support Devices: As directed, Steel or Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.

D. Structural Steel for Fabricated Supports and Restraints: ASTM A36/A36M steel plates, shapes, and bars; black and galvanized.

E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

2. Mechanical-Expansion Anchors: As directed, Insert-wedge-type, zinc-coated or stainless steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM F3125/F3125M, Grade A325 (Grade A325M).
6. Toggle Bolts: All or Stainless-steel springhead type as directed.
7. Hanger Rods: Threaded steel.

2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with the following standards for application and installation requirements of hangers and supports, except where requirements on Drawings or in this Section are stricter:

1. NECA 1.
2. NECA 101
3. NECA 102.
4. NECA 105.
5. NECA 111.

B. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

C. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

D. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and RMC as required by or scheduled in NECA 1, where its Table 1 lists maximum spacings that are less than those stated in NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter as directed.

E. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with two-bolt conduit clamps, single-bolt conduit clamps or single-bolt conduit clamps using spring friction action for retention in support channel as directed.

F. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings, and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC and RMC may be supported by openings through structure members, according to NFPA 70 as directed.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts, Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69 or Spring-tension clamps as directed.
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that comply with seismic-restraint strength and anchorage requirements.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

END OF SECTION 260529

SECTION 260533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal conduits and fittings.
2. Nonmetallic conduits and fittings.
3. Metal wireways and auxiliary gutters.
4. Nonmetal wireways and auxiliary gutters.
5. Surface raceways.
6. Boxes, enclosures, and cabinets.
7. Handholes and boxes for exterior underground cabling.

B. Related Requirements:

1. Section 078413 "Penetration Firestopping" for firestopping at conduit and box entrances.
2. Section 260543 "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.
3. Section 270528 "Pathways for Communications Systems" for conduits, wireways, surface pathways, innerduct, boxes, faceplate adapters, enclosures, cabinets, and handholes serving communications systems.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:

1. Structural members in paths of conduit groups with common supports.
2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

B. Seismic Qualification Data: Certificates, for enclosures, cabinets, and conduit racks and their mounting provisions, including those for internal components, from manufacturer.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

A. Metal Conduit:
   1. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   2. GRC: Comply with ANSI C80.1 and UL 6.
   3. ARC: Comply with ANSI C80.5 and UL 6A.
   4. IMC: Comply with ANSI C80.6 and UL 1242.
   5. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit or IMC.
      a. Comply with NEMA RN 1.
      b. Coating Thickness: 0.040 inch (1 mm), minimum.
   6. EMT: Comply with ANSI C80.3 and UL 797.
   7. FMC: Comply with UL 1; zinc-coated steel or aluminum as directed.
   8. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

B. Metal Fittings: Comply with NEMA FB 1 and UL 514B.
   1. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   2. Fittings, General: Listed and labeled for type of conduit, location, and use.
   3. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
   4. Fittings for EMT:
      a. Material: Steel or die cast.
      b. Type: Setscrew or compression.
   5. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
   6. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.

C. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS AND FITTINGS

A. Nonmetallic Conduit:

B. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   1. ENT: Comply with NEMA TC 13 and UL 1653.

2. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
3. LFNC: Comply with UL 1660.

C. Nonmetallic Fittings:
1. Fittings, General: Listed and labeled for type of conduit, location, and use.
2. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
3. Fittings for LFNC: Comply with UL 514B.
4. Solvents and Adhesives: As recommended by conduit manufacturer.

2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

A. Description: As directed, Sheet metal, complying with UL 870 and NEMA 250, Type 1, Type 3R, Type 4 or Type 12 unless otherwise indicated, and sized according to NFPA 70.

1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

2.4 NONMETALLIC WIREWAYS AND AUXILIARY GUTTERS

A. Listing and Labeling: Nonmetallic wireways and auxiliary gutters shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Description: PVC, extruded and fabricated to required size and shape, and having snap-on cover, mechanically coupled connections, and plastic fasteners.

C. Fittings and Accessories: Couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings shall match and mate with wireways as required for complete system.

D. Solvents and Adhesives: As recommended by conduit manufacturer.

2.5 BOXES, ENCLOSURES, AND CABINETS

A. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

B. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

C. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy or aluminum, Type FD, with gasketed cover as directed.

D. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.

E. Metal Floor Boxes:

1. Material: Cast metal or sheet metal.
2. Type: Fully adjustable or Semi-adjustable as directed.
3. Shape: Rectangular.
4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

F. Nonmetallic Floor Boxes: Nonadjustable, round or rectangular as directed.

1. Listing and Labeling: Nonmetallic floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb (23 kg). Outlet boxes designed for attachment of luminaires weighing more than 50 lb (23 kg) shall be listed and marked for the maximum allowable weight.

H. Paddle Fan Outlet Boxes: Nonadjustable, designed for attachment of paddle fan weighing 70 lb (32 kg).

1. Listing and labeling: Paddle fan outlet boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

I. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

J. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum or galvanized, cast iron with gasketed cover as directed.

K. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

L. Device Box Dimensions: 4 inches square by 2-1/8 inches deep (100 mm square by 60 mm deep) or 4 inches by 2-1/8 inches by 2-1/8 inches deep (100 mm by 60 mm by 60 mm deep) as directed.

M. Gangable boxes are allowed or prohibited as directed.

N. Hinged-Cover Enclosures: As directed, comply with UL 50 and NEMA 250, Type 1, Type 3R, Type 4 or Type 12 with continuous-hinge cover with flush latch unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
2. Nonmetallic Enclosures: Plastic.
3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

O. Cabinets:

1. As directed, NEMA 250, Type 1, Type 3R or Type 12 galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.
6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.6 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. General Requirements for Handholes and Boxes:

1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.
1. Standard: Comply with SCTE 77.
2. Configuration: Designed for flush burial with open, closed or integral closed bottom unless otherwise indicated as directed.
3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
5. Cover Legend: Molded lettering, "ELECTRIC.".
6. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.

C. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with frame and covers of polymer concrete, reinforced concrete, cast iron or hot-dip galvanized-steel diamond plate or fiberglass as directed.
1. Standard: Comply with SCTE 77.
2. Configuration: Designed for flush burial with open, closed or integral closed bottom unless otherwise indicated.
3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
5. Cover Legend: Molded lettering, "ELECTRIC".
6. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed Conduit: GRC, IMC, RNC, Type EPC-40-PVC or RNC, Type EPC-80-PVC as directed.
2. Concealed Conduit, Aboveground: GRC, IMC, EMT or RNC, Type EPC-40-PVC as directed.
3. Underground Conduit: RNC, Type EPC-40-PVC, Type EPC-80-PVC, direct buried or concrete encased as directed.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC or LFNC as directed.
5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R or Type 4 as directed.

B. Indoors: Apply raceway products as specified below unless otherwise indicated.

1. Exposed, Not Subject to Physical Damage: EMT, ENT or RNC as directed.
2. Exposed, Not Subject to Severe Physical Damage: EMT or RNC identified for such use as directed.
3. Exposed and Subject to Severe Physical Damage: As directed, GRC or IMC. Raceway locations include the following:

    a. Loading dock.
    b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
    c. Mechanical rooms.
    d. Gymnasiums.

4. Concealed in Ceilings and Interior Walls and Partitions: EMT, ENT or RNC, Type EPC-40-PVC as directed.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
6. Damp or Wet Locations: GRC or IMC as directed.
7. Boxes and Enclosures: As directed, NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel or nonmetallic in institutional and commercial kitchens and damp or wet locations.

C. Minimum Raceway Size: 1/2-inch (16-mm) or 3/4-inch (21-mm) trade size as directed.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.

3. EMT: Use setscrew or compression, steel or cast-metal fittings as directed. Comply with NEMA FB 2.10.
4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

E. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

F. Install surface raceways only where indicated on Drawings.

G. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F (49 deg C).

3.2 INSTALLATION

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.

B. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

C. Do not install raceways or electrical items on any "explosion-relief" walls or rotating equipment.

D. Do not fasten conduits onto the bottom side of a metal deck roof.

E. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

F. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.

G. Arrange stub-ups so curved portions of bends are not visible above finished slab.

H. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches (300 mm) of changes in direction.

I. Make bends in raceway using large-radius preformed ells. Field bending shall be according to NFPA 70 minimum radii requirements. Use only equipment specifically designed for material and size involved.

J. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

K. Support conduit within 12 inches (300 mm) of enclosures to which attached.

L. Raceways Embedded in Slabs:

1. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-foot (3-m) intervals.
2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
3. Arrange raceways to keep a minimum of 1 inch (25 mm) or 2 inches (50 mm) of concrete cover in all directions as directed.
4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
5. Change from ENT to RNC, Type EPC-40-PVC, GRC or IMC before rising above floor as directed.

M. Stub-ups to Above Recessed Ceilings:

1. Use EMT, IMC, or RMC for raceways.
2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

N. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

O. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.

P. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.

Q. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch (35-mm) trade size and insulated throat metal bushings on 1-1/2-inch (41-mm) trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

R. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

S. Surface Raceways:

1. Install surface raceway with a minimum 2-inch (50-mm) radius control at bend points.
2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches (1200 mm) and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

T. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces.

U. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service raceway enters a building or structure.
3. Conduit extending from interior to exterior of building.
4. Conduit extending into pressurized duct and equipment.
5. Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.
6. Where otherwise required by NFPA 70.

V. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F (17 deg C) and that has straight-run length that exceeds 25 feet (7.6 m).
2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:

    a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) temperature change.
    b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
    c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.
    d. Attics: 135 deg F (75 deg C) temperature change.

3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per degree F (0.06 mm per meter of length of straight run per degree C) of temperature change for PVC conduits.
4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

W. Flexible Conduit Connections: Comply with NEMA RV 3. As directed, Use a maximum of 36 inches (915 mm) or 72 inches (1830 mm) of flexible conduit for recessed and semi-recessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.

X. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center, top or bottom of box unless otherwise indicated.

Y. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between the box and cover plate or the supported equipment and box.

Z. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

AA. Locate boxes so that cover or plate will not span different building finishes.

BB. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

CC. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

DD. Set metal floor boxes level and flush with finished floor surface.

EE. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section 312000 "Earth Moving" for pipe less than 6 inches (150 mm) in nominal diameter.
2. Install backfill as specified in Section 312000 "Earth Moving."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches (300 mm) of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 312000 "Earth Moving."
4. Install manufactured duct elbows for stub-up at poles and equipment and at building entrances through floor unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.

    a. Couple steel conduits to ducts with adapters designed for this purpose and encase coupling with 3 inches (75 mm) of concrete for a minimum of 12 inches (300 mm) on each side of the coupling.
    b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.

6. Underground Warning Tape: Comply with requirements in Section 260553 "Identification for Electrical Systems."

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch (25 mm) above finished grade.

D. Install handholes with bottom below frost line, depth of frost line below grade as directed.

E. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.6 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.7 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 260533

SECTION 260536 - CABLE TRAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Ladder cable tray.
2. Wire-mesh cable tray.
3. Channel cable tray.
4. Fiberglass cable tray.
5. Fiberglass channel cable tray.
6. Cable tray accessories.
7. Warning signs.

B. Related Requirements:

1. Section 270536 "Cable Trays for Communications Systems" for cable trays and accessories serving communications systems.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For each type of cable tray.

1. Show fabrication and installation details of cable trays, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.
2. Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:

    a. Vertical and horizontal offsets and transitions.
    b. Clearances for access above and to sides of cable trays.
    c. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
    d. Load calculations to show dead and live loads as not exceeding manufacturer's rating for tray and its support elements.

C. Delegated-Design Submittal: For seismic restraints.

1. Seismic-Restraint Details: Signed and sealed by a qualified professional engineer who is licensed in the state where Project is located and who is responsible for their preparation.
2. Design Calculations: Calculate requirements for selecting seismic restraints.
3. Detail fabrication, including anchorages and attachments to structure and to supported cable trays.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and sections, drawn to scale, and coordinated with each other, using input from installers of the items involved:

B. Seismic Qualification Certificates: For cable trays, accessories, and components, from manufacturer.

C. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design cable tray supports and seismic bracing.

B. Seismic Performance: Cable trays and supports shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "cable trays will remain in place without separation of any parts when subjected to the seismic forces specified."
2. Component Importance Factor: 1.5 or 1.0 as directed.

C. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes in cable tray installed outdoors.

1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.2 GENERAL REQUIREMENTS FOR CABLE TRAY

A. Cable Trays and Accessories: Identified as defined in NFPA 70 and marked for intended location, application, and grounding.

B. Sizes and Configurations: See the Cable Tray Schedule on Drawings for specific requirements for types, materials, sizes, and configurations.

C. Structural Performance: See articles on individual cable tray types for specific values for the following parameters:

1. Uniform Load Distribution: Capable of supporting a uniformly distributed load on the indicated support span when supported as a simple span and tested according to NEMA VE 1.
2. Concentrated Load: A load applied at midpoint of span and centerline of tray.
3. Load and Safety Factors: Applicable to both side rails and rung capacities.

2.3 LADDER CABLE TRAY

A. Description: Two longitudinal side rails with transverse rungs swaged or welded to side rails, complying with NEMA VE 1.

B. Capacities and Characteristics:

1. Width: 6 inches (150 mm), 9 inches (225 mm), 12 inches (300 mm), 18 inches (450 mm), 24 inches (600 mm), 30 inches (750 mm) or 36 inches (900 mm) unless otherwise indicated on Drawings.
2. Minimum Usable Load Depth: 3 inches (75 mm), 4 inches (100 mm), 5 inches (125 mm) or 6 inches (150 mm) as directed.
3. Straight Section Lengths: 10 feet (3.0 m), 12 feet (3.7 m), 20 feet (6.0 m) or 24 feet (7.4 m), except where shorter lengths are required to facilitate tray assembly.
4. Rung Spacing: 6 inches (150 mm), 9 inches (225 mm), 12 inches (300 mm) or 18 inches (450 mm) o.c. as directed
5. Radius-Fitting Rung Spacing: 9 inches (225 mm) at center of tray's width.
6. Minimum Cable-Bearing Surface for Rungs: 7/8-inch (22-mm) width with radius edges.
7. No portion of the rungs shall protrude below the bottom plane of side rails.
8. Structural Performance of Each Rung: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200-lb (90-kg) concentrated load, when tested according to NEMA VE 1.
9. Fitting Minimum Radius: 12 inches (300 mm), 24 inches (600 mm), 36 inches (900 mm) or 48 inches (1200 mm) as directed.
10. Class Designation: Comply with NEMA VE 1, Class 5AA, Class 5A, Class 8AA, Class 8A, Class 10AA, Class 10A, Class 12AA, Class 12A, Class 20AA or Class 20A as directed.
11. Splicing Assemblies: Bolted type using serrated flange locknuts.
12. Splice-Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.
13. Covers: As directed, Solid, Louvered, Ventilated-hat or 2-in-3 pitch type made of same materials and with same finishes as cable tray.

C. Materials and Finishes:

1. Steel:

a. Straight Section and Fitting Side Rails and Rungs: Steel complies with the minimum mechanical properties of ASTM A1011/A1011M, SS, Grade 33 or ASTM A1008/A1008M, Grade 33, Type 2 as directed.
b. Steel Tray Splice Plates: ASTM A1011/A1011M, HSLAS, Grade 50, Class 1.
c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A510/A510M, Grade 1008.
d. Finish: Hot-dipped galvanized after fabrication, complying with ASTM A123/A123M, Class B2.

1) Hardware: Galvanized, ASTM B633, Chromium-zinc plated, ASTM F1136 or Stainless steel, Type 316 as directed.

e. Finish: Hot-dipped galvanized after fabrication, complying with ASTM A653/A653M, G90 (Z275).

1) Hardware: Galvanized, ASTM B633 or Chromium-zinc plated, ASTM F1136 as directed.

2. Aluminum:

a. Materials: Alloy 6063-T6 according to ANSI H35.1/H 35.1M for extruded components, and Alloy 5052-H32 or Alloy 6061-T6 according to ANSI H35.1/H 35.1M for fabricated parts.
b. Hardware: Chromium-zinc-plated steel, ASTM F1136 or Stainless steel, Type 316, ASTM F593 and ASTM F594 as directed.
c. Hardware for Aluminum Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F593 and ASTM F594.

2.4 WIRE-MESH CABLE TRAY

A. Description: Galvanized-steel wire mesh, complying with NEMA VE 1.

B. Capacities and Characteristics:

1. Width: 2 inches (50 mm), 4 inches (100 mm), 6 inches (150 mm), 8 inches (200 mm), 12 inches (300 mm), 16 inches (400 mm), 18 inches (450 mm), 20 inches (500 mm) or 24 inches (600 mm) unless otherwise indicated on Drawings.
2. Minimum Usable Load Depth: 1 inch (25 mm), 2 inches (50 mm), 4 inches (100 mm) or 6 inches (150 mm) as directed.
3. Straight Section Lengths: 10 feet (3.0 m) or 12 feet (3.7 m), except where shorter lengths are required to facilitate tray assembly as directed.
4. Structural Performance: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200-lb (90-kg) concentrated load, when tested according to NEMA VE 1.
5. Class Designation: Comply with NEMA VE 1, Class 5AA, Class 5A, Class 8AA, Class 8A, Class 10AA, Class 10A, Class 12AA, Class 12A, Class 20AA or Class 20A as directed.
6. Splicing Assemblies: Bolted type using serrated flange locknuts.
7. Splice-Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.

C. Materials and Finishes:

1. Steel:

a. Straight Sections and Fittings: Steel complies with the minimum mechanical properties of ASTM A1011/A1011M, SS, Grade 33 or ASTM A1008/A1008M, Grade 33, Type 2.
b. Steel Tray Splice Plates: ASTM A1011/A1011M, HSLAS, Grade 50, Class 1.
c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A510/A510M, Grade 1008.
d. Finish: Hot-dipped galvanized after fabrication, complying with ASTM A123/A123M, Class B2.

1) Hardware: Galvanized, ASTM B633, Chromium-zinc plated, ASTM F1136 or Stainless steel, Type 316 as directed.

e. Finish: Hot-dipped galvanized after fabrication, complying with ASTM A653/A653M, G90 (Z275).

1) Hardware: Galvanized, ASTM B633 or Chromium-zinc plated, ASTM F1136 as directed.

2.5 CHANNEL CABLE TRAY

A. Description: Single, formed sheet with a solid or ventilated bearing surface, complying with NEMA VE 1 as directed.

B. Capacities and Characteristics:

1. Width: 3 inches (75 mm), 4 inches (100 mm) or 6 inches (150 mm) unless otherwise indicated on Drawings.
2. Minimum Usable Load Depth: 1-1/4 inches (30 mm) or 2 inches (50 mm) as directed.
3. Straight Section Lengths: 10 feet (3.0 m) or 12 feet (3.7 m), except where shorter lengths are required to facilitate tray assembly.
4. Structural Performance: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200-lb (90-kg) concentrated load, when tested according to NEMA VE 1.
5. Fitting Minimum Radius: 12 inches (300 mm), 24 inches (600 mm), 36 inches (900 mm) or 48 inches (1200 mm) as directed.
6. Class Designation: Comply with NEMA VE 1, Class 5AA, Class 5A, Class 8AA, Class 8A, Class 10AA, Class 10A, Class 12AA, Class 12A, Class 20AA or Class 20A as directed.
7. Splicing Assemblies: Bolted type using serrated flange locknuts.
8. Splicing Assembly Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.
9. Covers: As directed, Solid, Louvered, Ventilated-hat or 2-in-3 pitch type made of same materials and with same finishes as cable tray.

C. Materials and Finishes:

1. Steel:

a. Straight Section and Fitting Side Rails and Rungs: Steel complies with the minimum mechanical properties of ASTM A1011/A1011M, SS, Grade 33 or ASTM A1008/A1008M, Grade 33, Type 2 as directed.
b. Steel Tray Splice Plates: ASTM A1011/A1011M, HSLAS, Grade 50, Class 1.
c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A510/A510M, Grade 1008.
d. Finish: Hot-dip galvanized after fabrication complying with ASTM A123/A123M, Class B2.

1) Hardware: Galvanized, ASTM B633, Chromium-zinc plated, ASTM F1136 or Stainless steel, Type 316 as directed.

e. Finish: Hot-dip mill galvanized before fabrication complying with ASTM A653/A653M, G90 (Z275).

1) Hardware: Galvanized, ASTM B633 or Chromium-zinc plated, ASTM F1136 as directed.

2. Aluminum:

a. Materials: Alloy 6063-T6 according to ANSI H35.1/H 35.1M for extruded components, and Alloy 5052-H32 or Alloy 6061-T6 according to ANSI H35.1/H 35.1M for fabricated parts.
b. Hardware: Chromium-zinc-plated steel, ASTM F1136 or Stainless steel, Type 316, ASTM F593 and ASTM F594 as directed.
c. Hardware for Aluminum Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F593 and ASTM F594.

3. Stainless Steel:

a. Materials: Low-carbon, passivated stainless steel, Type 304L or Type 316L, ASTM F593 and ASTM F594 as directed.
b. Hardware for Stainless-Steel Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F593 and ASTM F594.

2.6 FIBERGLASS CABLE TRAY

A. Description: Two longitudinal members with rounded edges and smooth surfaces, supporting a bearing surface, complying with NEMA FG 1.

B. Capacities and Characteristics:

1. Materials: Straight section structural elements; side rails, rungs, and splice plates shall be pultruded from glass-fiber-reinforced polyester or vinyl ester resin, complying with NEMA FG 1 and UL 568.
2. Width: 6 inches (150 mm), 9 inches (225 mm), 12 inches (300 mm), 18 inches (450 mm), 24 inches (600 mm), 30 inches (750 mm) or 36 inches (900 mm) unless otherwise indicated on Drawings.
3. Minimum Usable Load Depth: 1 inch (25 mm), 2 inches (50 mm), 3 inches (75 mm), 5 inches (125 mm) or 7 inches (175 mm) according to NEMA FG 1.
4. Straight Section Lengths: 10 feet (3.0 m) or 20 feet (6.0 m).
5. Class Designation: Comply with NEMA VE 1, Class 5AA, Class 5A, Class 8AA, Class 8A, Class 10AA, Class 10A, Class 12AA, Class 12A, Class 20AA, Class 20A.
6. Temperature Rating: Reduce the load rating of trays exposed to temperatures above 75 deg F (24 deg C) according to Table 4-3, "Working Loads," in NEMA FG 1.
7. Fitting Minimum Radius: 12 inches (300 mm) or 24 inches (600 mm).
8. Splicing Assemblies: Minimum four nuts and bolts per plate. Splice plates shall be furnished with straight sections and fittings.
9. Splicing Assembly Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.
10. Fasteners: Fiberglass-encapsulated, ASTM F593 and ASTM F594 stainless steel, Type 316. Design fasteners so that no metal is visible when fully assembled and

tightened. Fastener encapsulation shall not be damaged when torqued to manufacturer's recommended value.

11. Covers: As directed, Solid, Louvered, Ventilated-hat or 2-in-3 pitch type made of same materials and with same finishes as cable tray.

2.7 FIBERGLASS CHANNEL CABLE TRAY

A. Description: Two longitudinal members with rounded edges and smooth surfaces, supporting a solid or ventilated bearing surface, complying with NEMA FG 1.

B. Capacities and Characteristics:

1. Materials: Straight section structural elements; side rails, rungs, and splice plates shall be pultruded from glass-fiber-reinforced polyester or vinyl ester resin, complying with NEMA FG 1 and UL 568.
2. Width: 3 inches (75 mm), 4 inches (100 mm) or 6 inches (150 mm) unless otherwise indicated on Drawings.
3. Minimum Usable Load Depth: 1-1/4 inches (30 mm) or 2 inches (50 mm) as directed.
4. Straight Section Lengths: 10 feet (3.0 m), 12 feet (3.7 m), except where shorter lengths are required to facilitate tray assembly.
5. Class Designation: Comply with NEMA VE 1, Class 5AA, Class 5A, Class 8AA, Class 8A, Class 10AA, Class 10A, Class 12AA, Class 12A, Class 20AA or Class 20A.
6. Temperature Rating: Reduce the load rating of trays exposed to temperatures above 75 deg F (24 deg C) according to Table 4-3, "Working Loads," in NEMA FG 1.
7. Fitting Minimum Radius: 12 inches (300 mm) or 24 inches (600 mm) as directed.
8. Splicing Assemblies: Minimum four nuts and bolts per plate. Splice plates shall be furnished with straight sections and fittings.
9. Splicing Assembly Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.
10. Fasteners: Fiberglass-encapsulated, ASTM F593 and ASTM F594 stainless steel, Type 316. Design fasteners so that no metal is visible when fully assembled and tightened. Fastener encapsulation shall not be damaged when torqued to manufacturer's recommended value.
11. Covers: Solid, Louvered, Ventilated-hat or 2-in-3 pitch type made of same materials and with same finishes as cable tray as directed.

2.8 CABLE TRAY ACCESSORIES

A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.

B. Barrier Strips: Same materials and finishes as for cable tray.

C. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

2.9 WARNING SIGNS

A. Lettering: 1-1/2-inch- (40-mm-) high, black letters on yellow background, with legend "WARNING! NOT TO BE USED AS WALKWAY, LADDER, OR SUPPORT FOR LADDERS OR PERSONNEL."

B. Comply with Section 260553 "Identification for Electrical Systems."

PART 3 - EXECUTION

3.1 CABLE TRAY INSTALLATION

A. Install cable tray and support systems according to NEMA FG 1 or NEMA VE 2 as directed.

B. Install cable tray as a complete system, including fasteners, hold-down clips, support systems, barrier strips, adjustable horizontal and vertical splice plates, elbows, reducers, tees, crosses, cable dropouts, adapters, covers, and bonding.

C. Install cable tray, so that the tray is accessible for cable installation and all splices are accessible for inspection and adjustment.

D. Remove burrs and sharp edges from cable trays.

E. Fasten cable tray supports to building structure and install seismic restraints.

F. Design fasteners and supports to carry cable tray, cables, and a concentrated load of 200 lb (90 kg). Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems." Comply with seismic-restraint details according to Section 260548.16 "Seismic Controls for Electrical Systems."

G. Place supports, so that spans do not exceed maximum spans on schedules, and provide clearances shown on Drawings. Install intermediate supports when cable weight exceeds the load-carrying capacity of tray rungs.

H. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.

I. Do not install more than one cable tray splice between supports.

J. Make changes in direction and elevation using manufacturer's recommended fittings.

K. Make cable tray connections using manufacturer's recommended fittings.

L. Seal penetrations through fire and smoke barriers. Comply with requirements in Section 078413 "Penetration Firestopping."

M. Install capped metal sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.

N. Install cable trays with enough workspace to permit access for installing cables.

O. Install barriers to separate cables of different systems, such as power, communications, and data processing, or of different insulation levels, such as 600, 5000, and 15 000 V.

P. Install permanent covers and cover clamps, if used, after installing cable.

Q. Clamp covers on cable trays installed outdoors with heavy-duty clamps.

R. Install warning signs in visible locations on or near cable trays after cable tray installation.

3.2 CABLE TRAY GROUNDING

A. Ground cable trays according to NFPA 70 unless additional grounding is specified. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

B. Cable trays with electrical power conductors shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.

C. Cable trays with single-conductor power conductors shall be bonded together with a grounding conductor run in the tray along with the power conductors and bonded to the tray at 72-inch (1800-mm) intervals. The grounding conductor shall be sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors," and Article 392, "Cable Trays."

D. When using epoxy- or powder-coat painted cable trays as a grounding conductor, completely remove coating at all splice contact points or ground connector attachment. After completing splice-to-grounding-bolt attachment, repair the coated surfaces with coating materials recommended by cable tray manufacturer.

E. Bond cable trays to power source for cables contained within with bonding conductors sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors."

F. In existing construction, remove inactive or dead cables from cable trays.

3.3 CONNECTIONS

A. Remove paint from all connection points before making connections. Repair paint after the connections are completed.

B. Connect raceways to cable trays according to requirements in NEMA VE 2 and NEMA FG 1.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements.

2. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable trays, vibrations, and thermal expansion and contraction conditions, which may cause or have caused damage.
3. Verify that the number, size, and voltage of cables in cable trays do not exceed that permitted by NFPA 70. Verify that communications or data-processing circuits are separated from power circuits by barriers or are installed in separate cable trays.
4. Verify that there are no intruding items, such as pipes, hangers, or other equipment, in the cable tray.
5. Remove dust deposits, industrial process materials, trash of any description, and any blockage of tray ventilation.
6. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.
7. Check for improperly sized or installed bonding jumpers.
8. Check for missing, incorrect, or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
9. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable trays. Test entire cable tray system for continuity. Maximum allowable resistance is 1 ohm.

B. Prepare test and inspection reports.

3.5 PROTECTION

A. Protect installed cable trays and cables.

1. Install temporary protection for cables in open trays to safeguard exposed cables against falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials and shall remain in place until the risk of damage is over.
2. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
3. Repair damage to paint finishes with matching touchup coating recommended by cable tray manufacturer.

END OF SECTION 260536

SECTION 260539 - UNDERFLOOR RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Flat-top, single- or multichannel, underfloor raceways.
2. Flush, flat-top underfloor raceways.
3. Cellular metal underfloor raceways.
4. Trench-type underfloor raceways.
5. Supports, raceway fittings, and hardware.
6. Junction boxes.
7. Service fittings.

1.2 ACTION SUBMITTALS

A. Product Data: For underfloor raceway components, fittings, and accessories.

B. Shop Drawings: For underfloor raceways.

1. Include floor plans, elevations, sections, and details.
2. Identify components and accessories, such as expansion-joint assemblies, straight raceway lengths, preset and afterset inserts, and service fittings.
3. Provide dimensions locating raceway header and distribution elements. Include spacing between preset inserts and between preset inserts and ends of duct runs, walls, columns, junction boxes, and header duct connections.
4. Provide raceway fill charts for each duct size provided for each conductor size the duct is identified to accept.
5. Show connections between raceway elements and relationships between components and adjacent structural and architectural elements, including slab reinforcement, floor finish work, permanent partitions, expansion joints, architectural module lines, and pretensioning or post-tensioning components.
6. Indicate height of preset inserts, junction boxes, and raceways coordinated with depth of concrete slab and floor fill.
7. Indicate thickening of slabs where required for adequate encasement of raceway components.
8. Document coordination of exposed components with floor-covering materials to ensure that fittings and trim are suitable for indicated floor-covering material.
9. Revise locations from those indicated in the Contract Documents, as required to suit field conditions and to ensure a functioning layout. Identify proposed deviations from the Contract Documents.
10. Show details of connections and terminations of underfloor raceways at panelboards and communication terminal equipment in equipment rooms, wire closets, and similar spaces.
11. Identify those cells of cellular floor deck that are to be connected and fitted.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

B. Project record documents.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

B. Comply with UL 884.

C. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Jacks, Receptacles, and Fittings:

1. Comply with Section 262726 "Wiring Devices" for power outlets, faceplates, and connectors.
2. Comply with Section 271513 "Communications Copper Horizontal Cabling" for twisted pair jacks, outlets, assemblies, and faceplates.
3. Comply with Section 271523 "Communications Optical Fiber Horizontal Cabling" for optical fiber jacks, outlets, assemblies, and faceplates.
4. Comply with Section 271533 "Communications Coaxial Horizontal Cabling" for coaxial jacks, outlets, assemblies, and faceplates.

2.2 FLAT-TOP, STEEL UNDERFLOOR RACEWAYS

A. Description: Steel, rectangular, flat-top, single-channel raceways with premanufactured inserts.

B. Source Limitations: Obtain underfloor raceway components for each system through single source from single manufacturer.

C. Material: As directed, one-piece, continuous weld, minimum 0.0598-inch- (1.5-mm-) thick steel, with corrosion-resistant or galvanized coating inside and out after welding.

D. Cross-Section Shape: Rectangular, with rounded corners.

E. Number of Longitudinal Channels: As directed, Two, Three or Four, separated by steel wall(s).

F. Minimum Bending Radius for Communication Cables: Combination of raceways, fittings, inserts, junction boxes, service fittings, and mounting and connection arrangements for wiring devices and jacks shall provide a 2-inch- (50-mm-) minimum bending radius for communication cables.

G. Service Raceways: Fitted with preset inserts.

1. Nominal Multichannel Underfloor Raceway Dimensions:

   a. Depth: 1-3/8 inches (35 mm).
   b. Power Service Channel Width: 3-1/2 inches (88 mm) or 4-3/8 inches (110 mm) as directed.
   c. Communication Service Channel Width: 3-1/2 inches (88 mm), 4 inches (100 mm) or 6-1/2 inches (163 mm) as directed.

2. Nominal Single-Channel Underfloor Raceway Dimensions:

   a. Depth: 1-1/2 inches (38 mm).
   b. Power Service Raceway Width: 3-1/4 inches (81 mm).
   c. Communication Service Raceway Width: 3-1/4 inches (81 mm) or 6 inches (150 mm) as directed.
   d. Number of Single-Channel Raceways per Run: One, Two, Three, Four or Five unless otherwise indicated.

3. Preset Inserts: Rectangular or Round as directed.

   a. Spacing: 12 inches (300 mm) or 24 inches (600 mm) o.c. as directed
   b. Size: Rectangular dimensions as required to accommodate mounting and connection of flush- and surface-mounted, single- and multiple-outlet service fittings or to connect to wiring extensions for feeding wall outlets for power, communications or power and communications as directed.
   c. Size: 2 inches (50 mm) in diameter.
   d. Equip each insert with a disposable cover and select insert height so cover is 1/8 inch (3 mm) below surface of concrete.
   e. Arrange insert for optional attachment of flush-, surface-, or wiring-extension service fitting to replace disposable cover. Arrange brackets, mountings, barriers, and floor access covers to support, isolate, and provide access to flush or surface outlet-mounting connector, jack, and receptacle devices.

H. Header Raceways: Single- or Multi channel, without preset inserts (blank raceway) as directed.

1. Nominal Raceway Dimensions:

a. Depth: Same as service raceways, 2-1/2 inches (63 mm), 2-3/4 inches (69 mm), 3 inches (75 mm) or 3-1/2 inches (88 mm).
b. Power Header Raceway Width: 3-1/2 inches (88 mm) or 4-3/8 inches (110 mm) as directed.
c. Communication Header Raceway Width: 3-1/2 inches (88 mm), 4 inches (100 mm) or 6-1/2 inches (163 mm) as directed.

2. Arrangement: In same plane as or Below service raceways as directed.
3. Connections: Arranged to connect with service raceways at single or two-level junction boxes as directed.

2.3 FLUSH, FLAT-TOP UNDERFLOOR RACEWAYS

A. Description: Single or multichannel underfloor raceways installed on floor slab with top of raceway flush with concrete topping added hereafter, and then covered with finish material.

B. Source Limitations: Obtain underfloor raceway components for each system through single source from single manufacturer.

C. Material: Steel.

D. Cross-Section Shape: Rectangular, single channel and multichannel, separated by steel wall(s).

E. Listed and labeled for installation with top flush with concrete floor.

F. Number of Levels: One.

G. Service Raceways: Fitted with preset inserts.

1. Number of Longitudinal Channels per Multichannel Raceway: Two or Three as directed.
2. Number of Single-Channel Raceways per Run: One, Two or Three unless otherwise indicated.
3. Nominal Channel Dimensions: 3 inches (75 mm) wide by 1-1/4 inches (31 mm) deep.
4. Preset Inserts: Threaded opening with removable steel plug that is flush with top of raceway when screwed in place.

a. Spacing: As directed, 12 inches (300 mm) or 24 inches (600 mm) o.c., full length of each service raceway.
b. Arrangement: Stagger insert locations on parallel raceways or channels to accommodate placement of adjacent service fittings.
c. Size: 1-5/8-inch (41-mm) diameter.

H. Trench Duct Cross-under: Fitting attached to underside of trench duct.

1. Nominal Channel Dimensions: Same as service raceways.
2. Arrangement: Offset by depth of trench duct.
3. Connections: Arranged to connect trench duct to flush duct through factory-cut, grommeted openings.

I. Header Raceways: Raceways same as service raceways, except without preset inserts (blank raceway).

1. Nominal Channel Dimensions: Same as service raceways.
2. Arrangement: In same plane as service raceways.
3. Connections: Arranged to connect with service raceways at junction boxes.

2.4 CELLULAR METAL UNDERFLOOR RACEWAYS

A. Description: Multichannel, cellular, underfloor service raceways installed on floor slab with top of raceway flush concrete topping added hereafter, and then covered with finish material.

B. Source Limitations: Obtain underfloor raceway components for each system through single source from single manufacturer.

C. Material: Galvanized-steel sheet, ASTM A653/A653M, Structural Steel (SS), Grade 33 (230) minimum, G60 (Z180) or G90 (Z275) zinc coating as directed.

D. Material: Galvanized- and shop-primed steel sheet, ASTM A653/A653M, Structural Steel (SS), Grade 33 (230), G60 (Z180) zinc coating; with underside surface cleaned, pretreated, and primed with manufacturer's standard gray or white baked-on, rust-inhibitive primer as directed.

E. Number of Longitudinal Cells: Three, separated by steel walls.

F. Nominal Dimensions of Cells:

1. Overall Depth: 1-1/4 inches (31 mm) unless otherwise indicated.
2. Cross-Sectional Area of Cells: Power cells: 5-1/2 sq. in. (34.4 sq. cm); communication system cells: 16 sq. in. (100 sq. cm).

G. Minimum Bending Radius for Communication Cables: Combination of raceways, fittings, inserts, junction boxes, service fittings, and mounting and connection arrangements for wiring devices and jacks shall provide a 2-inch (50-mm) minimum bending radius for communication cables.

H. Service Raceways: Fitted with preset inserts.

1. Preset Inserts: Rectangular-shaped metal housing assemblies arranged to provide electrical outlet access to each cell of each raceway designated for service raceway use. Inserts shall be provided throughout the entire length of each such raceway.

    a. Spacing: 12 inches (300 mm), 24 inches (600 mm) or 30 inches (750 mm) o.c. as directed
    b. Include housing and connecting provisions for a flush or recessed, single-, double-, or triple-outlet service fitting.
    c. Include mounting and connecting provisions for a surface, single- or multiple-outlet service fitting.
    d. Include connecting provisions for a wiring-extension service fitting to feed wall outlets.

e. Equip each insert with a disposable cover plate arranged for installation with top 1/8 inch (3 mm) below surface of concrete. Arrange insert to receive a flush-, recessed-, or wiring-extension service fitting to replace disposable top.

I. Header Assembly: A junction box and raceway arrangement positioned to feed wires and cables to service raceways.

1. Three-compartment junction box connecting blank, multicell cellular or flat-top, multichannel header raceway (no inserts) with cellular service raceways at right angles to header raceway as directed.
2. Cellular header raceway shall be made of the same material and have the same nominal dimensions as service raceways.
3. Provide capability for service raceways to be run in both perpendicular directions at the intersection with header raceway.

2.5 TRENCH-TYPE UNDERFLOOR RACEWAYS

A. Description: Trench-type raceways used as header or feeder raceways to serve service raceways.

B. Source Limitations: Obtain underfloor raceway components for each system through single source from single manufacturer.

C. Trench: Steel, shop or factory welded and fabricated to indicated sizes. Include the following features:

1. Slab Depth Adjustment: Minimum of minus 1/8 inch (3 mm) to plus 5/8 inch (17 mm) before and during concrete placement.
2. Cover Supports: Height adjustable, with leveling screws to rigidly support cover assembly.
3. Screed Strip: Extruded aluminum along both edges at proper elevation without requiring shim material.
4. Trim Strip: Select to accommodate floor finish material.
5. Partitions: Arranged to separate channels and isolate wiring of different systems.
6. Grommeted openings in active floor cells or service raceways.
7. Manufacturer's standard corrosion-resistant finish, applied after fabrication.

D. Cover Plates: Removable, steel plates, 1/4 inch (6 mm) thick, each weighing 60 lb (27 kg) or less with full gasket attached to side units. Fabricate intermediate supports to limit unsupported spans to 15 inches (375 mm) or less. Fabricate covers with appropriate depth recess to receive indicated floor finish.

2.6 SUPPORTS, RACEWAY FITTINGS, AND HARDWARE

A. Source Limitations: Obtain underfloor raceway supports, fittings, and hardware components for each system through single source from single manufacturer.

B. Supports, fittings, and hardware shall be compatible with raceway and outlet system and shall be listed for use with raceway systems and components delivered.

C. Supports: Adjustable for height and arranged to maintain alignment and spacing of raceways during concrete placement. Include hold-down straps.

D. Raceway Fittings: Couplings, expansion-joint sleeves, cross-under offsets, vertical and horizontal elbows, grounding screws, adapters, end caps, and other fittings suitable for use with basic components to form a complete installation.

2.7 JUNCTION BOXES

A. Description: Raceway manufacturer's standard enclosure for indicated type, quantity, arrangement, and configuration of raceways at each raceway junction, intersection, and access location. Include the following accessories and features:

1. Mounting brackets.
2. Escutcheons and holders to accommodate surrounding floor covering.
3. Means for leveling and height adjustment more than 3/8 inch (10 mm) before and after concrete is placed.
4. Boxes shall withstand a minimum 300-lb (136-kg) concentrated load. Internal supports shall be provided as needed to meet this requirement.
5. All boxes shall provide 2-inch- (50-mm-) minimum bend radius for data and communication cables.
6. Raceway Openings: For underfloor raceways and conduits arranged to accommodate raceway layout.
7. Covers shall have appropriate depth recess to receive specific floor finish material.
8. Partitions to separate wiring of different systems.

2.8 SERVICE FITTINGS/ACTIVATIONS

A. Source Limitations: Obtain underfloor raceway service fittings and hardware for each system through single source from single manufacturer.

B. Exposed Parts Finish: Brass or Brushed aluminum as directed.

C. Flush, Single-System Service Fitting for Round Inserts: Include mounting and cover to support and provide access to single connector, jack, or receptacle device; mounted flush with floor within body of insert.

D. Flush, Single- or Multiple-System Service Fitting for Rectangular Inserts: Include mounting, hinged cover, and trim to support and provide access to connector, jack, or receptacle devices mounted flush with floor within insert.

1. Recess-Mounted Service Fitting: Modular fittings compatible with preset inserts. Include device plates for indicated systems and provisions for receptacles, jacks, and connectors. Include hinged flush covers with recessed depth to match thickness of floor finish material. Provide for internally mounted receptacle- and communication-jack and connector assemblies.

E. Surface-Mounted Service Fitting: Modular pedestal type, with locking attachment matched to insert floor opening.

1. Power-outlet, double-faced, surface-mounted unit for duplex receptacle on both sides.
2. Power-outlet, single-faced, surface-mounted unit for duplex receptacle on one side.
3. Communication-outlet, double-faced, surface-mounted unit.

    a. Include bushed openings on both sides; 1-inch (25-mm) minimum diameter; insulated with nonconducting material.
    b. Include provisions for modular dual fiber-optic connector assembly on both sides.
    c. Include provisions for modular dual jack-connector assembly, rated for Category 5, Category 5e or Category 6 on both sides as directed.

4. Communication-outlet, single-faced, surface-mounted unit with bushed opening on one side; 1-inch (25-mm) minimum diameter; insulated with nonconducting material.
5. Combination surface-mounted unit for duplex receptacle on one side and with communication cable connection provision on opposite side.
6. Flush-Mounted Service Fittings: Modular fittings compatible with preset inserts and shall include covers, provisions for receptacles jacks and connector assemblies and wiring extensions to wall-mounted outlets, and associated device plates for indicated systems. Include flush covers, recessed to suit floor finish material.
7. Indicate types and locations of devices on Drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install raceways aligned and leveled and, unless otherwise indicated, parallel or perpendicular to floor supports.

B. Maintain arrangement of conductor services throughout the raceway system.

C. Install a concrete mud slab for support of cellular metal, flush duct, or trench duct raceway. Construct mud slab with wire mesh in the top 1 inch (25 mm) of concrete.

D. Install a vapor barrier between the cellular metal raceway and a substrate in contact with earth.

E. Arrange supports to attain proper elevation, alignment, and spacing of raceways. Fasten supports securely at ends and at intervals not to exceed 60 inches (1500 mm), to prevent movement during concrete pour.

F. Level raceway components with finished slab and make adjustments in raceway component elevation to accommodate indicated floor finishes.

G. Junction Boxes: Install tops level and flush with finished floor. Install blank closure plates or plugs to close unused junction-box openings. Grout boxes in place to prevent movement during construction. Place top covers in inverted position during construction to prevent damage to surface of cover. Reinstall covers in proper position prior to final acceptance of the Work.

H. Install preset inserts per manufacturer's instructions.

I. Adjust supports to maintain a 1/8- to 3/8-inch (3.0- to 10-mm) finished concrete cover over preset inserts.

J. Remove burrs, sharp edges, dents, and mechanical defects.

K. Cap or plug boxes, insert- and service-fitting openings, and open ends of raceways.

L. Install expansion fittings with suitable bonding jumper where raceways cross building expansion joints.

M. Bond underfloor raceway components to create a continuous bonding path.

N. Seal raceways, cells, junction boxes, and inserts, as recommended in writing by underfloor raceway manufacturer, to prevent water, concrete, or foreign matter from entering raceways before and during pouring slab or placing fill.

O. Install a marker at the center of the last insert of each cell and channel of each straight run of metal underfloor service raceway to locate the insert and identify the system.

1. Install markers at last inserts on both sides of permanent walls and at first inserts adjacent to each junction box.
2. Use slotted-head screw to identify electrical power; use Phillips-head screw to identify conventional communications and use another distinctive screw head to identify third system, such as special-purpose wiring.

P. Protect underfloor raceway system from damage. Do not use the installed duct system as working platforms or walkways. Do not allow equipment or heavy traffic over duct during construction period, without first installing ramps over the duct. Ramps shall be designed so that imposed loads are not transferred to the duct. Components of the system that are damaged during construction shall be replaced.

Q. Install concrete surrounding underfloor raceways according to Section 033000 "Cast-in-Place Concrete."

R. Afterset Inserts: Cut, hole saw, and drill slab and raceways to allow for installation at locations indicated on plans.

S. Wiring shall comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and NFPA 70 requirements for wet locations.

3.3 FIELD QUALITY CONTROL

A. Testing Agency: As directed, Owner will engage or Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform visual inspection of interior of each junction box or section of trench raceway to verify absence of dirt, dust, construction debris, and moisture. Replace damaged and malfunctioning components.
2. Prior to and after concrete pour, perform point-to-point tests of ground continuity and resistance of ground path between the most remote accessible fitting on each branch of each underfloor raceway system and the main electrical distribution grounding system.

    a. Determine cause and perform correction of any point-to-point resistance value that exceeds 0.05 ohms.
    b. Comply with NETA Acceptance Testing Specification about safety, suitability of test equipment, test instrument calibration, and test report and records.

D. Prepare test and inspection reports.

3.4 CLEANING

A. Clean and swab out underfloor raceways, inserts, and junction boxes after finish has been applied to floor slab, and remove foreign material, dirt, and moisture. Leave interiors clean and dry.

END OF SECTION 260539

SECTION 260543 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal conduits and fittings, including GRC and PVC-coated steel conduit.
2. Rigid nonmetallic duct.
3. Flexible nonmetallic duct.
4. Duct accessories.
5. Precast concrete handholes.
6. Polymer concrete handholes and boxes with polymer concrete cover.
7. Fiberglass handholes and boxes with polymer concrete cover.
8. Fiberglass handholes and boxes.
9. High density plastic boxes.
10. Precast manholes.
11. Utility structure accessories.

1.2 DEFINITIONS

A. Direct Buried: Duct or a duct bank that is buried in the ground, without any additional casing materials such as concrete.

B. Duct: A single duct or multiple ducts. Duct may be either installed singly or as component of a duct bank.

C. Duct Bank:

1. Two or more ducts installed in parallel, with or without additional casing materials.
2. Multiple duct banks.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Precast or Factory-Fabricated Underground Utility Structures:

a. Include plans, elevations, sections, details, attachments to other work, and accessories.
b. Include duct entry provisions, including locations and duct sizes.
c. Include reinforcement details.
d. Include frame and cover design and manhole chimneys.

e. Include ladder or step details as directed.
f. Include grounding details.
g. Include dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
h. Include joint details.

2. Factory-Fabricated Handholes and Boxes Other Than Precast Concrete:

a. Include dimensioned plans, sections, and elevations, and fabrication and installation details.
b. Include duct entry provisions, including locations and duct sizes.
c. Include cover design.
d. Include grounding details.
e. Include dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

C. Sustainable Design Submittals:

1.4 INFORMATIONAL SUBMITTALS

A. Duct and Duct-Bank Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures. Drawings shall be signed and sealed by a qualified professional engineer.

B. Qualification Data: For professional engineer and testing agency responsible for testing nonconcrete handholes and boxes.

C. Product Certificates: For concrete and steel used in precast concrete manholes and handholes, as required by ASTM C858.

D. Source quality-control reports.

E. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM E329 for testing indicated.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND FITTINGS

A. GRC: Comply with ANSI C80.1 and UL 6.

B. Coated Steel Conduit: PVC-coated GRC or IMC.

1. Comply with NEMA RN 1.
2. Coating Thickness: 0.040 inch (1 mm), minimum.

C. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.

2.2 RIGID NONMETALLIC DUCT

A. Underground Plastic Utilities Duct: Type EPC-80-PVC and Type EPC-40-PVC RNC, complying with NEMA TC 2 and UL 651, with matching fittings complying with NEMA TC 3 by same manufacturer as duct.

B. Underground Plastic Utilities Duct: Type DB-60 PVC and Type DB-120 PVC RNC, complying with NEMA TC 6 & 8 and ASTM F512 for direct burial, with matching fittings complying with NEMA TC 9 by same manufacturer as duct.

C. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.

D. Solvents and Adhesives: As recommended by conduit manufacturer.

2.3 FLEXIBLE NONMETALLIC DUCTS

A. HDPE Duct: As directed, Type EPEC-40 HDPE or Type EPEC-80 HDPE, complying with NEMA TC 7 and UL 651A.

B. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.

2.4 DUCT ACCESSORIES

A. Duct Spacers: Factory-fabricated, rigid, PVC interlocking spacers; sized for type and size of duct with which used and selected to provide minimum duct spacing indicated while supporting duct during concreting or backfilling.

B. Underground-Line Warning Tape: Comply with requirements for underground-line warning tape specified in Section 260553 "Identification for Electrical Systems."

2.5 PRECAST CONCRETE HANDHOLES AND BOXES

A. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom unless open-bottom enclosures are indicated. Frame and cover shall form top of enclosure and shall have load rating consistent with that of handhole or box.

B. Comply with ASTM C858 for design and manufacturing processes.

C. Frame and Cover: Weatherproof cast-iron frame, with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.

D. Frame and Cover: Weatherproof steel frame, with steel cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.

E. Frame and Cover: Weatherproof steel frame, with hinged steel access door assembly with tamper-resistant, captive, cover-securing bolts.

1. Cover Hinges: Concealed, with hold-open ratchet assembly.
2. Cover Handle: Recessed.

F. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

G. Cover Legend: Molded lettering, "ELECTRIC" as indicated for each service.

H. Configuration: Units shall be designed for flush burial and have open, closed or integral closed bottom unless otherwise indicated as directed.

I. Extensions and Slabs: Designed to mate with bottom of enclosure. Same material as enclosure.

1. Extension shall provide increased depth of 12 inches (300 mm).
2. Slab: Same dimensions as bottom of enclosure and arranged to provide closure.

J. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

K. Knockout Panels: Precast openings in walls, arranged to match dimensions and elevations of approaching duct, plus an additional 12 inches (300 mm) vertically and horizontally to accommodate alignment variations.

L. Duct Entrances in Handhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.

M. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.6 POLYMER CONCRETE HANDHOLES AND BOXES WITH POLYMER CONCRETE COVER

A. Description: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.

B. Standard: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.

C. Color: Gray or Green as directed.

D. Configuration: Units shall be designed for flush burial and have open, closed or integral closed bottom unless otherwise indicated.

E. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.

F. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

G. Cover Legend: Molded lettering, "ELECTRIC" as indicated for each service.

H. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.

I. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering duct for secure, fixed installation in enclosure wall.

J. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have factory-installed inserts for cable racks and pulling-in irons.

2.7 FIBERGLASS HANDHOLES AND BOXES WITH POLYMER CONCRETE FRAME AND COVER

A. Description: Sheet-molded, fiberglass-reinforced, polyester resin enclosure joined to polymer concrete top ring or frame.

B. Standard: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.

C. Color: Gray or Green as directed.

D. Configuration: Units shall be designed for flush burial and have open, closed or integral closed bottom unless otherwise indicated.

E. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.

F. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

G. Cover Legend: Molded lettering, "ELECTRIC" as indicated for each service.

H. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.

I. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering duct for secure, fixed installation in enclosure wall.

J. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have factory-installed inserts for cable racks and pulling-in irons.

2.8 FIBERGLASS HANDHOLES AND BOXES

A. Description: Molded of fiberglass-reinforced polyester resin, with covers made of polymer concrete, reinforced concrete, cast iron, hot-dip galvanized-steel diamond plate or fiberglass as directed.

B. Standard: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.

C. Color: Gray or Green as directed.

D. Configuration: Units shall be designed for flush burial and have open, closed or integral closed bottom unless otherwise indicated.

E. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.

F. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

G. Cover Legend: Molded lettering, "ELECTRIC" as indicated for each service.

H. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.

I. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering duct for secure, fixed installation in enclosure wall.

J. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have factory-installed inserts for cable racks and pulling-in irons.

2.9 HIGH-DENSITY PLASTIC BOXES

A. Description: Injection molded of HDPE or copolymer-polypropylene. Cover shall be made of polymer concrete or hot-dip galvanized-steel diamond plate or plastic.

B. Standard: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.

C. Color: Gray or Green as directed.

D. Configuration: Units shall be designed for flush burial and have open, closed or integral closed bottom unless otherwise indicated.

E. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.

F. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

G. Cover Legend: Molded lettering, "ELECTRIC" as indicated for each service.

H. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.

I. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering duct for secure, fixed installation in enclosure wall.

J. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have factory-installed inserts for cable racks and pulling-in irons.

2.10 PRECAST MANHOLES

A. Description: One-piece units and units with interlocking mating sections, complete with accessories, hardware, and features.

B. Comply with ASTM C858.

C. Structural Design Loading: Comply with requirements in "Underground Enclosure Application" Article.

D. Knockout Panels: Precast openings in walls, arranged to match dimensions and elevations of approaching duct, plus an additional 12 inches (300 mm) vertically and horizontally to accommodate alignment variations.

E. Duct Entrances in Manhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.

F. Ground Rod Sleeve: Provide a 3-inch (75-mm) PVC sleeve in manhole floors 2 inches (50 mm) from the wall adjacent to, but not underneath, the duct entering the structure.

G. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

2.11 UTILITY STRUCTURE ACCESSORIES

A. Accessories for Utility Structures: Utility equipment and accessory items used for utility structure access and utility support, listed and labeled for intended use and application.

B. Manhole Frames, Covers, and Chimney Components: Comply with structural design loading specified for manhole.

1. Frame and Cover: As directed, Weatherproof, gray cast iron complying with ASTM A48/A48M, Class 30B or cast aluminum with milled cover-to-frame bearing surfaces; diameter, 26 inches (660 mm) or 29 inches (725 mm).

    a. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

2. Cover Legend: Cast in. Selected to suit system.

    a. Legend: "ELECTRIC-LV" for duct systems with power wires and cables for systems operating at 600 V and less.

3. Manhole Chimney Components: Precast concrete rings with dimensions matched to those of roof opening.

a. Mortar for Chimney Ring and Frame and Cover Joints: Comply with ASTM C270, Type M, except for quantities less than 2.0 cu. ft. (60 L) where packaged mix complying with ASTM C387, Type M, may be used.
b. Seal joints watertight using preformed plastic or rubber complying with ASTM C990. Install sealing material according to sealant manufacturers' written instructions.

C. Manhole Sump Frame and Grate: ASTM A48/A48M, Class 30B, gray cast iron.

D. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2-inch- (50-mm-) diameter eye, and 1-by-4-inch (25-by-100-mm) bolt.

1. Working Load Embedded in 6-Inch (150-mm), 4000-psi (27.6-MPa) Concrete: 13,000-lbf (58-kN) minimum tension.

E. Pulling Eyes in Nonconcrete Walls: Eyebolt with reinforced fastening, 1-1/4-inch- (31-mm-) diameter eye, rated 2500-lbf (11-kN) minimum tension.

F. Pulling-in and Lifting Irons in Concrete Floors: 7/8-inch- (22-mm-) diameter, hot-dip galvanized, bent steel rod; stress relieved after forming; and fastened to reinforcing rod. Exposed triangular opening.

1. Ultimate Yield Strength: 40,000-lbf (180-kN) shear and 60,000-lbf (270-kN) tension.

G. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2-inch (13-mm) ID by 2-3/4 inches (69 mm) deep, flared to 1-1/4 inches (31 mm) minimum at base.

1. Tested Ultimate Pullout Strength: 12,000 lbf (53 kN) minimum.

H. Ground Rod Sleeve: 3-inch (75-mm) PVC sleeve in manhole floors 2 inches (50 mm) from the wall adjacent to, but not underneath, the ducts routed from the facility.

I. Cable Rack Assembly: As directed, Steel, hot-rolled or hot-dip galvanized, except insulators.

1. Stanchions: T-section or channel with provisions to connect to other sections or channels to form a continuous unit; 1-1/2 inches (38 mm) in width by nominal 24 inches (600 mm) long; punched with 14 hook holes on 1-1/2-inch (38-mm) centers for cable-arm attachment.
2. Arms: 1-1/2 inches (38 mm) wide, lengths ranging from 3 inches (75 mm) with 450-lb (204-kg) minimum capacity to 18 inches (450 mm) with 250-lb (114-kg) minimum capacity. Arms shall have slots along full length for cable ties and be arranged for secure mounting in horizontal position at any vertical location on stanchions.
3. Insulators: High-glaze, wet-process porcelain arranged for mounting on cable arms.

J. Cable Rack Assembly: Nonmetallic. Components fabricated from nonconductive, fiberglass-reinforced polymer.

1. Stanchions: Nominal 36 inches (900 mm) high by 4 inches (100 mm) wide, with provisions to connect to other sections to form a continuous unit, with minimum of nine holes for arm attachment.
2. Arms: Arranged for secure, drop-in attachment in horizontal position at any location on cable stanchions, and capable of being locked in position. Arms shall be available in lengths ranging from 3 inches (75 mm) with 450-lb (204-kg) minimum capacity to 20 inches (500 mm) with 250-lb (114-kg) minimum capacity. Top of arm shall be nominally 4 inches (100 mm) wide, and arm shall have slots along full length for cable ties.

K. Duct-Sealing Compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F (2 deg C). Capable of withstanding temperature of 300 deg F (150 deg C) without slump and adhering to clean surfaces of plastic ducts, metallic conduit, conduit and duct coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.

L. Fixed Manhole Ladders: Arranged for attachment to roof or wall and floor of manhole. Ladder and mounting brackets and braces shall be fabricated from nonconductive, structural-grade, fiberglass-reinforced resin or hot-dip galvanized steel as directed.

M. Portable Manhole Ladders: UL-listed, heavy-duty wood or fiberglass specifically designed for portable use for access to electrical manholes. Minimum length equal to distance from deepest manhole floor to grade plus 36 inches (900 mm). One required.

N. Cover Hooks: Heavy duty, designed for lifts 60 lbf (270 N) and greater or Light duty, designed for lifts less than 60 lbf (270 N). Two.

2.12 SOURCE QUALITY CONTROL

A. Test and inspect precast concrete utility structures according to ASTM C1037.

B. Nonconcrete Handhole and Pull-Box Prototype Test: Test prototypes of manholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.

1. Tests of materials shall be performed by an independent testing agency.
2. Strength tests of complete boxes and covers shall be by an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
3. Testing machine pressure gages shall have current calibration certification, complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

PART 3 - EXECUTION

3.1 PREPARATION

A. Coordinate layout and installation of duct, duct bank, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field. Notify Architect if there is a conflict between areas of excavation and existing structures or archaeological sites to remain.

B. Coordinate elevations of duct and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of duct and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct and duct bank will drain to manholes and handholes, and as approved by Architect.

3.2 UNDERGROUND DUCT APPLICATION

A. Duct for Electrical Feeders 600 V and Less: RNC Type EPC-80-PVC or Type EPC-40-PVC, concrete-encased unless otherwise indicated.

B. Duct for Electrical Feeders 600 V and Less: RNC Type EPC-80-PVC or Type EPC-40-PVC, direct-buried unless otherwise indicated.

C. Duct for Electrical Branch Circuits: RNC Type EPC-80-PVC or Type EPC-40-PVC, direct-buried unless otherwise indicated.

D. Bored Underground Duct: Type EPEC-40 HDPE or Type EPEC-80-HDPE unless otherwise indicated.

E. Underground Ducts Crossing Paved Paths, Walks, and, Driveways, Roadways and Railroads as directed: RNC Type EPC-40 PVC, encased in reinforced concrete.

F. Stub-ups: Concrete-encased RNC, GRC or PVC-coated GRC as directed.

3.3 UNDERGROUND ENCLOSURE APPLICATION

A. Handholes and Boxes for 600 V and Less:

1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete. AASHTO HB 17, H-10 or H-20 structural load rating as directed.
2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Precast concrete, AASHTO HB 17, H-20, Polymer concrete, SCTE 77, Tier 15, Fiberglass enclosures with polymer concrete frame and cover, SCTE 77, Tier 15, Fiberglass-reinforced polyester resin, SCTE 77, Tier 15 or High-density plastic, SCTE 77, Tier 15 structural load rating as directed.
3. Units in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Precast concrete, AASHTO HB 17, H-10, Polymer concrete units, SCTE 77, Tier 8, Heavy-duty fiberglass units with polymer concrete frame and cover, SCTE 77, Tier 8 or High-density plastic, SCTE 77, Tier 8 structural load rating as directed.
4. Units Subject to Light-Duty Pedestrian Traffic Only: As directed, Fiberglass-reinforced polyester resin or High-density plastic, structurally tested according to SCTE 77 with 3000-lbf (13 345-N) vertical loading.
5. Cover design load shall not exceed the design load of the handhole or box.

B. Manholes: Precast concrete.

1. Units Located in Roadways and Other Deliberate Traffic Paths by Heavy or Medium Vehicles: H-20 structural load rating according to AASHTO HB 17.
2. Units Not Located in Deliberate Traffic Paths by Heavy or Medium Vehicles: H-10 load rating according to AASHTO HB 17.

3.4 EARTHWORK

A. Excavation and Backfill: Comply with Section 312000 "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.

B. Restoration: Replace area immediately after backfilling is completed or after construction vehicle traffic in immediate area is complete.

C. Restore surface features at areas disturbed by excavation and re-establish original grades unless otherwise indicated. Replace removed sod immediately after backfilling is completed.

D. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Section 329200 "Turf and Grasses" and Section 329300 "Plants."

E. Cut and patch existing pavement in the path of underground duct, duct bank, and underground structures according to "Cutting and Patching" Article in Section 017300 "Execution."

3.5 DUCT AND DUCT-BANK INSTALLATION

A. Where indicated on Drawings, install duct, spacers, and accessories into the duct-bank configuration shown. Duct installation requirements in this Section also apply to duct bank.

B. Install duct according to NEMA TCB 2.

C. Slope: Pitch duct a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope duct from a high point between two manholes, to drain in both directions.

D. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48 inches (1200 mm), 12.5 feet (4 m) or 25 feet (7.5 m) as directed, both horizontally and vertically, at other locations unless otherwise indicated.

1. Duct shall have maximum of two 90 degree bends or the total of all bends shall be no more 180 degrees between pull points.

E. Joints: Use solvent-cemented joints in duct and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent duct do not lie in same plane.

F. Installation Adjacent to High-Temperature Steam Lines: Where duct is installed parallel to underground steam lines, perform calculations showing the duct will not be subject to environmental temperatures above 40 deg C. Where environmental temperatures are calculated

to rise above 40 deg C, and anywhere the duct crosses above an underground steam line, install insulation blankets listed for direct burial to isolate the duct bank from the steam line.

G. End Bell Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches (250 mm) o.c. for 5-inch (125-mm) duct, and vary proportionately for other duct sizes.

H. Terminator Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use manufactured, cast-in-place duct terminators, with entrances into structure spaced approximately 6 inches (150 mm) o.c. for 4-inch (100-mm) duct and vary proportionately for other duct sizes.

I. Building Wall Penetrations: Make a transition from underground duct to GRC at least 10 feet (3 m) outside the building wall, without reducing duct line slope away from the building and without forming a trap in the line. Use fittings manufactured for RNC-to-GRC transition. Install GRC penetrations of building walls as specified in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

J. Sealing: Provide temporary closure at terminations of duct with pulled cables. Seal spare duct at terminations. Use sealing compound and plugs to withstand at least 15-psig (1.03-MPa) hydrostatic pressure.

K. Pulling Cord: Install 200-lbf (1000-N) test nylon cord in empty ducts.

L. Concrete-Encased Ducts and Duct Bank:

1. Excavate trench bottom to provide firm and uniform support for duct. Prepare trench bottoms as specified in Section 312000 "Earth Moving" for pipes less than 6 inches (150 mm) in nominal diameter.
2. Width: Excavate trench 12 inches (300 mm) wider than duct on each side.
3. Width: Excavate trench 3 inches (75 mm) wider than duct on each side.
4. Depth: Install so top of duct envelope is at least 24 inches (600 mm) below finished grade in areas not subject to deliberate traffic, and at least 30 inches (750 mm) below finished grade in deliberate traffic paths for vehicles unless otherwise indicated.
5. Support duct on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
6. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than four or five spacers per 20 feet (6 m) of duct as directed. Place spacers within 24 inches (600 mm) of duct ends. Stagger spacers approximately 6 inches (150 mm) between tiers. Secure spacers to earth and to duct to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
7. Minimum Space between Duct: 3 inches (75 mm) between edge of duct and exterior envelope wall, 2 inches (50 mm) between ducts for like services, and 4 inches (100 mm) between power and communications ducts.
8. Elbows: Use manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct unless otherwise indicated. Extend encasement throughout length of elbow.

9. Elbows: Use manufactured GRC elbows for stub-ups, at building entrances, and at changes of direction in duct run.
10. Reinforcement: Reinforce concrete-encased duct where crossing disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
11. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
12. Concrete Cover: Install a minimum of 3 inches (75 mm) of concrete cover between edge of duct to exterior envelope wall, 2 inches (50 mm) between duct of like services, and 4 inches (100 mm) between power and communications ducts.
13. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
14. Pouring Concrete: Comply with requirements in "Concrete Placement" Article in Section 033000 "Cast-in-Place Concrete." Place concrete carefully during pours to prevent voids under and between duct and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Allow concrete to flow around duct and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-installation application.

M. Direct-Buried Duct and Duct Bank:

1. Excavate trench bottom to provide firm and uniform support for duct. Comply with requirements in Section 312000 "Earth Moving" for preparation of trench bottoms for pipes less than 6 inches (150 mm) in nominal diameter.
2. Width: Excavate trench 12 inches (300 mm) wider than duct on each side.
3. Width: Excavate trench 3 inches (75 mm) wider than duct on each side.
4. Depth: Install top of duct at least 36 inches (900 mm) below finished grade unless otherwise indicated.
5. Set elevation of bottom of duct bank below frost line.
6. Support ducts on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
7. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than four or five spacers per 20 feet (6 m) of duct as directed. Place spacers within 24 inches (600 mm) of duct ends. Stagger spacers approximately 6 inches (150 mm) between tiers. Secure spacers to earth and to ducts to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
8. Install duct with a minimum of 3 inches (75 mm) between ducts for like services and 6 inches (150 mm) between power and communications duct.
9. Elbows: Install manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct direction unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
10. Install manufactured GRC elbows for stub-ups, at building entrances, and at changes of direction in duct.
11. After installing first tier of duct, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand place backfill to 4 inches (100 mm) over duct and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct

connections at end of run and complete backfilling with normal compaction. Comply with requirements in Section 312000 "Earth Moving" for installation of backfill materials.

a. Place minimum 3 inches (75 mm) of sand as a bed for duct. Place sand to a minimum of 6 inches (150 mm) above top level of duct.
b. Place minimum 6 inches (150 mm) of engineered fill above concrete encasement of duct.

N. Underground-Line Warning Tape: As directed, Bury nonconducting or conducting underground line specified in Section 260553 "Identification for Electrical Systems" no less than 12 inches (300 mm) above all concrete-encased duct and duct banks and approximately 12 inches (300 mm) below grade. Align tape parallel to and within 3 inches (75 mm) of centerline of duct bank. Provide an additional warning tape for each 12-inch (300-mm) increment of duct-bank width over a nominal 18 inches (450 mm). Space additional tapes 12 inches (300 mm) apart, horizontally.

3.6 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES, AND BOXES

A. Precast Concrete Handhole and Manhole Installation:

1. Comply with ASTM C891 unless otherwise indicated.
2. Install units level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for proper entrances.
3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch (25-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

B. Elevations:

1. Manhole Roof: Install with rooftop at least 15 inches (375 mm) below finished grade.
2. Manhole Frame: In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames 1 inch (25 mm) above finished grade.
3. Install handholes with bottom below frost line, as directed, below grade.
4. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch (25 mm) above finished grade.
5. Where indicated, cast handhole cover frame integrally with handhole structure.

C. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.

D. Manhole Access: Circular opening in manhole roof; sized to match cover size.

1. Manholes with Fixed Ladders: Offset access opening from manhole centerlines to align with ladder.
2. Install chimney, constructed of precast concrete collars and rings, to support cast-iron frame to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for frame to chimney.

E. Waterproofing: Apply waterproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. Waterproofing materials and installation are specified in Section 071353 "Elastomeric Sheet Waterproofing" or Section 071354 "Thermoplastic Sheet Waterproofing" After duct has been connected and grouted, and before backfilling, waterproof joints and connections, and touch up abrasions and scars. Waterproof exterior of manhole chimneys after mortar has cured at least three days.

F. Dampproofing: Apply dampproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. Dampproofing materials and installation are specified in Section 071113 "Bituminous Dampproofing." After ducts are connected and grouted, and before backfilling, dampproof joints and connections, and touch up abrasions and scars. Dampproof exterior of manhole chimneys after mortar has cured at least three days.

G. Hardware: Install removable hardware, including pulling eyes, cable stanchions, and cable arms, and insulators, as required for installation and support of cables and conductors and as indicated.

H. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.

I. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches (97 mm) for manholes and 2 inches (50 mm) for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

3.7 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of duct, and seal joint between box and extension as recommended by manufacturer.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas and trafficways, set cover flush with finished grade. Set covers of other handholes 1 inch (25 mm) above finished grade.

D. Install handholes and boxes with bottom below frost line, frost line below grade at Project as directed.

E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.

F. Field cut openings for duct according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

G. For enclosures installed in asphalt paving and subject to occasional, nondeliberate, heavy-vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box cover frame. Bottom of ring shall rest on compacted earth.

1. Concrete: 3000 psi (20 kPa), 28-day strength, complying with Section 033000 "Cast-in-Place Concrete," with a troweled finish.
2. Dimensions: 10 inches wide by 12 inches deep (250 mm wide by 300 mm deep).

3.8 GROUNDING

A. Ground underground ducts and utility structures according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.9 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Demonstrate capability and compliance with requirements on completion of installation of underground duct, duct bank, and utility structures.
2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide a minimum 12-inch- (300-mm-) long mandrel equal to duct size minus 1/4 inch (6 mm). If obstructions are indicated, remove obstructions and retest.
3. Test manhole and handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 260526 "Grounding and Bonding for Electrical Systems."

B. Correct deficiencies and retest as specified above to demonstrate compliance.

C. Prepare test and inspection reports.

3.10 CLEANING

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of duct until duct cleaner indicates that duct is clear of dirt and debris. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

B. Clean internal surfaces of manholes, including sump.

1. Sweep floor, removing dirt and debris.
2. Remove foreign material.

END OF SECTION 260543

SECTION 260544 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

B. Related Requirements:

1. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

PART 2 - PRODUCTS

2.1 SLEEVES

A. Wall Sleeves:

1. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. Sleeves for Rectangular Openings:

1. Material: Galvanized sheet steel.
2. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and with no side larger than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
b. For sleeve cross-section rectangle perimeter 50 inches (1270 mm) or more and one or more sides larger than 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

2.2 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
1. Sealing Elements: As directed, EPDM or Nitrile (Buna N) rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: As directed, Carbon steel, Plastic or Stainless steel.
3. Connecting Bolts and Nuts: As directed, Carbon steel, with corrosion-resistant coating, Stainless steel of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.

2.4 GROUT

A. Description: Non-shrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.

B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, non-shrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:

1. Interior Penetrations of Non-Fire-Rated Walls and Floors:

a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."
b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.

2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
3. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.
4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:

1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel or cast-iron pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.

B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION 260544

SECTION 260548.16 - SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Restraint channel bracings.
2. Restraint cables.
3. Seismic-restraint accessories.
4. Mechanical anchor bolts.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.

    a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service member of ICC-ES, OSHPD or an agency acceptable to authorities having jurisdiction as directed.
    b. Annotate to indicate application of each product submitted and compliance with requirements.

B. Delegated-Design Submittal: For each seismic-restraint device.

1. Include design calculations and details for selecting seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Design Calculations: Calculate static and dynamic loading caused by equipment weight, operation, and seismic and wind forces required to select seismic and wind restraints and for designing vibration isolation bases.

    a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.

3. Seismic- and Wind-Restraint Details:

    a. Design Analysis: To support selection and arrangement of seismic and wind restraints. Include calculations of combined tensile and shear loads.
    b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and

values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.

c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.

d. Preapproval and Evaluation Documentation: As directed, by an evaluation service member of ICC-ES, OSHPD or an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints.

B. Qualification Data: For professional engineer and testing agency.

C. Welding certificates.

D. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

B. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Seismic-restraint devices shall have horizontal and vertical load testing and analysis. They shall bear anchorage preapproval from OSHPD in addition to preapproval, showing maximum seismic-restraint ratings, by ICC-ES or another agency acceptable to authorities having jurisdiction. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) that support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

D. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Wind-Restraint Loading:

1. Basic Wind Speed: As directed.
2. Building Classification Category: I, II, III or IV as directed.

3. Minimum 10 lb/sq. ft. (48.8 kg/sq. m) multiplied by maximum area of component projected on vertical plane normal to wind direction and 45 degrees either side of normal.

B. Seismic-Restraint Loading:

1. Site Class as Defined in the IBC: A, B, C, D, E or F as directed.
2. Assigned Seismic Use Group or Building Category as Defined in the IBC: I, II or III as directed.

   a. Component Importance Factor: 1.0 or 1.5 as directed.
   b. Component Response Modification Factor: 1.5, 2.5, 3.5 or 5.0 as directed.
   c. Component Amplification Factor: 1.0 or 2.5 as directed.

3. Design Spectral Response Acceleration at Short Periods (0.2 Second): As directed.
4. Design Spectral Response Acceleration at 1.0-Second Period: As directed.

2.2 RESTRAINT CHANNEL BRACINGS

A. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end, with other matching components, and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.3 RESTRAINT CABLES

A. Restraint Cables: As directed, ASTM A603 galvanized or ASTM A492 stainless-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.4 SEISMIC-RESTRAINT ACCESSORIES

A. Hanger-Rod Stiffener: As directed, Steel tube or steel slotted-support-system sleeve with internally bolted connections or Reinforcing steel angle clamped to hanger rod.

B. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.

C. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings and matched to type and size of anchor bolts and studs.

D. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings and matched to type and size of attachment devices used.

E. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.5 MECHANICAL ANCHOR BOLTS

A. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an evaluation service member of ICC-ES, OSHPD or an agency acceptable to authorities having jurisdiction as directed.

B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods caused by seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.2 SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed

B. Equipment and Hanger Restraints:

1. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
2. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES, OSHPD or an agency acceptable to authorities having jurisdiction providing required submittals for component.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

E. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

F. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.

2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.3 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where connection is terminated to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
2. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
3. Test to 90 percent of rated proof load of device.

B. Seismic controls will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 260548.16

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Color and legend requirements for raceways, conductors, and warning labels and signs.
2. Labels.
3. Bands and tubes.
4. Tapes and stencils.
5. Tags.
6. Signs.
7. Cable ties.
8. Paint for identification.
9. Fasteners for labels and signs.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For each type of label and sign to illustrate composition, size, colors, lettering style, mounting provisions, and graphic features of identification products.

C. Delegated-Design Submittal: For arc-flash hazard study.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with ASME A13.1 and IEEE C2.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Comply with NFPA 70E and Section 260573.19 "Arc-Flash Hazard Analysis" requirements for arc-flash warning labels.

F. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

G. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.2 COLOR AND LEGEND REQUIREMENTS

A. Raceways and Cables Carrying Circuits at 600 V or Less:

1. Black letters on an orange field.
2. Legend: Indicate voltage and system or service type.

B. Color-Coding for Phase- and Voltage-Level Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder and branch-circuit conductors as directed.

1. Color shall be factory applied or field applied for sizes larger than No. 8 AWG if authorities having jurisdiction permit.
2. Colors for 208/120-V Circuits:

a. Phase A: Black.
b. Phase B: Red.
c. Phase C: Blue.

3. Colors for 240-V Circuits:

a. Phase A: Black.
b. Phase B: Red.

4. Colors for 480/277-V Circuits:

a. Phase A: Brown.
b. Phase B: Orange.
c. Phase C: Yellow.

5. Color for Neutral: White or gray.
6. Color for Equipment Grounds: Bare copper, Green or Green with a yellow stripe.
7. Colors for Isolated Grounds: Green two or more yellow stripes.

C. Warning Label Colors:

1. Identify system voltage with black letters on an orange background.

D. Warning labels and signs shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES (915 MM)."

E. Equipment Identification Labels:

1. Black letters on a white field.

2.3 LABELS

A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.

B. Snap-around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameter and that stay in place by gripping action.

C. Self-Adhesive Wraparound Labels: As directed, Preprinted or Write-on, 3-mil- (0.08-mm-) thick, polyester or vinyl flexible label with acrylic pressure-sensitive adhesive.
1. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized such that the clear shield overlaps the entire printed legend.
2. Marker for Labels: Permanent, waterproof, black ink marker recommended by tag manufacturer.
3. Marker for Labels: Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

D. Self-Adhesive Labels: As directed, Polyester or Vinyl, thermal, transfer-printed, 3-mil- (0.08-mm-) thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
1. Minimum Nominal Size:

a. 1-1/2 by 6 inches (37 by 150 mm) for raceway and conductors.
b. 3-1/2 by 5 inches (76 by 127 mm) for equipment.
c. As required by authorities having jurisdiction.

2.4 BANDS AND TUBES

A. Snap-around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches (50 mm) long, with diameters sized to suit diameter and that stay in place by gripping action.

B. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameters of and shrunk to fit firmly around item being identified. Full shrink recovery occurs at a maximum of 200 deg F (93 deg C). Comply with UL 224.

2.5 TAPES AND STENCILS

A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide; compounded for outdoor use.

C. Tape and Stencil: 4-inch (100-mm) wide black stripes on 10-inch (250-mm) centers placed diagonally over orange background and is 12 inches (300 mm) wide. Stop stripes at legends.

D. Floor Marking Tape: 2-inch (50-mm) wide, 5-mil (0.125-mm) pressure-sensitive vinyl tape, with black and white or yellow and black stripes as directed, and clear vinyl overlay.

E. Underground-Line Warning Tape:
1. Tape:

a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
b. Printing on tape shall be permanent and shall not be damaged by burial operations.
c. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.

2. Color and Printing:

a. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, ANSI Z535.4, and ANSI Z535.5.
b. Inscriptions for Red-Colored Tapes: "ELECTRIC LINE, HIGH VOLTAGE".
c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE".

3. Tag: Type I:

a. Pigmented polyolefin, bright colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
b. Width: 3 inches (75 mm).
c. Thickness: 4 mils (0.1 mm).
d. Weight: 18.5 lb/1000 sq. ft. (9.0 kg/100 sq. m).
e. Tensile according to ASTM D882: 30 lbf (133.4 N) and 2500 psi (17.2 MPa).

4. Tag: Type ID:

a. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core; bright colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
b. Width: 3 inches (75 mm).
c. Overall Thickness: 5 mils (0.125 mm).
d. Foil Core Thickness: 0.35 mil (0.00889 mm).
e. Weight: 28 lb/1000 sq. ft. (13.7 kg/100 sq. m).
f. Tensile according to ASTM D882: 70 lbf (311.3 N) and 4600 psi (31.7 MPa).

F. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch (25 mm).

2.6 TAGS

A. Write-on Tags:
1. Polyester Tags: As directed, 0.010 inch (0.25 mm) or 0.015 inch (0.38 mm) thick, with corrosion-resistant grommet and cable tie for attachment.
2. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.

3. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.7 SIGNS

A. Baked-Enamel Signs:
1. Preprinted aluminum signs, high-intensity reflective, punched or drilled for fasteners, with colors, legend, and size required for application.
2. 1/4-inch (6.4-mm) grommets in corners for mounting.
3. Nominal Size: 7 by 10 inches (180 by 250 mm).

B. Metal-Backed Butyrate Signs:
1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs, with 0.0396-inch (1-mm) galvanized-steel backing, punched and drilled for fasteners, and with colors, legend, and size required for application.
2. 1/4-inch (6.4-mm) grommets in corners for mounting.
3. Nominal Size: 10 by 14 inches (250 by 360 mm).

C. Laminated Acrylic or Melamine Plastic Signs:
1. Engraved legend.
2. Thickness:

a. For signs up to 20 sq. in. (129 sq. cm), minimum 1/16 inch (1.6 mm) thick.
b. For signs larger than 20 sq. in. (129 sq. cm), 1/8 inch (3.2 mm) thick.
c. Engraved legend with black letters on white face or white letters on a dark gray background as directed.
d. Punched or drilled for mechanical fasteners with 1/4-inch (6.4-mm) grommets in corners for mounting or Self-adhesive as directed.
e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.8 CABLE TIES

A. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength at 73 Deg F (23 Deg C) according to ASTM D638: 12,000 psi (82.7 MPa).
3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
4. Color: Black, except where used for color-coding.

B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength at 73 Deg F (23 Deg C) according to ASTM D638: 12,000 psi (82.7 MPa).
3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
4. Color: Black.

C. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.

1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength at 73 Deg F (23 Deg C) according to ASTM D638: 7000 psi (48.2 MPa).
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F (Minus 46 to plus 140 deg C).
5. Color: Black.

2.9 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

B. Install identifying devices before installing acoustical ceilings and similar concealment.

C. Verify identity of each item before installing identification products.

D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

E. Apply identification devices to surfaces that require finish after completing finish work.

F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.

G. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

H. System Identification for Raceways and Cables under 600 V: Identification shall completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.

1. Secure tight to surface of conductor, cable, or raceway.

I. System Identification for Raceways and Cables over 600 V: Identification shall completely encircle cable or conduit. Place adjacent identification of two-color markings in contact, side by side.

1. Secure tight to surface of conductor, cable, or raceway.

J. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.

K. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch- (10-mm-) high letters for emergency instructions at equipment used for power transfer or load shedding as directed.

L. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.

M. Accessible Fittings for Raceways: Identify the covers of each junction and pull box of the following systems with the wiring system legend and system voltage. System legends shall be as follows:

1. "EMERGENCY POWER."
2. "POWER."
3. "UPS."

N. Vinyl Wraparound Labels:

1. Secure tight to surface at a location with high visibility and accessibility.
2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.

O. Snap-around Labels: Secure tight to surface at a location with high visibility and accessibility.

P. Self-Adhesive Wraparound Labels: Secure tight to surface of raceway or cable at a location with high visibility and accessibility.

Q. Self-Adhesive Labels:

1. On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.

R. Snap-around Color-Coding Bands: Secure tight to surface at a location with high visibility and accessibility.

S. Heat-Shrink, Preprinted Tubes: Secure tight to surface at a location with high visibility and accessibility.

T. Marker Tapes: Secure tight to surface at a location with high visibility and accessibility.

U. Self-Adhesive Vinyl Tape: Secure tight to surface at a location with high visibility and accessibility.

1. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding.

V. Tape and Stencil: Comply with requirements in painting Sections for surface preparation and paint application.

W. Floor Marking Tape: Apply stripes to finished surfaces following manufacturer's written instructions.

X. Underground Line Warning Tape:

1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches (150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches (400 mm) overall.
2. Limit use of underground-line warning tape to direct-buried cables.
3. Install underground-line warning tape for direct-buried cables and cables in raceways.

Y. Write-on Tags:

1. Place in a location with high visibility and accessibility.
2. Secure using general-purpose, UV-stabilized or plenum-rated cable ties as directed.

Z. Baked-Enamel Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on minimum 1-1/2-inch (38-mm) high sign; where two lines of text are required, use signs minimum 2 inches (50 mm) high.

AA. Metal-Backed Butyrate Signs:

1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on minimum 1-1/2-inch (38-mm) high sign; where two lines of text are required, use signs minimum 2 inches (50 mm) high.

BB. Laminated Acrylic or Melamine Plastic Signs:

1. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch (13-mm) high letters on minimum 1-1/2-inch (38-mm) high sign; where two lines of text are required, use signs minimum 2 inches (50 mm) high.

CC. Cable Ties: General purpose, for attaching tags, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

3.2 IDENTIFICATION SCHEDULE

A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.

C. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits, More Than 30A and 120V to Ground: Identify with self-adhesive raceway labels or vinyl tape applied in bands as directed.

1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.

D. Accessible Fittings for Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive labels containing the wiring system legend and system voltage. System legends shall be as follows:

1. "EMERGENCY POWER."
2. "POWER."
3. "UPS."

E. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use vinyl wraparound labels, self-adhesive wraparound labels, snap-around labels, snap-around color-coding bands or self-adhesive vinyl tape to identify the phase as directed.

1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.

F. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use write-on tags or self-adhesive wraparound labels as directed, with the conductor or cable designation, origin, and destination.

G. Control-Circuit Conductor Termination Identification: For identification at terminations, provide heat-shrink preprinted tubes or self-adhesive wraparound labels as directed, with the conductor designation.

H. Conductors to Be Extended in the Future: As directed, Attach write-on tags or marker tape to conductors and list source.

I. Auxiliary Electrical Systems Conductor Identification: Marker tape or Self-adhesive vinyl tape that is uniform and consistent with system used by manufacturer for factory-installed connections as directed.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.

J. Locations of Underground Lines: Underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.

K. Workspace Indication: Apply floor marking tape or tape and stencil to finished surfaces. Show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70

and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

L. Instructional Signs: Self-adhesive labels, including the color code for grounded and ungrounded conductors.

M. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive equipment labels, Baked-enamel warning signs or Metal-backed, butyrate warning signs as directed.

1. Apply to exterior of door, cover, or other access.
2. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:

    a. Power-transfer switches.
    b. Controls with external control power connections.

N. Arc Flash Warning Labeling: Self-adhesive labels.

O. Operating Instruction Signs: Self-adhesive labels, Baked-enamel warning signs, Metal-backed, butyrate warning signs or Laminated acrylic or melamine plastic signs as directed.

P. Emergency Operating Instruction Signs: As directed, Self-adhesive labels, Baked-enamel warning signs, Metal-backed, butyrate warning signs or Laminated acrylic or melamine plastic signs with white legend on a red background with minimum 3/8-inch- (10-mm-) high letters for emergency instructions at equipment used for power transfer or load shedding.

Q. Equipment Identification Labels:

1. Indoor Equipment: Self-adhesive label, Baked-enamel signs, Metal-backed butyrate signs or Laminated acrylic or melamine plastic sign as directed.
2. Outdoor Equipment: Laminated acrylic or melamine sign or Stenciled legend 4 inches (100 mm) high as directed.

END OF SECTION 260553

SECTION 260573.13 - SHORT-CIRCUIT STUDIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes a computer-based, fault-current study to determine the minimum interrupting capacity of circuit protective devices.

1.2 ACTION SUBMITTALS

A. Product Data:

1. For computer software program to be used for studies.
2. Submit the following after the approval of system protective devices submittals. As directed, Submittals shall or may be in digital form.

    a. Short-circuit study input data, including completed computer program input data sheets.
    b. Short-circuit study and equipment evaluation report; signed, dated, and sealed by a qualified professional engineer.

        1) Submit study report for action prior to receiving final approval of distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.
        2) Revised one-line diagram, reflecting field investigation results and results of short-circuit study.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data:

1. For Power Systems Analysis Software Developer.
2. For Power System Analysis Specialist.
3. For Field Adjusting Agency.

B. Product Certificates: For short-circuit study software, certifying compliance with IEEE 399.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Study shall be performed using commercially developed and distributed software designed specifically for power system analysis.

B. Software algorithms shall comply with requirements of standards and guides specified in this Section.

C. Manual calculations are unacceptable.

1. Power System Analysis Software Qualifications: Computer program shall be designed to perform short-circuit studies or have a function, component, or add-on module designed to perform short-circuit studies.
2. Computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

D. Power Systems Analysis Specialist Qualifications: Professional engineer licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

E. Short-Circuit Study Certification: Short-Circuit Study Report shall be signed and sealed by Power Systems Analysis Specialist.

F. Field Adjusting Agency Qualifications:

1. Employer of a NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification responsible for all field adjusting of the Work.
2. A member company of NETA.
3. Acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 POWER SYSTEM ANALYSIS SOFTWARE DEVELOPERS

A. Comply with IEEE 399 and IEEE 551.

1. Analytical features of power systems analysis software program shall have capability to calculate "mandatory" features as listed in IEEE 399.

B. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output.

2.2 SHORT-CIRCUIT STUDY REPORT CONTENTS

A. Executive summary of study findings.

B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.

C. One-line diagram of modeled power system, showing the following:

1. Protective device designations and ampere ratings.
2. Conductor types, sizes, and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, and panelboard designations and ratings.
6. Derating factors and environmental conditions.
7. Any revisions to electrical equipment required by the study.

D. Comments and recommendations for system improvements or revisions in a written document, separate from one-line diagram.

E. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to available short-circuit currents. Verify that equipment withstand ratings exceed available short-circuit current at equipment installation locations.
2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
3. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
4. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in standards to 1/2-cycle symmetrical fault current.

F. Short-Circuit Study Input Data:

1. One-line diagram of system being studied.
2. Power sources available.
3. Manufacturer, model, and interrupting rating of protective devices.
4. Conductors.
5. Transformer data.

G. Short-Circuit Study Output Reports:

1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

    a. Voltage.
    b. Calculated fault-current magnitude and angle.
    c. Fault-point X/R ratio.
    d. Equivalent impedance.

2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

    a. Voltage.
    b. Calculated symmetrical fault-current magnitude and angle.
    c. Fault-point X/R ratio.
    d. Calculated asymmetrical fault currents:

1) Based on fault-point X/R ratio.
2) Based on calculated symmetrical value multiplied by 1.6.
3) Based on calculated symmetrical value multiplied by 2.7.

3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

a. Voltage.
b. Calculated symmetrical fault-current magnitude and angle.
c. Fault-point X/R ratio.
d. No AC Decrement (NACD) ratio.
e. Equivalent impedance.
f. Multiplying factors for 2, 3, 5, and 8-cycle circuit breakers rated on a symmetrical basis.
g. Multiplying factors for 2, 3, 5, and 8-cycle circuit breakers rated on a total basis.

PART 3 - EXECUTION

3.1 POWER SYSTEM DATA

A. Obtain all data necessary for conduct of the study.

B. Gather and tabulate the required input data to support the short-circuit study. Comply with requirements in Section 017839 "Project Record Documents" for recording circuit protective device characteristics. Record data on a Record Document copy of one-line diagram. Comply with recommendations in IEEE 551 as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under direct supervision and control of the engineer in charge of performing the study and shall be by the engineer or its representative who holds NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification.

3.2 SHORT-CIRCUIT STUDY

A. Perform study following the general study procedures contained in IEEE 399.

B. Calculate short-circuit currents according to IEEE 551.

C. Base study on device characteristics supplied by device manufacturer.

D. Extent of electrical power system to be studied is indicated on Drawings.

E. Begin short-circuit current analysis at the service, extending down to system overcurrent protective devices as follows:

1. To normal system low-voltage load buses where fault current is 10 kA or less.
2. Exclude equipment rated 240 V ac or less when supplied by a single transformer rated less than 125 kVA.

F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

G. Include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and apply to low- and medium-voltage, three-phase ac systems. Also account for the fault-current dc decrement to address asymmetrical requirements of interrupting equipment.

H. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and a single line-to-ground fault at each equipment indicated on one-line diagram.

1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

I. Include in the report identification of any protective device applied outside its capacity.

END OF SECTION 260573.13

SECTION 260573.16 - COORDINATION STUDIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes computer-based, overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.

1.2 ACTION SUBMITTALS

A. Product Data:

1. For computer software program to be used for studies.
2. Submit the following after the approval of system protective devices submittals. As directed, Submittals shall or may be in digital form.

    a. Coordination-study input data, including completed computer program input data sheets.
    b. Study and equipment evaluation reports.

3. Overcurrent protective device coordination study report; signed, dated, and sealed by a qualified professional engineer.

    a. Submit study report for action prior to receiving final approval of distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data:

1. For Power System Analysis Software Developer.
2. For Power Systems Analysis Specialist.
3. For Field Adjusting Agency.

B. Product Certificates: For overcurrent protective device coordination study software, certifying compliance with IEEE 399.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Studies shall be performed using commercially developed and distributed software designed specifically for power system analysis.

B. Software algorithms shall comply with requirements of standards and guides specified in this Section.

C. Manual calculations are unacceptable.

D. Power System Analysis Software Qualifications:

1. Computer program shall be designed to perform coordination studies or have a function, component, or add-on module designed to perform coordination studies.
2. Computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

E. Power Systems Analysis Specialist Qualifications: Professional engineer licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

F. Field Adjusting Agency Qualifications:

1. Employer of a NETA ETT-Certified Technician Level III responsible for all field adjusting of the Work.
2. A member company of NETA.
3. Acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 POWER SYSTEM ANALYSIS SOFTWARE DEVELOPERS

A. Comply with IEEE 242 and IEEE 399.

B. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory" features as listed in IEEE 399.

C. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.

2.2 COORDINATION STUDY REPORT CONTENTS

A. Executive summary of study findings.

B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.

C. One-line diagram of modeled power system, showing the following:

1. Protective device designations and ampere ratings.
2. Conductor types, sizes, and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, and panelboard designations.
6. Any revisions to electrical equipment required by the study.
7. Study Input Data: As described in "Power System Data" Article.

    a. Short-Circuit Study Output: As specified in "Short-Circuit Study Output Reports" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260573.13 "Short-Circuit Studies."

D. Protective Device Coordination Study:

1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.

    a. Phase and Ground Relays:

        1) Device tag.
        2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
        3) Recommendations on improved relaying systems, if applicable.

    b. Circuit Breakers:

        1) Adjustable pickups and time delays (long time, short time, and ground).
        2) Adjustable time-current characteristic.
        3) Adjustable instantaneous pickup.
        4) Recommendations on improved trip systems, if applicable.

    c. Fuses: Show current rating, voltage, and class.

E. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:

1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.
2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
3. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
4. Plot the following listed characteristic curves, as applicable:

    a. Power utility's overcurrent protective device.

b. Low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
c. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
d. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
e. Ground-fault protective devices.
f. The largest feeder circuit breaker in each motor-control center and panelboard.

5. Maintain selectivity for tripping currents caused by overloads.
6. Provide adequate time margins between device characteristics such that selective operation is achieved.
7. Comments and recommendations for system improvements.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance of the Work. Devices to be coordinated are indicated on Drawings.

1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

3.2 POWER SYSTEM DATA

A. Obtain all data necessary for conduct of the overcurrent protective device study.

1. Verify completeness of data supplied in one-line diagram on Drawings. Call any discrepancies to Architect's attention.
2. For equipment included as Work of this Project, use characteristics submitted under provisions of action submittals and information submittals for this Project.

B. Gather and tabulate all required input data to support the coordination study. List below is a guide. Comply with recommendations in IEEE 551 for the amount of detail required to be acquired in the field. Field data gathering shall be under direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification.

3.3 COORDINATION STUDY

A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.

B. Comply with IEEE 399 for general study procedures.

C. Base study on device characteristics supplied by device manufacturer.

D. Extent of electrical power system to be studied is indicated on Drawings.

E. Begin analysis at the service, extending down to system overcurrent protective devices as follows:

1. To normal system low-voltage load buses where fault current is 10 kA or less.
2. Exclude equipment rated 240 V ac or less when supplied by a single transformer rated less than 125 kVA.

F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

G. Transformer Primary Overcurrent Protective Devices:

1. Device shall not operate in response to the following:

   a. Inrush current when first energized.
   b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
   c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.

2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.

H. Motor Protection:

1. Select protection for low-voltage motors according to IEEE 242 and NFPA 70.
2. Select protection for motors served at voltages more than 600 V according to IEEE 620.

I. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

J. Generator Protection: Select protection according to manufacturer's written instructions and to IEEE 242.

K. Include the ac fault-current decay from induction motors and apply to low- and medium-voltage, three-phase ac systems. Also account for fault-current dc decrement, to address asymmetrical requirements of interrupting equipment.

L. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and a single line-to-ground fault at each equipment indicated on one-line diagram.

1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

M. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short-circuit ratings.
2. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.
3. Include in the report identification of any protective device applied outside its capacity.

3.4 LOAD-FLOW AND VOLTAGE-DROP STUDY

A. Perform a load-flow and voltage-drop study to determine the steady-state loading profile of the system. Analyze power system performance two times as follows:

1. Determine load flow and voltage drop based on full-load currents obtained in "Power System Data" Article.
2. Determine load flow and voltage drop based on 80 percent of the design capacity of load buses.
3. Prepare load-flow and voltage-drop analysis and report to show power system components that are overloaded or might become overloaded; show bus voltages that are less than as prescribed by NFPA 70.

3.5 MOTOR-STARTING STUDY

A. Prepare the motor-starting study report, noting light flicker for limits proposed by IEEE 141, and applicable standards as directed, and voltage sags so as not to affect operation of other utilization equipment on system supplying the motor.

3.6 FIELD ADJUSTING

A. Adjust relay and protective device settings according to recommended settings provided by the coordination study. Field adjustments shall be completed by the engineering service division of equipment manufacturer under the "Startup and Acceptance Testing" contract portion.

B. Make minor modifications to equipment as required to accomplish compliance with short-circuit and protective device coordination studies.

C. Testing and adjusting shall be by a full-time employee of the Field Adjusting Agency, who holds NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification.

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for all adjustable overcurrent protective devices.

3.7 DEMONSTRATION

A. Engage Power Systems Analysis Specialist to train Owner's maintenance personnel in the following:

1. Acquaint personnel in fundamentals of operating the power system in normal and emergency modes.
2. Hand-out and explain the coordination study objectives, study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpreting time-current coordination curves.
3. For Owner's maintenance staff certified as NETA ETT-Certified Technicians Level III or NICET Electrical Power Testing Level III Technicians, teach how to adjust, operate, and maintain overcurrent protective device settings.

END OF SECTION 260573.16

SECTION 260573.19 - ARC-FLASH HAZARD ANALYSIS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes a computer-based, arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

1.2 ACTION SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Study Submittals: Submit the following submittals after the approval of system protective devices submittals. As directed, Submittals shall or may be in digital form:

1. Arc-flash study input data, including completed computer program input data sheets.
2. Arc-flash study report; signed, dated, and sealed by Power Systems Analysis Specialist.
3. Submit study report for action prior to receiving final approval of distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data:

1. For Power Systems Analysis Software Developer.
2. For Power System Analysis Specialist.
3. For Field Adjusting Agency.

B. Product Certificates: For arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Study shall be performed using commercially developed and distributed software designed specifically for power system analysis.

B. Software algorithms shall comply with requirements of standards and guides specified in this Section.

C. Manual calculations are unacceptable.

D. Power System Analysis Software Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. Computer program shall be designed to perform arc-flash analysis or have a function, component, or add-on module designed to perform arc-flash analysis.
2. Computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

E. Power Systems Analysis Specialist Qualifications: Professional engineer in charge of performing the arc-flash study, analyzing the arc flash, and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

F. Arc-Flash Study Certification: Arc-Flash Study Report shall be signed and sealed by Power Systems Analysis Specialist.

G. Field Adjusting Agency Qualifications:

1. Employer of a NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification responsible for all field adjusting of the Work.
2. A member company of NETA.
3. Acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Comply with IEEE 1584 and NFPA 70E.

B. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory" features as listed in IEEE 399.

2.2 ARC-FLASH STUDY REPORT CONTENT

A. Executive summary of study findings.

B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.

2. Conductor types, sizes, and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings, including derating factors and environmental conditions.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, panelboard designations, and ratings.

D. Study Input Data: As described in "Power System Data" Article.

E. Short-Circuit Study Output Data: As specified in "Short-Circuit Study Output Reports" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260573.13 "Short-Circuit Studies."

F. Protective Device Coordination Study Report Contents: As specified in "Coordination Study Report Contents" Article in Section 260573.16 "Coordination Studies."

G. Arc-Flash Study Output Reports:

1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each equipment location included in the report:

a. Voltage.
b. Calculated symmetrical fault-current magnitude and angle.
c. Fault-point X/R ratio.
d. No AC Decrement (NACD) ratio.
e. Equivalent impedance.
f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

H. Incident Energy and Flash Protection Boundary Calculations:

1. Arcing fault magnitude.
2. Protective device clearing time.
3. Duration of arc.
4. Arc-flash boundary.
5. Restricted approach boundary.
6. Limited approach boundary.
7. Working distance.
8. Incident energy.
9. Hazard risk category.
10. Recommendations for arc-flash energy reduction.

I. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of computer printout.

2.3 ARC-FLASH WARNING LABELS

A. Comply with requirements in Section 260553 "Identification for Electrical Systems" for self-adhesive equipment labels. Produce a 3.5-by-5-inch (76-by-127-mm) self-adhesive equipment label for each work location included in the analysis.

B. Label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:

1. Location designation.
2. Nominal voltage.
3. Protection boundaries.
    a. Arc-flash boundary.
    b. Restricted approach boundary.
    c. Limited approach boundary.
4. Arc flash PPE category.
5. Required minimum arc rating of PPE in Cal/cm squared.
6. Available incident energy.
7. Working distance.
8. Engineering report number, revision number, and issue date.

C. Labels shall be machine printed, with no field-applied markings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals. Proceed with arc-flash study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to arc-flash study may not be used in study.

3.2 ARC-FLASH HAZARD ANALYSIS

A. Comply with NFPA 70E and its Annex D for hazard analysis study.

B. Preparatory Studies: Perform the Short-Circuit and Protective Device Coordination study or studies prior to starting the Arc-Flash Hazard Analysis or obtain results from another source.

1. Short-Circuit Study Output: As specified in "Short-Circuit Study Output Reports" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260573.13 "Short-Circuit Studies."
2. Coordination Study Report Contents: As specified in "Coordination Study Report Contents" Article in Section 260573.16 "Coordination Studies."

C. Calculate maximum and minimum contributions of fault-current size.

1. Maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.
2. Calculate arc-flash energy at 85 percent of maximum short-circuit current according to IEEE 1584 recommendations.
3. Calculate arc-flash energy at 38 percent of maximum short-circuit current according to NFPA 70E recommendations.

4. Calculate arc-flash energy with the utility contribution at a minimum and assume no motor contribution.

D. Calculate the arc-flash protection boundary and incident energy at locations in electrical distribution system where personnel could perform work on energized parts.

E. Include low-voltage equipment locations, except equipment rated 240 V ac or less fed from transformers less than 125 kVA.

F. Calculate the limited, restricted, and prohibited approach boundaries for each location.

G. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators shall be decremented as follows:

1. Fault contribution from induction motors shall not be considered beyond three to five cycles.

H. Arc-flash energy shall generally be reported for the maximum of line or load side of a circuit breaker. However, arc-flash computation shall be performed and reported for both line and load side of a circuit breaker as follows:

1. When the circuit breaker is in a separate enclosure.
2. When the line terminals of the circuit breaker are separate from the work location.

I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

3.3 POWER SYSTEM DATA

A. Obtain all data necessary for conduct of the arc-flash hazard analysis.

1. Verify completeness of data supplied on one-line diagram on Drawings and under "Preparatory Studies" Paragraph in "Arc-Flash Hazard Analysis" Article. Call discrepancies to Architect's attention.
2. For new equipment, use characteristics from approved submittals under provisions of action submittals and information submittals for this Project.

3.4 LABELING

A. Apply one arc-flash label on the front cover of each section of the equipment and on side or rear covers with accessible live parts and hinged doors or removable plates for each equipment included in the study. Base arc-flash label data on highest values calculated at each location.

B. Each piece of equipment listed below shall have an arc-flash label applied to it:

1. Motor-control center.
2. Low-voltage switchboard.

3. Switchgear.
4. Medium-voltage switch.
5. Medium voltage transformers
6. Low voltage transformers. Exclude transformers with high voltage side 240 V or less and less than 125 kVA.
7. Panelboard and safety switch over 250 V.
8. Applicable panelboard and safety switch under 250 V.
9. Control panel.

C. Note on record Drawings the location of equipment where the personnel could be exposed to arc-flash hazard during their work.

1. Indicate arc-flash energy.
2. Indicate protection level required.

3.5 APPLICATION OF WARNING LABELS

A. Install arc-flash warning labels under the direct supervision and control of Power System Analysis Specialist.

3.6 DEMONSTRATION

A. Engage Power Systems Analysis Specialist to train Owner's maintenance personnel in potential arc-flash hazards associated with working on energized equipment and the significance of arc-flash warning labels.

END OF SECTION 260573.19

SECTION 260800 - COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes Cx process requirements for the following electrical components, systems, assemblies, and equipment:

1. Electrical equipment connected to Normal power systems.
2. Electrical equipment connected to Essential power systems that provide an alternative source of power in the absence of power from the Normal power system.
3. Controls and instrumentation.
4. Systems testing and verification, including Normal and Essential power systems, and transitions from Normal to Essential power systems and back.

1.2 DEFINITIONS

A. BoD: Basis-of-Design Document, as defined in Section 019113 "General Commissioning Requirements."

B. Cx: Commissioning, as defined in Section 019113 "General Commissioning Requirements."

C. CxA: Commissioning Authority, as defined in Section 019113 "General Commissioning Requirements."

D. Essential Power Systems: A power system that a facility transitions to in the absence of Normal power. This power includes all systems classified as "standby" or "emergency," including "legally required."

E. Low Voltage: 600 V and below.

F. Medium Voltage: 601 V and above.

G. Normal Power Systems: A power system that provides primary power to a facility.

H. OPR: Owner's Project Requirements, as defined in Section 019113 "General Commissioning Requirements."

I. "Systems," "Assemblies," "Subsystems," "Equipment," and "Components": Where these terms are used together or separately, they shall mean "as-built" systems, assemblies, subsystems, equipment, and components.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For BAS and electrical testing technician.

B. Construction Checklists: Draft construction checklists will be created by CxA for Contractor review.

C. Construction Checklists: Include construction checklists for Normal and Essential power systems, and include controls and instrumentation that comply with requirements in Section 019113 "General Commissioning Requirements" for construction checklists:

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Electrical Testing Technician Qualifications: Technicians to perform electrical Construction Checklist verification tests, Construction Checklist verification test demonstrations, Cx tests, and Cx test demonstrations shall have the following minimum qualifications:

1. Journey level or equivalent skill level. Vocational school four-year-program graduate or an Associate's degree in electrical systems, or similar field.
2. Minimum three years' experience installing, servicing, and operating systems manufactured by approved manufacturer.

B. Testing Equipment and Instrumentation Quality and Calibration: For test equipment and instrumentation required to perform electrical Cx work, perform the following:

1. Submit test equipment and instrumentation list. For each equipment or instrument, identify the following:

    a. Equipment/instrument identification number.
    b. Planned Cx application or use.
    c. Manufacturer, make, model, and serial number.
    d. Calibration history, including certificates from agencies that calibrate the equipment and instrumentation.

2. Test equipment and instrumentation shall meet the following criteria:

    a. Capable of testing and measuring performance within the specified acceptance criteria.
    b. Be calibrated at manufacturer's recommended intervals with current calibration tags permanently affixed to the instrument being used.
    c. Be maintained in good repair and operating condition throughout duration of use on Project.
    d. Be recalibrated/repaired if dropped or damaged in any way since last calibrated.

C. Proprietary Test Instrumentation and Tools:

1. Equipment Manufacturer's Proprietary Instrumentation and Tools: For installed equipment included in the Cx process, test instrumentation and tools manufactured or prescribed by equipment manufacturer to service, calibrate, adjust, repair, or otherwise

work on its equipment or required as a condition of equipment warranty, perform the following:

a. Submit proprietary instrumentation and tools list. For each instrument or tool, identify the following:

   1) Instrument or tool identification number.
   2) Equipment schedule designation of equipment for which the instrument or tool is required.
   3) Manufacturer, make, model, and serial number.
   4) Calibration history, including certificates from agencies that calibrate the instrument or tool, where appropriate.

b. Include a separate list of proprietary test instrumentation and tools in operation and maintenance manuals.

c. Electrical proprietary test instrumentation and tools become property of Owner at the time of Substantial Completion.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 CONSTRUCTION CHECKLISTS

A. Prepare detailed construction checklists for electrical systems, subsystems, equipment, and components. Complete and submit construction checklists.

3.2 CONSTRUCTION CHECKLIST REVIEW

A. Review and provide written comments on draft construction checklists. CxA will create required draft construction checklists and provide them to Contractor.

B. Return draft Construction Checklist review comments within 10 days of receipt.

C. When review comments have been resolved, CxA will provide final construction checklists, marked "Approved for Use, (date)."

D. Use only construction checklists, marked "Approved for Use, (date)."

3.3 GENERAL TESTING REQUIREMENTS

A. Certify that electrical systems, subsystems, and equipment have been installed, calibrated, and started and that they are operating according to the Contract Documents and approved Shop Drawings and submittals.

B. Certify that electrical instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents and approved Shop Drawings and submittals, and that pretest set points have been recorded.

C. Set systems, subsystems, and equipment into operating mode to be tested according to approved test procedures (for example, normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

D. Measure capacities and effectiveness of systems, assemblies, subsystems, equipment, and components, including operational and control functions to verify compliance with acceptance criteria.

E. Test systems, assemblies, subsystems, equipment, and components operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and response according to acceptance criteria.

F. Construction Checklists: Prepare and submit detailed construction checklists for electrical systems, subsystems, equipment, and components.

G. Perform tests using design conditions, whenever possible.

H. If tests cannot be completed because of a deficiency outside the scope of the electrical system, document the deficiency and report it to Owner. After deficiencies are resolved, reschedule tests.

I. If seasonal testing is specified, complete appropriate initial performance tests and documentation and schedule seasonal tests.

J. Coordinate schedule with and perform Cx activities at the direction of the CxA.

K. Comply with Construction Checklist requirements, including material verification, installation checks, startup, and performance tests requirements specified in Sections specifying electrical systems and equipment.

L. Provide technicians, instrumentation, tools, and equipment to complete and document the following:

1. Performance tests.
2. Demonstration of a sample of performance tests.
3. Cx tests.
4. Cx test demonstrations.

3.4 Cx TESTS FOR ELECTRICAL SYSTEMS

A. Verification of Normal Power System Operation:

1. Prerequisites: Acceptance of results for construction checklists for Division 26 electrical components associated with Normal power system.
2. Equipment and Systems to Be Tested: Division 26 electrical equipment.
3. Test Purpose: Verify operation of Normal power system.

4. Test Conditions: Energize components of Normal power system, one at a time.
5. Acceptance Criteria: Proper operation of Normal power system over a 24 or 48-hour period as directed.

B. Verification of Essential Power System Operation:

1. Prerequisites:

   a. Acceptance of results for construction checklists for Division 26 electrical components associated with Essential power system.
   b. Completion of "Verification of Normal Power System Operation" tests.

2. Equipment and Systems to Be Tested: Division 26 electrical equipment.
3. Test Purpose: Verify operation of Essential power system.
4. Test Conditions:

   a. Energize components of Normal power system.
   b. Simulate a failure of Normal power system.

5. Acceptance Criteria: Transfer of power from Normal to Essential power system within OPR.

C. Verification of Control and Instrumentation:

1. Prerequisites: Acceptance of results for construction checklists.

D. Test Purpose: Verify operation of control and monitoring systems for Normal and Essential power systems.

E. Test Conditions:

1. Energize components of Normal power system.
2. Test operation of equipment.

F. Acceptance Criteria: Operation of equipment according to OPR.

END OF SECTION 260800

SECTION 260913 - ELECTRICAL POWER MONITORING AND CONTROL

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes equipment and systems used to monitor and control electrical consumption:

1. Multifunction meters.
2. Power meters.
3. Circuit meters and monitors.
4. Electrical power monitoring system software.
5. Electrical power monitoring and control software.
6. Network configuration software.
7. Monitoring and control of power distribution equipment.
8. System operator interfaces.
9. Desktop workstations.
10. Raceways and boxes.
11. Wires and cables.
12. Identification.

B. Related Requirements:

1. Section 230923.13 "Energy Meters" for electricity meters for HVAC equipment.
2. Section 262713 "Electricity Metering" for equipment to meter electricity consumption and demand for tenant submetering.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: For power monitoring and control equipment.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, method of field assembly, components, and location and size of each field connection.

    a. Attach copies of approved Product Data submittals for products (such as switchboards, switchgear, and motor-control centers) that describe the following:

        1) Location of the meters and gateways, and routing of the connecting wiring.
        2) Details of power monitoring and control features to illustrate coordination among related equipment and power monitoring and control.

3. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data

communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.

4. Include diagrams for power, signal, and control wiring.
5. Surge Suppressors: Data for each device used and where applied.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Design Data:

1. Manufacturer's system installation and setup guides, with data forms to plan and record options and setup decisions.

    a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format on compact disk or portable storage device with a USB interface.
    b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
    c. As-built versions of submittal Product Data.
    d. Names, addresses, e-mail addresses, and 24-hour telephone numbers of Installer and service representatives for the system and products.
    e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing set points and variables.
    f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
    g. Engineering, installation, and maintenance manuals that explain how to do the following:

        1) Design and install new points, panels, and other hardware.
        2) Perform preventive maintenance and calibration.
        3) Debug hardware problems.
        4) Repair or replace hardware.

    h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
    i. Backup copy of graphic files, programs, and database on compact disk or portable storage device with a USB interface.
    j. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
    k. Complete original-issue copies of furnished software, including operating systems, custom programming language, workstation software, and graphics software on compact disk or portable storage device with a USB interface.
    l. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
    m. Owner training materials.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

B. Software and firmware operational documentation.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

1.6 COORDINATION

A. Coordinate features of distribution equipment and power monitoring and control components to form an integrated interconnection of compatible components.

1. Match components and interconnections for optimum performance of specified functions.

B. Coordinate Work of this Section with those in Sections specifying distribution components that are monitored or controlled by power monitoring and control equipment.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Microprocessor-based monitoring and control of electrical power distribution system(s) that includes the following:

1. Electrical meters that monitor, control, and connect to the data transmission network.
2. LAN: High-speed, multi-access, open, nonproprietary, industry-standard communication protocols.
3. As directed, Include PC-based workstation or multiple PC-based workstations with web access, with its operating system and application software, connected to data transmission network.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. UL Compliance: Listed and labeled as complying with UL 61010-1.

2.2 PERFORMANCE REQUIREMENTS

A. Surge Protection: For external wiring of each conductor entry connection to components to protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads.

1. Minimum Protection for Power Lines 120 V and More: SPDs complying with UL 1449, listed and labeled for intended use by an NRTL acceptable to authorities having jurisdiction. Auxiliary panel suppressors complying with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."
2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Lines: Comply with requirements as recommended by manufacturer for type of line being protected.

B. Addressable Devices: All transmitters and receivers shall communicate unique device identification and status reports to monitoring and control clients.

C. Interface with DDC System for HVAC: Provide factory-installed hardware and software to enable the DDC system for HVAC to monitor, display, and record data for use in processing reports.

1. Hardwired Monitoring Points: Electrical power demand (kilowatts), electrical power consumption (kilowatt-hours), power factor.
2. As directed, ASHRAE 135 (BACnet), LonTalk, Modbus or Industry-accepted, open-protocol communication interface with the DDC system for HVAC shall enable the DDC system for HVAC operator to remotely monitor meter information from a DDC system for HVAC operator workstation. Control features and monitoring points displayed locally at metering panel shall be available through the DDC system for HVAC.

D. Backup Power Source:

1. Electrical power distribution equipment served by a backup power source for controls shall have associated power monitoring and control system products that monitor and control such systems and equipment also served from a backup power source.

2.3 MULTIFUNCTION ENERGY METERS

A. Multifunction Energy Meter: Separately mounted, modular, permanently installed, solid-state, digital I/O instrument for power and energy metering and monitoring; complying with UL 61010-1.

1. Capable of metering 4-wire Y, 3-wire Y, 3-wire delta, and single-phase power systems.
2. Equipped with security lock to protect revenue related metering from unauthorized and accidental changes.

B. Environment: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

1. As directed, indoor installation in non-air-conditioned or nontemperature-controlled spaces that have environmental controls to maintain ambient conditions of minus 4 deg to 158 deg F (minus 20 to plus 70 deg C) dry bulb and 5 to 95 percent relative humidity, noncondensing.
2. Comply with IEC 60529 degree of protection code of IP65 for the front of the meter, and code of IP30 for the body.

C. Overvoltage: Comply with UL 61010-1 overvoltage withstand rating for CAT III.

D. Accuracy:

1. Comply with ANSI C12.20, Class 0.5.
2. Neutral Current Measurement: Not more than 0.65 percent.
3. Power Factor: 1.0 percent.
4. Frequency: 0.1 percent.
5. THD: 1.0 percent.
6. Waveform Sampling: 64 per cycle.

E. Data Link:

F. Meter Physical Characteristics:

1. Display: Backlit LCD with antiglare and scratch-resistant lens.
2. Display of Metered Values:

a. One screen to show at least three user-selected values displayed at the same time. Selections available to display shall include the following:

1) All meters.
2) Measurements.
3) THD.
4) Energy.
5) Demand.
6) Minimum and maximum values.
7) Power demand.

G. Sampling Rate: Continuously sample and record voltage and current at a rate not less than 64 samples per cycle, simultaneously on all voltage and current channels of the meter.

H. Meters:

1. Instantaneous, rms:

a. Current: Each phase, neutral and three-phase average.
b. Voltage: L-L each phase, L-L three-phase average, L-N each phase, and L-N three-phase average.
c. Active Power (kW): Each phase and three-phase total.
d. Reactive Power (kVAR): Each phase and three-phase total.
e. Apparent Power (kVA): Each phase and three-phase total.
f. Power Factor: Each phase and three-phase total.

2. Energy:

a. Active Energy (kWh): Three-phase total.

3. Demand, Derived from Instantaneous rms Meters:

a. Current: Present and maximum.

b. Active: Present and maximum.
c. Reactive: Present and maximum.
d. Apparent: Present and maximum.

4. Power Quality Measurements:

a. THD: Current and voltage from measurements simultaneously from the same cycle, as can be calculated from the specified sampling rate.

I. I/O: Two optically isolated digital outputs for KY pulsing or control. Output signal characteristics shall be 150 mA at 200 V.

1. KY Pulse: Generate standard KY pulses for a user-defined increment of metered active energy as follows:

a. User-defined pulse output, associated with kWh.
b. User-defined pulse output, associated with kVARh.

J. Capacities and Characteristics:

1. Power Supply: 120-V ac, 60 Hz.
2. Circuit Connections:

a. Voltage: Measurement autoranging, 60- to 400-V ac L-N. Connect directly to low-voltage (600 V and less) without using voltage transformers. Connect to instrument grade potential transformers secondary at 120 V. Meter impedance shall be 2-megohm L-L or greater. Overload Tolerance: 1500-V ac, rms, continuously.
b. Current: Connect to instrument grade current transformer with a metering range of 5 mA to 6 A. Overcurrent tolerance of the instrument shall be 10 A continuous, 50 A for 10 seconds once per hour, and 120 A for one second per hour.
c. Frequency: 45 to 65 Hz.
d. Time: Input from a GPS receiver to synchronize the internal clock of the instrument and to time-synchronize this instrument with the network to a deviation of not greater than 1 ms.

2.4 POWER METERS

A. Description: Separately mounted, modular, permanently installed, solid-state, digital I/O instrument for power monitoring and control; complying with UL 61010-1.

1. Capable of metering 4-wire Y, 3-wire Y, 3-wire delta, and single-phase power systems.
2. Equipped with security lock to protect revenue related metering from unauthorized and accidental changes.

B. Environment: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

1. As directed, indoor installation in non-air-conditioned or nontemperature-controlled spaces that have environmental controls to maintain ambient conditions of minus 13 to

158 deg F (minus 25 to plus 70 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing.

2. Comply with IEC 60529 degree of protection code of IP51 for the front of the meter, and code of IP30 for the body.

C. Overvoltage: Comply with UL 61010-1 overvoltage withstand rating for CAT III.

D. Accuracy:

1. Comply with ANSI C12.20, Class 0.5.
2. Neutral Current Measurement: Not more than 0.65 percent.
3. Power: 0.6 percent.
4. Power Factor: 0.5 percent.
5. Active Energy: 0.6 percent.
6. Reactive Energy: 2.5 percent.
7. Frequency: 0.05 percent.
8. THD: 1.0 percent.
9. Waveform Sampling: 32 per cycle.

E. Data Link:

1. Provide for firmware and software updates through the communications port.

F. Meter Physical Characteristics:

1. Display: Backlit LCD with antiglare and scratch-resistant lens.
2. Display of Metered Values: One screen to show at least four lines of user-selected values on one screen at the same time. Provide graphical representation of user-selected values. The screen selections available at the display shall include the following:

    a. All meters, including those listed under the following:

        1) Measurements.
        2) THD.
        3) Energy.
        4) Demand.
        5) Minimum and maximum values.
        6) Power demand.

G. Sampling Rate: Continuously sample and record voltage and current at a rate not less than 32 samples per cycle, simultaneously on all voltage and current channels of the meter.

H. Meters:

1. Measurements: Instantaneous, in real time, rms to the 15th harmonic.

    a. Voltage: L-L each phase, L-N each phase, and three-phase average.
    b. Current: Each phase, three-phase average, and neutral.
    c. Unbalanced current, L-L V ac and L-N V ac.
    d. Active Power (+/- kW): Each phase and three-phase total.
    e. Reactive Power (+/- kVAR): Each phase and three-phase total.

f. Apparent Power (+/- kVA): Each phase and three-phase total.
g. Displacement Power Factor: Each phase and three-phase total.
h. Distortion Power Factor: Each phase and three-phase total.
i. Frequency.

2. THD from measurements simultaneously from the same cycle, through 15th harmonic.

a. Voltage THD: L-L each phase, L-N each phase, and three-phase average.
b. Current THD: Each phase and three-phase average.
c. Total demand distortion.

3. Energy: Accumulated, indicate whether in-flow or out-flow, net and absolute values. Store the values in instrument's nonvolatile memory.

a. Active kWh.
b. Reactive kVARh.
c. Apparent kVAh.

4. Demand: Present, last, predicted, peak.

a. Three-phase average current.
b. Three-phase total active power (kW).
c. Reactive power (kVAR).
d. Apparent power (kVA).

5. Minimum and Maximum Values:

a. L-L and L-N voltages.
b. Current in each phase.
c. Power factor.
d. Active power total.
e. Reactive power total.
f. Apparent power total.
g. THD L-L and L-N voltages.
h. THD current in each phase.
i. Frequency.

I. Power Demand, User Selectable:

1. Thermal Demand: Sliding window updated every second for the present demand and at end of the interval for the last interval. Adjustable window that can be set in 1-minute intervals, from 1 to 60 minutes.
2. Block Interval with Optional Subintervals: Adjustable for 1-minute intervals, from 1 to 60 minutes. User-defined parameters for the following block intervals:

a. Sliding block that calculates demand every second, with intervals less than 15 minutes, and every 15 seconds with an interval between 15 and 60 minutes.
b. Fixed block that calculates demand at end of the interval.
c. Rolling block subinterval that calculates demand at end of each subinterval and displays it at end of the interval.

3. Demand Calculation Initiated by a Synchronization Signal:

    a. Signal is a pulse from an external source. Demand period begins with every pulse. Calculation shall be configurable as either a block or rolling block calculation.
    b. Signal is a communication signal. Calculation shall be configurable as either a block or rolling block calculation.
    c. Provide for synchronizing the demand with the internal of this instrument.

J. Data Recording: Store the listed values in instrument's nonvolatile memory, indicate which of the three phases relates to the value. Attach a date and time stamp to the peak values and the alarms.

1. Minimum and maximum of real-time rms measurement.
2. Energy.
3. Demand values.
4. Alarms store the last 40 events.

K. Alarms: Transmit a digital output and show on display when alarmed. Provide for no fewer than 15 metered items. Each alarm shall be user configured, by using the following options:

1. Date and time stamp.
2. Enable-disable (default) or enable.
3. Pickup magnitude.
4. Pickup time delay.
5. Dropout magnitude.
6. Dropout time delay.
7. Alarm type.
8. Alarm label.

L. Output Signals: Provide two mechanical relays, rated not less than 250-V ac, 2-A resistive, and rated for 200-k cycles or more. The relays shall be user configurable in one of the following listed modes:

1. Normal contact closure where the contacts change state for as long as the signal exists.
2. Latched mode when the contacts change state when a pickup signal is received and are held until a dropout signal is received.
3. Timed mode when the contacts change state when a pickup signal is received and are held for a preprogrammed duration.

M. Meter Face:

1. Display: Backlit LCD display, six lines, with antiglare and scratch-resistant lens.
2. Display of Metered Values: One screen to show at least four user-selected values on one screen at the same time.
3. Provide for the reset of metered peak values.

N. Capacities and Characteristics:

1. Power Supply: 120-V ac, 60 Hz.
2. Circuit Connections:

a. Voltage: Measurements autoranging, 60- to 400-V ac L-N. Connect directly to low-voltage (600 V and less) without using voltage transformers. Connect to instrument grade potential transformers secondary at 120 V. Meter impedance shall be 2-megohm L-L or greater. Overload Tolerance: 1500-V ac, rms, continuously.
b. Current: Connect to instrument grade current transformer with a metering range of 5 mA to 6 A. Overcurrent tolerance of the instrument shall be 10 A continuous, 50 A for 10 seconds once per hour, and 120 A for one second per hour.
c. Frequency: 45 to 65 Hz.
d. Time: Input from a GPS receiver to synchronize the internal clock of the instrument and to time-synchronize this instrument with the network to a deviation of not greater than 1 ms.

2.5 CIRCUIT METERS AND MONITORS

A. Description: Separately mounted, modular, permanently installed, solid-state, digital I/O instrument for power monitoring and control; complying with UL 61010-1. Capable of metering 4-wire Y, 3-wire Y, 3-wire delta, and single-phase power systems.

1. Equipped with security lock to protect revenue related metering from unauthorized and accidental changes.

B. Environmental Conditions: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

1. As directed, indoor installation in non-air-conditioned or non-temperature-controlled spaces that have environmental controls to maintain ambient conditions of 14 to 122 deg F (minus 10 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing.
2. Comply with IEC 60529 degree of protection code of IP52 for the front of the meter, and code of IP30 for the back.

C. Overvoltage: Comply with UL 61010-1 overvoltage withstand rating for CAT III.

D. Accuracy:

1. Comply with ANSI C12.20, Class 0.5.
2. For Voltage and Current: 0.5 percent of reading.
3. For Active Power: 0.2 percent.
4. For Active and Reactive Energy: ANSI 12.20, Class 0.2.
5. For Frequency: 0.01 Hz in the range of 45 to 65 Hz.
6. For Power Factor: 0.2 percent from 0.5 leading to 0.5 lagging.

E. Data Link:

1. Modbus TCP:

a. 10/100BaseTX balanced twisted-pair cabling. RJ-45 connector, 100-m link.

b. Optical fiber 100BaseFX, LC duplex connector, 1300-m link. Multimode 62.5/125-microsecond, 2000-m link.
c. Provide for firmware and software updates through the communications port.
d. Ethernet 10/100BaseTX balanced twisted-pair cabling port.
e. Ethernet 10/100BaseTX balanced twisted-pair cabling port, Ethernet to serial line gateway, and embedded web server.

F. Meter Physical Characteristics:

1. Display: Backlit LCD screen with antiglare and scratch-resistant lens.
2. Display of Metered Values: One screen to show at least four lines of user-selected values on one screen at the same time. Provide graphical representation of user-selected values.
3. Allow user to select a date/time format and the ability to create additional screens for user-specified views and custom quantities without overwriting existing standard screens.

G. Sampling Rate:

1. Continuously sample and record voltage and current at a rate not less than 128 samples per cycle, simultaneously on all voltage and current channels of the meter.

H. Meters shall measure, record with time stamp, calculate, and on request display the following:

1. Measurements: Instantaneous, in real time, rms to the 31st or 63rd harmonic as directed:

a. Voltage: L-L each phase, L-L three-phase average, L-N each phase, and L-N three-phase average.
b. Current: Each phase, three-phase average, and neutral.
c. Active Power (kW): Each phase and three-phase total.
d. Reactive Power (kVAR): Each phase and three-phase total.
e. Apparent Power (kVA): Each phase and three-phase total.
f. Displacement Power Factor: Each phase and three-phase total.
g. Distortion Power Factor: Each phase and three-phase total.
h. Frequency.

2. THD from measurements simultaneously from the same cycle, through 31st or 63rd harmonic as directed:

a. Voltage: L-L each phase, L-L three-phase average, L-N each phase, and L-N three-phase average.
b. Current: Each phase, three-phase average, and neutral.

3. Energy: Accumulated, indicate in-flow or out-flow, net and absolute values. Store the values in instrument's nonvolatile memory. Provide for storing accumulated energy at user-defined intervals, up to three intervals per day.

a. Active kWh.
b. Reactive kVARh.
c. Apparent kVAh.

4. Demand: Three-phase totals, present, predicted, peak.

a. Average current.
b. Active power (kW).
c. Reactive power (kVAR).
d. Apparent power (kVA).

5. Average, Minimum and Maximum Values:

a. Record, date and time stamp, and save the minimum and maximum values of all rms metered values since the last reset.

I. Power Demand, User Selectable:

1. Thermal Demand: Sliding window updated every second for the present demand and at end of the interval for the last interval. Adjustable window that can be set in 1-minute intervals, from 1 to 60 minutes.
2. Block Interval with Optional Subintervals: Adjustable for 1-minute intervals, from 1 to 60 minutes. User-defined parameters for the following block intervals:

a. Sliding block that calculates demand every second, with intervals less than 15 minutes, and every 15 seconds with an interval between 15 and 60 minutes.
b. Fixed block that calculates demand at end of the interval.
c. Rolling block subinterval that calculates demand at end of each subinterval and displays it at end of the interval.

3. Demand Calculation Initiated by a Synchronization Signal:

a. Synchronize demand with receipt of a signal pulse from an external source. Demand period begins with every pulse. Calculation shall be configurable as either a block or rolling block calculation.
b. Synchronize demand with receipt of a communication signal. Calculation shall be configurable as either a block or rolling block calculation.
c. Provide for synchronization to the clock in the instrument.

J. Trend Curves: Provide for recording four trend curves at intervals of one minute, one hour, one day, or one month; and forecast values for the trended parameters.

1. Record minimum, maximum, and average values of eight user-selected parameters as follows:

a. Every second for one minute for the one-minute curve.
b. Every minute for one hour for the one-hour curve.
c. Every hour for one day for the one-day curve.
d. Every day for one month for the one-month curve.

2. Forecast the trended parameters for the following:

a. The next four hours.
b. The next four days.

K. Waveform Capture:

1. Steady State Waveform Capture: Manually initiated.

    a. Capture, record with time stamp, and store voltage and current waveforms for two cycles.
    b. Capture, record with time stamp, and store 128 digitally sampled data points for each cycle of each phase voltage. The number of waveform captures stored onboard shall be user configurable.
    c. Harmonic analysis performed on the captured waveforms shall resolve harmonics through the 63rd.
    d. Captured waveforms shall be recorded from actual circuit performance.

2. Disturbance Waveform Capture:

    a. Capture, record with time stamp, and store 128 digitally sampled data points for each cycle of each phase voltage. Disturbance waveform capture may be initiated manually, by an external contact closure, or by an alarm. The waveform captures shall be user configurable from 185 cycles on 1 channel at 16 points per cycle, to 3 cycles on 6 channels at 128 points per cycle.

L. Disturbance Detection and Alarm:

1. Detect and initiate alarm when detecting voltage or current sag and swell.

    a. Detect disturbance events of less than half-cycle in length, by monitoring and calculating rms magnitude of each half-cycle.
    b. Event detection shall be with user-defined parameters of threshold and delay. The threshold shall be user defined as a fixed or relative set point. With relative set point, the instrument will alarm based on the nominal current or voltage equal to its present average value. The instrument shall automatically adjust the nominal current and voltage values to avoid nuisance alarms caused by gradual daily variations of currents and voltages.
    c. When detecting an alarm condition:

        1) Initiate disturbance waveform capture.
        2) Record the disturbance parameters into an onboard alarm log with a date and time stamp to the millisecond.
        3) Alarm on shall be visible on the display and be transmitted over the data link.
        4) Display the voltage sag/swell events on ITIC or SEMI graphs to quantify the event for accepted industry standards.

M. Harmonics Information:

1. Calculate the harmonic magnitudes and angles for each phase voltage and current through the 63rd harmonic. Provide harmonic power flows up to the 41st harmonic for active, reactive, and apparent power.
2. The current and voltage information for all phases shall be obtained simultaneously from the same cycle.
3. Report harmonic information as a percentage of the fundamental or as a percentage of the rms values, as selected by the user.

N. Alarms: Alarm events shall be user definable. Provide a minimum of 40 user-defined alarm conditions.

1. User Configuration Options:

   a. Date and time stamp.
   b. Enable-disable (default) or enable.
   c. Pickup magnitude.
   d. Pickup time delay.
   e. Dropout magnitude.
   f. Dropout time delay.
   g. Alarm type.
   h. Alarm label.

2. The following classes of events shall be available to be programmed as alarm events:

   a. Over/under current.
   b. Over/undervoltage.
   c. Current imbalance.
   d. Phase loss, current.
   e. Phase loss, voltage.
   f. Voltage imbalance.
   g. Over kVA.
   h. Over kW or kVAR into/out of load.
   i. Over/under frequency.
   j. Under power factor, true or displacement.
   k. Over THD.
   l. Over demand, current or power.
   m. Reverse power.
   n. Phase reversal.
   o. Status input change.
   p. End of incremental energy interval.
   q. End of demand interval.
   r. Over/under analog inputs.
   s. Current sag/swell.
   t. Voltage sag/swell.

3. For each over/under metered alarm value, provide for the user to define a pickup, dropout, and delay.
4. The circuit meter and monitor alarms response time shall be not less than one second.
5. Provide for up to four alarms to be combined to give a single result using Boolean algebra operations.

O. EN 50160 Evaluation: Report EN 50160 evaluation data in the following formats: summary of active evaluations, summary of evaluation status, detailed information for each evaluated parameter, and detailed information for each abnormal event.

P. I/O Module: Modular, with multiple I/O options to accomplish specified performance and one or more spare positions for future.

1. KY Pulse: Generate a standard KY pulses for a user-defined increment of metered active energy as follows:

    a. User-defined pulse output, associated with kWh.
    b. Alarm pulse output, which turns on the pulsing at user-defined point.

2. Digital Inputs: As follows:

    a. One input connection rated 24- to 125-V ac or -V dc, +/- 10 percent, less than 5-mA burden, 1350-V rms isolation.
    b. Six input connections rated 19- to 30-V dc, 5 mA maximum at 24-V dc. Provide an onboard 24-V dc power supply.
    c. Two input connections rated 20- to 150-V dc or -V ac, 2 mA maximum.

3. Analog inputs, no fewer than two, adjustable from 0- to 5-V dc or 4 to 20 mA.
4. Outputs to operate field-installed relays, no fewer than two, providing 6- to 240-V ac or 6- to 30-V dc, 2 A rms. 5 A maximum for 10 seconds per hour.
5. Analog outputs, no fewer than two, 4- to 20-mA dc into 600 ohms maximum.

Q. Data Recording: Store the listed values in instrument's nonvolatile memory, indicate which of the three phases relates to the value. Attach a date and time stamp to the peak values and the alarms.

1. Data Logs, General: User configurable. Automatically stamp each entry to the millisecond with date and time.

    a. Each log entry shall hold data of up to 96 parameters each.
    b. Each log shall be user configurable to log data at a different user-defined schedule interval.
    c. Provide each log with user-defined event or a minimum/maximum condition that will trigger log file entries.
    d. Configure log entries to be recorded as Fill & Hold or Circular (First in, First out, or FIFO), as defined by the user.

2. Minimum/Maximum Logs:

    a. Minimum/Maximum/Average interval log also logs minimum/maximum/average of selected parameters on a selected interval from a user-selected interval length from 1 to 1440 seconds.
    b. Minimum/Maximum log shall include the time, date, and value for the minimum and maximum of each of the real-time metered values.

3. Alarm Log: Record time, date, event information, and coincident information for each user-defined and automatically initiated alarm or event. Record selected parameters at 100-ms intervals during events and alarms. Automatically stamp each entry to the millisecond with date and time.
4. Waveform Logs: Capture and store waveforms, from 185 cycles on one channel at 16 samples per cycle, up to 3 cycles on six channels at 128 samples per cycle as defined by the user. Waveform log entries shall be externally triggered or forced in response to a user-defined event. Configure log entries to be recorded as Fill & Hold or Circular (FIFO), as defined by the user.

R. Capacities and Characteristics:

1. Power Supply: 120-V ac, 60 Hz.
2. Circuit Connections:

   a. Voltage: Measurement autoranging, 0- to 600-V ac L-L, 0- to 347-V ac L-N. Connect directly to low-voltage (600 V and less) without using voltage transformers. Connect to instrument grade potential transformers secondary at 120 V. Meter impedance shall be 2-megohm L-L or greater. Overload Tolerance: 1500-V ac, rms, continuously.
   b. Current: Connect to instrument grade current transformer with a metering range of 5 mA to 6 A. Overcurrent tolerance of the instrument shall be 10 A continuous, 50 A for 10 seconds once per hour, and 120 A for one second per hour.
   c. Frequency: 45 to 65 Hz.
   d. Time: Input from a GPS receiver to synchronize the internal clock of the instrument and to time-synchronize this instrument with the network to a deviation of not greater than 1 ms.

2.6 PC OPERATING SYSTEM SOFTWARE

A. Description: System software shall monitor, analyze, display, control, and save all the parameters and features available at the connected meter.

B. Software: Configured to run on a portable laptop computer, a single PC, or a tablet computer, with capability for accessing a single meter at a time, at the location of the meter. System is not connected to LAN.

C. Minimum Requirements:

1. Real-time multitasking and multiuser 32 or 64-bit operating system that allows execution of multiple real-time programs and custom program development.
2. Operating system shall be capable of operating Microsoft Windows applications.
3. Scheduling software shall schedule centrally based time and event, temporary, and exception day programs.

2.7 NETWORK CONFIGURATION SOFTWARE

A. Network Management Graphical Interface Features:

1. Add and remove devices in the power monitoring and control network.
2. Application for naming devices based on a user-defined naming scheme.
3. Add and remove I/O servers in the power monitoring and control network.
4. Edit communication properties for devices including timeouts and delays.
5. Display mandatory fields when adding a new device.
6. Allow to manually connect and disconnect serial, Ethernet, modem, and Ethernet gateway sites.
7. Enable and disable devices and sites in the power monitoring and control network without interruption to other devices or sites.
8. Pool modem resources so that the software uses any available modem.

9. Monitor the following diagnostics:

    a. Communication request/response and error rates, and timeouts.
    b. Log acquisition services.

B. Web Reporter: Allow viewing historical data in preformatted report templates via a web browser.

1. Features:

    a. User-configurable report generator to trigger on event, based on a schedule, or manual initiation.
    b. Format reports in HTML, PDF, TIF, Excel, XML, or user-selected printer, or network folder.
    c. Distribution of reports via email.

2. Report on power and demand profiles.
3. Power quality report with CBEMA evaluation.
4. EN 50160 compliance report.
5. 100-ms PQ report.
6. Energy over Period Report:

    a. User-defined rollup interval by day, week, month, or year.
    b. Compare daily energy to the following:

        1) Previous day.
        2) Same day, previous week.
        3) Same day, previous month.
        4) User-defined specific day.

    c. Compare weekly energy to the following:

        1) Previous week.
        2) Same week from previous month.
        3) Same week from previous year.
        4) User-defined specific week.

    d. Compare monthly energy to the following:

        1) Previous month.
        2) Same month from previous year.
        3) User-defined specific month.

    e. Compare annual energy to the following:

        1) Previous year.
        2) User-defined specific year.

7. Energy by daily period report for the user-defined periods. Aggregate consumption of the periods by the day, week, and year.

8. Tabular Report: Show values for multiple measurements and measurements from multiple devices in tabular format.
9. System Configuration Report:

    a. Device name.
    b. Device type.
    c. Device address.
    d. Connection status.
    e. Device protocol.
    f. Device description.

10. Each default report shall include the following:

    a. Summary aggregation of data from the selected devices.
    b. Individual device information.
    c. Raw data.

11. The reporting tool shall provide a graphical interface to create and manage multiple Time of Use schedules:

    a. Tariffs including energy cost rates per kWh, kVARh, and kVAh, and demand charges per kW, kVAR, and kVA.
    b. Off-peak and on-peak times.

2.8 MONITORING AND CONTROL OF POWER DISTRIBUTION EQUIPMENT

A. Power Distribution Equipment: Web-enabled, direct connected to the LAN or intranet.

B. Instrument Transformers: Comply with IEEE C57.13.

1. Potential Transformers: Secondary voltage rating of 120 V and NEMA C12.11 accuracy class of 0.3 with burdens of W, X, and Y.
2. Current Transformers: Burden and accuracy class suitable for connected relays, meters, and instruments.

C. Ethernet Connectivity:

1. Serial communications network shall be wired to an Ethernet server in the incoming section of the equipment. Hardware and cabling required for the connection to the network shall be included within the power distribution equipment.
2. Serial communications devices within the equipment shall be factory addressed and tested to verify reliable communications to the equipment's Ethernet Server.

D. Ethernet Gateways:

1. User configurable; complying with UL 60950-1, and IEEE 802.3, Class 3 PoE.
2. Include provisions to set initial Ethernet parameters via a local operator interface, or standard (RJ-45) Ethernet port, that is accessible from the front of the equipment. Initial setup shall be limited to basic Ethernet addressing parameters, as assigned by Owner.
3. Common Gateway Features:

a. User configurable, with secure password-protected login process.
b. Include communications diagnostic information for serial and Ethernet ports as well as internal health status and memory management information through embedded HTML web pages for viewing using a standard web browser.
c. Allow firmware upgrades through the communications port.

4. Include a "Quick-Start" guide with the equipment to describe the commissioning process for setting the equipment's Ethernet network address and for ensuring trouble-free data access from any PC on the network, using a standard web browser.
5. Implement a common user interface ("look and feel") across all styles of power equipment.

E. Distribution Equipment Monitoring:

1. Main menu and summary pages, factory configured, to display data for each communicating device within the power equipment lineup.
2. Display Data:

a. Circuit summary page to display circuit name, three-phase average rms current, real power (kW), power factor, and breaker status (if applicable).
b. Load current summary page to display circuit name, and phase a, b, and c rms current values.
c. Demand current summary page to display circuit name, and phase a, b, and c average demand current values.
d. Power summary page to display circuit name, present demand power (kW), peak demand power (kW), and recorded time and date.
e. Energy summary page to display circuit name, real energy (kWh), reactive energy (kVARh), and time/date of last reset.
f. For unit substations equipped with dry-type transformer(s) and microbased temperature controller(s), the circuit summary web page listed above shall be augmented with transformer coil temperatures, phase a, b and c current values, and cooling fan status (on/off).
g. For motor-control centers, the circuit summary web page shall be tailored specifically for this application, to display circuit name, three-phase average rms current, thermal capacity (percentage), drive output frequency (in Hertz, where applicable), and contactor status.

2.9 SYSTEM OPERATOR INTERFACES

A. Operator means of system access shall be through the following:

1. Desktop workstation with hardwired connection through LAN port.
2. Remote connection using outside of system PC, tablet, or phone using an internet portal.

2.10 DESKTOP WORKSTATIONS

A. Performance Requirements:

1. Performance requirements may dictate equipment exceeding minimum requirements indicated.
2. Capable of running Microsoft Windows.
3. ENERGY STAR compliant.

B. Personal Computer:

1. Minimum Processor Speed: As directed, Core i3, Core i5 or Core i7.
2. RAM:

    a. Capacity: As directed, 2, 4 or 8 GB.
    b. Speed and Type: 1333 MHz.

3. Primary Hard Drive:

    a. Media: As directed, Solid state, Rotating disc, nominal rotational speed of 7200 rpm or Hybrid solid-state and rotating disc.
    b. Number of Hard Drives: One or Two as directed.
    c. Capacity: As directed.
    d. Minimum Average Seek Time: As directed.
    e. Cache Buffer Size: As directed

4. Second Hard Drive:

    a. Media: As directed, Solid state, Rotating disc, nominal rotational speed of 7200 rpm or Hybrid solid-state and rotating disc.
    b. Capacity: As directed.
    c. Minimum Average Seek Time: As directed.
    d. Cache Buffer Size: As directed.

5. Optical Drive:

    a. Type: As directed.
    b. Minimum Average Access Time: As directed.
    c. Data Transfer Speed: As directed, MB or TB/s.
    d. Reading Formats: Data, audio, recordable, and rewritable as directed.

6. Video Card:

    a. Capable of supporting one, two, three or four monitors as directed.
    b. Resolution: 1920 by 1200 pixels minimum for each monitor.
    c. RAM: As directed, GB or TB.

7. Sound Card: High-resolution 16-bit stereo digital audio recording and playback with user-selectable sample rates up to 48,000 Hz.
8. Network Interface Card: Include card with connection, as applicable.

    a. 10-100-1000 base TX Ethernet with RJ45 connector port.

9. Wireless Ethernet, 802.11 a/b/g/n.
10. Optical Modem: Full duplex link for connection to optical fiber cable provided.

11. I/O Ports:

    a. Two USB 3.0 ports on front panel, six on back panel, and three internal on motherboard.
    b. One RJ-45.
    c. One stereo line-in and line-out on back panel.
    d. One microphone and headphone connector on front panel.
    e. One IEEE 1394 on front and back panel with PCI-e card.
    f. One ESATA port on back panel.

12. Battery: Life of at least three years to maintain system clock/calendar and ROM, as a minimum.

C. Keyboard:

1. 101-key enhanced keyboard.
2. Full upper- and lowercase ASCII keyset, numeric keypad, dedicated cursor control keypad, and 12 programmable function keys.

D. Pointing Device:

1. Either a two- or three-button mouse.

E. Flat Panel Display Monitor:

1. Number of Displays: As directed, One or Two.

    a. Display Support: Individual tilt adjustable base. Desk mounted, adjustable bracket capable of supporting number of monitors specified above with integral power and display cable organization. Wall mounted, adjustable bracket capable of supporting number of monitors specified above with integral power and display cable organization.

2. Color display with inches (mm) diagonal as directed, viewable area.
3. Aspect Ratio: 16 to 9.
4. Resolution: 1920 by 1080 pixels at 60 Hz with pixel size of 0.277 mm or smaller.
5. Digital or analog input signal.
6. ENERGY STAR compliant.
7. Antiglare display.

F. Speakers: Two, with individual controls for volume, bass, and treble.

G. I/O Cabling: Include applicable cabling to connect I/O devices.

H. Software:

1. Factory-installed operating system.

2.11 RACEWAYS AND BOXES

A. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for electrical power wiring and NFPA 70 Class 1 remote-control and signaling circuits.

B. Comply with requirements in Section 270528 "Pathways for Communications Systems" for control wiring, and NFPA 70 Class 2 remote-control and signaling circuits.

2.12 WIRES AND CABLES

A. Electrical Power Wiring: Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

1. Copper conductors are Type THHN/THWN-2.

B. Control Wiring:

1. Copper: Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."
2. Optical Fiber: Comply with requirements in Section 271323 "Communications Optical Fiber Backbone Cabling" and 271523 "Communications Optical Fiber Horizontal Cabling."

C. Optical-Fiber Cable: Multimode, 50/125-micrometer OM3, six-fiber, nonconductive, tight-buffer, optical-fiber cable, with aqua jacket.

D. Balanced Twisted-Pair Cable: 100-ohm, four-pair balanced twisted-pair cable, Category 5e or Category 6.

E. Low-Voltage Control Cable: Multiple conductor, color-coded, No. 20 AWG copper, minimum.

1. Sheath: PVC; except in plenum-type spaces, use sheath listed for plenums.
2. Ordinary Switching Circuits: Three conductors unless otherwise indicated.
3. Switching Circuits with Pilot Lights or Locator Feature: Five conductors unless otherwise indicated.

2.13 SURGE PROTECTION DEVICES

A. SPDs: As directed, Comply with UL 1449, Type 1 or Type 2.

1. Include LED indicator lights for power and protection status.
2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
3. Include Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.

B. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 100 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual metal-oxide varistors in a given mode.

C. Comply with UL 1283.

D. Protection modes and UL 1449 SPD for grounded wye circuits with 480Y/277 V or 208Y/120 V as directed, three-phase, four-wire circuits shall not exceed the following:

1. L-N: As directed, 1200 V for 480Y/277 V or 700 V for 208Y/120 V
2. L-G: As directed, 1200 V for 480Y/277 V or 700 V for 208Y/120 V.
3. N-G: As directed, 1200 V for 480Y/277 V or 700 V for 208Y/120 V.
4. L-L: As directed, 2000 V for 480Y/277 V or 1200 V for 208Y/120 V.

E. Protection modes and UL 1449 SPD for 240/120-V, single-phase, three-wire circuits shall not exceed the following:

1. L-N: 700 V.
2. L-G: 700 V.
3. N-G: 700 V.
4. L-L: 1200 V.

F. SCCR: As directed, Equal or exceed 100 or 200 kA.

G. Nominal Rating: As directed, 20 or 10 kA.

H. Indoor Enclosures: NEMA 250, Type 1.

I. Outdoor Enclosures: NEMA 250, Type 3R, Type 4 or Type 4X as directed.

PART 3 - EXECUTION

3.1 POWER MONITORING AND CONTROL SYSTEM INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters. Conceal raceway and cables except in unfinished spaces.

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

D. Wiring and Cabling Installation:

1. Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power wiring.
2. Comply with Section 260523 "Control-Voltage Electrical Power Cables" for control wiring.

E. Raceways Installation:

1. Comply with Section 260533 "Raceways and Boxes for Electrical Systems" for electrical power wiring and NFPA 70 Class 1 remote-control and signaling circuits.
2. Comply with Section 270528 "Pathways for Communications Systems" for control wiring, and NFPA 70 Class 2 remote-control and signaling circuits.

F. Identification Installation:

1. Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power wiring.
2. Comply with Section 271513 "Communications Copper Horizontal Cabling" for identification products and cable management system requirements for UTP and low-voltage control cable.
3. Comply with Section 271523 "Communications Optical Fiber Horizontal Cabling" for identification products and cable management system requirements for optical-fiber cable.

3.2 WORKSTATION INSTALLATION

A. Desktop Workstations Installation:

1. Install workstation(s) at location(s) directed by Owner.
2. Install multiple-receptacle power strip with cord for use in connecting multiple workstation components to a single, duplex electrical power receptacle.
3. Power each workstation through a dedicated UPS unit. Locate UPS adjacent to workstation.
4. Install software on workstation(s) and verify that software functions properly.
5. Develop Project-specific graphics, trends, reports, logs, and historical database.

B. Graphics Application:

1. Use system schematics indicated as starting point to create graphics.
2. Develop Project-specific library of symbols for representing system equipment and products.
3. Incorporate digital images of Project-completed installation into graphics where beneficial to enhance effect.
4. Submit sketch of graphic layout with description of all text for each graphic for Owner's and Architect's review before creating graphic using graphics software.
5. Seek Owner input in graphics development once using graphics software.
6. Final editing shall be done on-site with Owner's review and feedback.
7. Refine graphics as necessary for Owner acceptance.
8. On receiving Owner acceptance, print a hard copy to include in operation and maintenance manual. Prepare a scanned copy PDF file of each graphic and include with softcopy of the system operation and maintenance manual.

3.3 NETWORK NAMING AND NUMBERING

A. Coordinate with Owner and provide unique naming and addressing for networks and devices.

3.4 GROUNDING

A. For data communication wiring, comply with NECA/BICSI 568.

B. For low-voltage control wiring and cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
2. Visually inspect balanced twisted-pair cabling and optical-fiber cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments and inspect cabling connections to confirm compliance with TIA-568-C.1.
3. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
4. Test balanced twisted-pair cabling for direct-current loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination, but not after cross-connection.

    a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in its "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in its "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
    b. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.

5. Optical-Fiber Cable Tests:

    a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.0. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
    b. Link End-to-End Attenuation Tests:

        1) Multimode Link Measurements: Test at 850 or 1300 nm in one direction according to IEC 61280-4-1.

2) Attenuation test results for links shall be less than 2.0 dB or that calculated according to equation in TIA-568-C.0.

c. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide or transfer the data from the instrument to the computer, save as text files, print, and submit.

6. Power Monitoring and Control System Tests.

a. Test Analog Signals:

1) Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2) Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3) Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

b. Test Digital Signals:

1) Check digital signals using a jumper wire.
2) Check digital signals using an ohmmeter to test for contact making or breaking.

c. I/O Control Loop Tests:

1) Test every I/O point to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.
2) Test every I/O point throughout its full operating range.
3) Test every control loop to verify that operation is stable and accurate.
4) Adjust control loop proportional, integral, and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.
5) Test and adjust every control loop for proper operation according to sequence of operation.
6) Test software and hardware interlocks for proper operation.
7) Operate each analog point at the following:

a) Upper quarter of range.
b) Lower quarter of range.
c) At midpoint of range.

8) Exercise each binary point.
9) For every I/O point in the system, read and record each value at operator workstation, at controller, and at field instrument simultaneously. Value displayed at operator workstation and at field instrument shall match.

10) Prepare and submit a report documenting results for each I/O point in the system, and include in each I/O point a description of corrective measures and adjustments made to achieve desire results.

C. Wiring and cabling will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.6 FINAL REVIEW

A. Submit written request to Architect and Construction Manager when the power monitoring and control system is ready for final review. Written request shall state the following:

1. The system has been thoroughly inspected for compliance with Contract Documents and found to be in full compliance.
2. The system has been calibrated, adjusted, and tested and found to comply with requirements of operational stability, accuracy, speed, and other performance requirements indicated.
3. The system monitoring and control of electrical distribution systems results in operation according to sequences of operation indicated.
4. The system is complete and ready for final review.

B. Review by Architect and Construction Manager will be made after receipt of written request. A field report shall be issued to document observations and deficiencies.

C. Take prompt action to remedy deficiencies indicated in field report and submit a second written request when all deficiencies have been corrected. Repeat process until no deficiencies are reported.

D. Final review shall include a demonstration to parties participating in final review.

E. as directed, beginning at Substantial Completion, maintenance service shall include three, six, nine or 12 months' full maintenance by manufacturer's authorized service representative. As directed, include quarterly, semiannual or annual preventive maintenance, repair or replacement of defective components, cleaning, and adjusting as required for proper system operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.7 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.8 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or train Owner's maintenance personnel to adjust, operate, and maintain the power monitoring and control system.

B. Extent of Training:

1. Base extent of training on scope and complexity of power monitoring and control system indicated and training requirements indicated. Provide extent of training required to satisfy requirements indicated even if more than minimum training requirements are indicated.
2. Inform Owner of anticipated training requirements if more than minimum training requirements are indicated.
3. Minimum Training Requirements:

    a. Provide no fewer than two days of training total.
    b. Stagger training over multiple training classes to accommodate Owner's requirements. All training shall occur before end of warranty period.
    c. Total days of training shall be broken into not more than two, three or four separate training classes as directed.
    d. Each training class shall be no fewer than one, two or three consecutive day(s) as directed.

C. Training Outline: Submit training outline for Owner review at least 10 business days before scheduling training. Outline shall include a detailed agenda for each training day that is broken down into each training session that day, training objectives for each training session, and synopses for each lesson planned.

D. On-Site Training:

1. Owner will provide conditioned classroom or workspace with ample desks or tables, chairs, power, and data connectivity for instructor and each attendee.
2. Instructor shall provide training materials, projector, and other audiovisual equipment used in training.
3. Provide as much of training located on-site as deemed feasible and practical by Owner.
4. On-site training shall include regular walk-through tours, as required, to observe each unique product type installed with hands-on review of operation, calibration, and service requirements.
5. The operator workstation provided with the system shall be used in training. If operator workstation is not indicated, provide a temporary workstation to convey training content.

E. Off-Site Training:

1. Provide conditioned training rooms and workspace with ample tables, chairs, power, and data connectivity for each attendee.

2. Provide capability to remotely access to Project monitoring and control system for use in training.
3. Provide a workstation for use by each attendee.

END OF SECTION 260913

SECTION 260923 - LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Time switches.
2. Photoelectric switches.
3. Standalone daylight-harvesting switching and dimming controls.
4. Indoor occupancy and vacancy sensors.
5. Switchbox-mounted occupancy and vacancy sensors
6. Digital timer light switches.
7. High-bay occupancy and vacancy sensors.
8. Outdoor motion sensors.
9. Lighting contactors.

B. Related Requirements:

1. Section 262726 "Wiring Devices" for wall-box dimmers, non-networkable wall-switch occupancy sensors, and manual light switches.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Show installation details for the following:

a. Occupancy sensors.
b. Vacancy sensors.

2. Interconnection diagrams showing field-installed wiring.
3. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and elevations, drawn to scale and coordinated with each other, using input from installers of the items involved.

B. Field quality-control reports.

C. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

B. Software and firmware operational documentation.

1.5 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace lighting control devices that fail(s) in materials or workmanship within specified warranty period.

1. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 TIME SWITCHES

A. Electronic Time Switches: Solid state, programmable, with alphanumeric display; complying with UL 917.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Contact Configuration: SPST, DPST or DPDT as directed.
3. Contact Rating: As directed, 30-A inductive or resistive, 240-V ac or 20-A ballast load, 120-/240-V ac.
4. Programs: Eight on-off set points on a 24-hour schedule and an annual holiday schedule that overrides the weekly operation on holidays.
5. Programs: Two on-off set points on a 24-hour schedule, allowing different set points for each day of the week and an annual holiday schedule that overrides the weekly operation on holidays.
6. Programs: Number of channels as directed; each channel is individually programmable with eight on-off set points on a 24-hour schedule.
7. Programs: Number of channels as directed; each channel is individually programmable with two on-off set points on a 24-hour schedule with a skip-a-day weekly schedule.
8. Programs: Number of channels as directed; each channel is individually programmable with two on-off set points on a 24-hour schedule, allowing different set points for each day of the week.
9. Programs: Number of channels as directed; each channel is individually programmable with 40 on-off operations per week and an annual holiday schedule that overrides the weekly operation on holidays.
10. Programs: Number of channels as directed; each channel is individually programmable with 40 on-off operations per week, plus four seasonal schedules that modify the basic program and an annual holiday schedule that overrides the weekly operation on holidays.
11. Programs: As directed, Configuration and an annual holiday schedule that overrides the weekly operation on holidays.
12. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program on selected channels.
13. Astronomic Time: All or Selected channels. As directed

14. Automatic daylight savings time changeover.
15. Battery Backup: Not less than seven days reserve, to maintain schedules and time clock.

B. Electromechanical-Dial Time Switches: Comply with UL 917.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Contact Configuration: SPST, DPST, SPDT or DPDT as directed.
3. Contact Rating: 30-A inductive or resistive, 240-V ac or 20-A ballast load, 120-/240-V ac as directed.
4. Circuitry: Allows connection of a photoelectric relay as a substitute for the on-off function of a program.
5. Astronomic time dial.
6. Eight-Day Program: Uniquely programmable for each weekday and holidays.
7. Skip-a-day mode.
8. Wound-spring reserve carryover mechanism to keep time during power failures, minimum of 16 hours.

2.2 OUTDOOR PHOTOELECTRIC SWITCHES

A. Description: As directed, Solid state, with SPST or DPST dry contacts rated for 1000 W incandescent or 1800 VA inductive, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A, and compatible with ballasts and LED lamps.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Light-Level Monitoring Range: 1.5 to 10 fc (16.14 to 108 lux), with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of the photocell to prevent fixed light sources from causing turn-off.
3. Time Delay: Fifteen-second minimum, to prevent false operation.
4. Surge Protection: Metal-oxide varistor.
5. Mounting: Twist lock complies with NEMA C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.
6. Failure Mode: Luminaire stays ON.

B. Description: As directed, Solid state; one set of NO dry contacts rated for 24 V dc at 1 A or 24 V ac at 1 A, to operate connected load, complying with UL 773, and compatible with luminaire, power pack or lighting control panelboard as directed.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Light-Level Monitoring Range: 1.5 to 10 fc (16.14 to 108 lux), with an adjustment for turn-on and turn-off levels within that range.
3. Time Delay: Thirty-second minimum, to prevent false operation.
4. Mounting: 1/2-inch (13-mm) threaded male conduit.
5. Failure Mode: Luminaire stays ON.

6. Power Pack: As directed, Dry contacts rated for 20-A, ballast or LED load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.

    a. LED status lights to indicate load status.
    b. Plenum rated.

7. Power Pack: As directed, Digital controller capable of accepting three or four RJ45 inputs with one or two outputs rated for 20-A incandescent or LED load at 120- and 277-V ac, for 13-A or 16-A, ballast or LED at 120- and 277-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, Class 2 power source, as defined by NFPA 70.

    a. With integral current monitoring
    b. Compatible with digital addressable lighting interface.
    c. Plenum rated.

2.3 INDOOR OCCUPANCY AND VACANCY SENSORS

A. General Requirements for Sensors:

1. Wall or Ceiling-mounted, solid-state indoor occupancy and vacancy sensors as directed.
2. Passive infrared, Ultrasonic or Dual technology as directed.
3. Integrated or Separate power pack as directed.
4. Hardwired or Wireless connection to switch and BAS; and BAS and lighting control system as directed.
5. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
6. Operation:

    a. Occupancy Sensor: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
    b. Vacancy Sensor: Unless otherwise indicated, lights are manually turned on and sensor turns lights off when the room is unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
    c. Combination Sensor: Unless otherwise indicated, sensor shall be programmed to turn lights on when coverage area is occupied and turn them off when unoccupied, or to turn off lights that have been manually turned on; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.

7. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A, Sensor is powered from the power pack or Wireless.
8. Power: Line voltage or Integral photovoltaic collector as directed.
9. Power Pack: As directed, Dry contacts rated for 20-A ballast or LED load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
10. Mounting:

    a. Sensor: Suitable for mounting in any position on a standard outlet box.

b. Relay: Externally mounted through a 1/2-inch (13-mm) knockout in a standard electrical enclosure.
c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.

11. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
12. Bypass Switch: Override the "on" function in case of sensor failure.
13. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (21.5 to 2152 lux); turn lights off when selected lighting level is present.

B. PIR Type: As directed, Wall or Ceiling mounted; detect occupants in coverage area by their heat and movement.

1. Detector Sensitivity: Detect occurrences of 6-inch (150-mm) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm).
2. Detection Coverage (Room, Ceiling Mounted): Detect occupancy anywhere in a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch (2440-mm) high ceiling.
3. Detection Coverage (Corridor, Ceiling Mounted): Detect occupancy within 90 feet (27.4 m) when mounted on a 10-foot (3-m) high ceiling.
4. Detection Coverage (Room, Wall Mounted): As directed, detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of 1000 square feet (110 square meters), 2000 square feet (220 square meters) or 3000 square feet (330 square meters) when mounted 48 inches (1200 mm) above finished floor.

C. Ultrasonic Type: As directed, Wall or Ceiling mounted; detect occupants in coverage area through pattern changes of reflected ultrasonic energy.

1. Detector Sensitivity: Detect a person of average size and weight moving not less than 12 inches (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inches/s (305 mm/s).
2. Detection Coverage (Small Room): Detect occupancy anywhere within a circular area of 600 sq. ft. (56 sq. m) when mounted on a 96-inch (2440-mm) high ceiling.
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch (2440-mm) high ceiling.
4. Detection Coverage (Large Room): Detect occupancy anywhere within a circular area of 2000 sq. ft. (186 sq. m) when mounted on a 96-inch (2440-mm) high ceiling.
5. Detection Coverage (Corridor): Detect occupancy anywhere within 90 feet (27.4 m) when mounted on a 10-foot (3-m) high ceiling in a corridor not wider than 14 feet (4.3 m).
6. Detection Coverage (Room, Wall Mounted): As directed, occupants in coverage area using PIR and ultrasonic detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.

7. Sensitivity Adjustment: Separate for each sensing technology.
8. Detector Sensitivity: Detect occurrences of 6-inch (150-mm) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm), and detect a person of average size and weight moving not less than 12 inches (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inches/s (305 mm/s).

9. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch (2440-mm) high ceiling.
10. Detection Coverage (Room, Wall Mounted): As directed, detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of 1000 square feet (110 square meters), 2000 square feet (220 square meters) or 3000 square feet (330 square meters) when mounted 48 inches (1200 mm) above finished floor.

2.4 SWITCHBOX-MOUNTED OCCUPANCY SENSORS

A. General Requirements for Sensors: Automatic-wall-switch occupancy sensor with manual on-off switch, suitable for mounting in a single gang switchbox, with provisions for connection to BAS, using hardwired connection or using wireless connection.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application, and shall comply with California Title 24.
2. Occupancy Sensor Operation: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn lights off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
3. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F (0 to 49 deg C).
4. Switch Rating: Not less than 800-VA ballast or LED load at 120 V, 1200-VA ballast or LED load at 277 V, and 800-W incandescent.

B. Wall-Switch Sensor Tag WS1:

1. Standard Range: 180-degree field of view, field adjustable from 180 to 40 degrees; with a minimum coverage area of 900 sq. ft. (84 sq. m) or 2100 sq. ft (196 sq. m) as directed.
2. Sensing Technology: PIR or Dual technology - PIR and ultrasonic as directed.
3. Switch Type: As directed, SP. SP, dual circuit. SP, manual "on," automatic "off." SP, field-selectable automatic "on," or manual "on," automatic "off."
4. Capable of controlling load in three-way application.
5. Voltage: Match the circuit voltage, 120 V, 277 V or Dual voltage - 120 and 277 V as directed.
6. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc (108 to 1600 lux). The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
7. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
8. Concealed, "off" time-delay selector at 30 seconds and 5, 10, and 20 minutes.
9. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.
10. Color: White or Black as directed.
11. Faceplate: Color matched to switch.

C. Wall-Switch Sensor Tag WS2:

1. Standard Range: 210-degree field of view, with a minimum coverage area of 900 sq. ft. (84 sq. m).
2. Sensing Technology: PIR.
3. Switch Type: SP. SP, dual circuit. SP, manual "on," automatic "off." SP, field-selectable automatic "on," or manual "on," automatic "off."

4. Capable of controlling load in three-way application.
5. Voltage: Match the circuit voltage, 120 V, 277 V or Dual voltage, 120 and 277 V as directed.
6. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc (108 to 1600 lux). The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
7. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
8. Concealed, "off" time-delay selector at 30 seconds and 5, 10, and 20 minutes.
9. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.
10. Color: White or Black as directed.
11. Faceplate: Color matched to switch.

2.5 DIGITAL TIMER LIGHT SWITCH

A. Description: Combination digital timer and conventional switch lighting control unit. Switchbox-mounted, backlit LCD display, with selectable time interval in 10 or 20 minute increments, as directed.

1. Rated 960 W at 120-V ac for tungsten lighting, 10 A at 120-V ac or 10 amps at 277-V ac for ballast or LED, and 1/4 horsepower at 120-V ac.
2. Integral relay for connection to BAS.
3. Voltage: Match the circuit voltage, 120 V, 277 V or Dual voltage - 120 and 277 V as directed.
4. Color: White or Black as directed.
5. Faceplate: Color matched to switch.

2.6 OUTDOOR MOTION SENSORS

A. Description: Solid-state outdoor motion sensors.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application, and shall comply with California Title 24.
2. As directed, PIR or Dual-technology (PIR and ultrasonic) type, weatherproof. Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm). Comply with UL 773A.
3. Switch Rating:

    a. Luminaire-Mounted Sensor: 1000-W incandescent, 500-VA fluorescent/LED.
    b. Separately Mounted Sensor: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.

4. Switch Type: SP. SP, dual circuit. SP, manual "on," automatic "off." SP, field-selectable automatic "on," or manual "on," automatic "off." With bypass switch to override the "on" function in case of sensor failure.
5. Voltage: As directed, Match the circuit voltage, 120-V, 277-V or Dual voltage, 120- and 277-V type.
6. Detector Coverage:

a. Standard Range: 210-degree field of view, with a minimum coverage area of 900 sq. ft. (84 sq. m).
b. Long Range: 180-degree field of view and 110-foot (34-m) detection range.

7. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc (108 to 1600 lux). The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
8. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
9. Concealed, "off" time-delay selector at 30 seconds and 5, 10, and 20 minutes.
10. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and help eliminate false "off" switching.
11. Operating Ambient Conditions: Suitable for operation in ambient temperatures ranging from minus 40 to plus 130 deg F (minus 40 to plus 54 deg C), rated as "raintight" according to UL 773A.

2.7 LIGHTING CONTACTORS

A. Description: As directed, electrically operated and mechanically or electrically held, combination-type lighting contactors with fusible switch or non-fused disconnect, complying with NEMA ICS 2 and UL 508 as directed.

1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less THD of normal load current).
2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
3. Enclosure: Comply with NEMA 250.
4. Provide with control and pilot devices as indicated on Drawings or scheduled, matching the NEMA type specified for the enclosure.

2.8 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cable: As directed, Multiconductor cable with stranded-copper conductors not smaller than No. 18, No. 22 or No. 24 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cable: As directed, Multiconductor cable with stranded-copper conductors not smaller than No. 14, No. 16 or No. 18 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.

C. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.

D. Install and aim sensors in locations to achieve not less than 90-percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

E. Mount electrically held lighting contactors with elastomeric isolator pads to eliminate structure-borne vibration unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.2 WIRING INSTALLATION

A. Wiring Method: Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 1/2 inch (13 mm).

B. Wiring within Enclosures: Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

C. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.3 IDENTIFICATION

A. Identify components and power and control wiring according to Section 260553 "Identification for Electrical Systems."

B. Label time switches and contactors with a unique designation.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.

2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Lighting control devices will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting lighting control devices to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.
2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.
3. Align high-bay occupancy sensors using manufacturer's laser aiming tool.

3.6 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.7 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

END OF SECTION 260923

SECTION 260933 - CENTRAL DIMMING CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes microprocessor-based central dimming controls with the following components:

1. Digital control network.
2. Master-control stations.
3. Partitioned-space master-control stations.
4. Wall stations.
5. Dimmer cabinets.
6. Manual switches and plates for controlling dimmers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Detail assemblies of standard components, custom assembled for specific application on Project. Indicate dimensions, weights, arrangement of components, and clearance and access requirements.

1. Include elevation views of front panels of control and indicating devices and control stations.
2. Include diagrams for power, signal, and control wiring.
3. Address Drawing: Reflected ceiling plan and floor plans, showing connected luminaires, address for each luminaire, and luminaire groups. Base plans on construction plans, using the same legend, symbols, and schedules.
4. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices used. Describe characteristics of network and other data communication lines.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Submit evidence that lighting controls are compatible with connected monitoring and control devices and systems specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

1. For control interfaces and adapters, list network protocols and provide statements from manufacturers that input and output devices comply with interoperability requirements of the protocol.

B. Field quality-control reports.

C. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of central dimming controls that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Cost to repair or replace any parts for two years from date of Substantial Completion.
2. Extended Warranty Period: Cost of replacement parts (materials only, f.o.b. the nearest shipping point to Project site), for eight years, that failed in service due to transient voltage surges.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 SYSTEM DESCRIPTION

A. Compatibility:

1. Dimming control components shall be compatible with luminaires, ballasts, and transformers.
2. Dimming control devices shall be compatible with lighting control system components specified in Section 260943.16 "Addressable-Luminaire Lighting Controls" and Section 260943.23 "Relay-Based Lighting Controls," and in Section 260923 "Lighting Control Devices."

B. Line-Voltage Surge Suppression: Factory installed as an integral part of 120- and 277-V ac, solid-state dimmers and control panels.

1. Alternative Line-Voltage Surge Suppression: Comply with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits" for Category A or Category B locations as directed.

C. Dimmers and Dimmer Modules: Comply with UL 508.

1. Audible Noise and Radio-Frequency Interference Suppression: Solid-state dimmers shall operate smoothly over their operating ranges without audible lamp or dimmer noise or radio-frequency interference. Modules shall include integral or external filters to suppress audible noise and radio-frequency interference.
2. Dimmer or Dimmer-Module Rating: Not less than 125 percent of connected load unless otherwise indicated.

2.3 DIMMING CONTROLS

A. Description: Microprocessor-based, solid-state controls consisting of master-control station, wall stations, and dimmer panels; and a separately mounted dimmer cabinet.

1. Operation: Change variable dimmer settings of indicated number of zones simultaneously from one preset scene to another when a software preset, rocker switch, push button or slider is operated or enabled as directed.
2. Each zone shall be configurable to control the following light sources:

    a. Fluorescent lamps with electronic or magnetic ballasts as directed.
    b. LED lamps.
    c. Incandescent lamps.
    d. Cold cathode lamps.
    e. Non-dimmed loads.

3. Control of each zone shall interface with controls for the following accessory functions:

    a. Curtains and drapes.
    b. Blackout curtains.
    c. Projector screens.
    d. Motorized partitions.
    e. Manually positioned partitions.

4. Memory: Retain preset scenes and fade settings through power failures for at least 90 days by retaining physical settings of controls or by an on-board, automatically recharged battery.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with 47 CFR 15, Subparts A and B, for Class A digital devices.

2.4 TOUCHSCREEN CONTROLS

A. Description: Backlit, color, LCD, touchscreen with 640 by 480 SVGA resolution with 16-bit color graphics. Capable of displaying high resolution media and text.

B. Master-Control Station Screen Size: 5.7 inches (145 mm) or 3.6 inches (91 mm) as directed.

C. Partitioned-Space Master-Control Station Screen Size: 5.7 inches (145 mm) or 3.6 inches (91 mm) as directed.

D. Wall-Station Screen Size: 5.7 inches (145 mm) or 3.6 inches (91 mm) as directed.

E. Control Option: Backlit, push-button controls for on-screen menu navigation with custom engraving.

F. Control Option: Software-defined controls for on-screen menu navigation.

G. Mounting Location: Wall, Rack or Lectern as directed.

H. Device Plates: Style, material, and color shall comply with Section 262726 "Wiring Devices." Master-control cover plate shall be one piece.

I. Powerpack: 12-V dc, 24-V dc or 120-V ac as directed.

J. Communications: Ethernet or Wireless, 802.11g as directed.

2.5 KEYPAD CONTROLS

A. Description: Field configurable, backlit keypad with customized, engraved buttons capable of controlling preset lighting scenes.

B. Mounting: Single, flush wall box.

C. Device Plates: Style, material, and color shall comply with Section 262726 "Wiring Devices" with hinged transparent locking cover.

2.6 CONTROL NETWORK

A. Dimmers shall receive signals from control stations that are linked to dimmer cabinet with a common network data cable.

B. Functions of network control stations shall be set up at master station that include the number and arrangement of scene presets, zones, and fade times at wall stations.

1. Control Voltage: 24- or 10-V dc.
2. Comply with ESTA E1.11/USITT DMX 512-A for data transmission.
3. Communications: Ethernet or Wireless, 802.11g as directed.

2.7 MASTER-CONTROL STATION

A. Functions and Features:

1. Control adjustment of the lighting level for each scene of each zone, and adjustment of fade-time setting for each scene change from one preset scene to another. Controls shall use digital rocker switches with LCD graphic display of light level, keypad controls or touchscreen controls as directed.
2. Master channel shall raise and lower lighting level of all zones.
3. Fade rate for each scene shall be adjustable from zero to 60 seconds.
4. Fade override control for each scene.
5. Recall each preset scene and allow adjustment of zone controls associated with that scene.
6. Lockout switch to prevent changes when set.
7. On and off scene controls for non-dim channel contactors.
8. Emergency-control push button to bypass all controls, turning all dimmers to full bright and turning on non-dim channel contactors.
9. Master on and off switch; off position enables housekeeping controls.
10. Housekeeping controls to turn on selected luminaires for housekeeping functions.
11. Controls for accessory functions.

12. Enable and disable wall stations.
13. Communications link to other master stations.
14. Provide interface to program the master station.
15. Rear-illuminate all permanent controls.
16. Indicate lighting-level setting and fade-rate setting graphically.
17. Native communication with building audiovisual system.
18. BAS interface.

B. Mounting: Single, flush wall box.

C. Device Plates: Style, material, and color shall comply with Section 262726 "Wiring Devices" or with hinged transparent locking cover as directed

2.8 WALL STATIONS

A. Functions and Features:

1. Wall stations shall function as a submaster to a master station, containing limited control of selected scenes of the master station.
2. Touchscreen controls to adjust the lighting level of each dimmer for each scene, and the fade time setting for each scene change from one preset scene to another.
3. Numbered push buttons to select scenes.
4. Off switch to turn master station off. Operating the off switch at any remote station shall automatically turn on selected housekeeping lighting.
5. On switch turns all scenes of master station to full bright.
6. Push-button controls for accessory functions.

B. Mounting: Flush, wall box.

C. Device Plates: Style, material, and color shall comply with Section 262726 "Wiring Devices."

2.9 DIMMER CABINETS

A. As directed, Factory wired, convection cooled without fans, with barriers to accommodate 120- and 277-V feeders and suitable to control designated lighting equipment or accessory functions.

B. Ambient Conditions:

1. Temperature: 60 to 95 deg F (15 to 35 deg C).
2. Relative Humidity: 10 to 90 percent, noncondensing.
3. Filtered air supply.

C. Dimmer Cabinet Assembly: Listed and labeled by an NRTL.

D. Cabinet Type: Plug in, modular, and accepting dimmers of each specified type in any plug-in position.

1. Integrated Fault-Current Rating: 10,000-A rms symmetrical.

E. Lighting Dimmers: Solid-state SCR dimmers.

1. Primary Protection: Magnetic or thermal-magnetic circuit breaker, also serving as the disconnecting means.
2. Dimmer response to control signal shall follow the "Square Law Dimming Curve" specified in the "IES Lighting Handbook."
3. Dimming Range: Zero to 100 percent, full output voltage not less than 98 percent of line voltage.
4. Dimmed circuits shall be filtered to provide a minimum 350-microsecond current-rise time at a 90-degree conduction angle and 50 percent of rated dimmer capacity. Rate of current rise shall not exceed 30 mA/microseconds, measured from 10 to 90 percent of load-current waveform.
5. Protect controls of each dimmer with a fuse and surge protective devices.

F. Non-dim modules shall include relays with contacts rated to switch 20-A tungsten-filament load at 120-V ac and 20-A electronic ballast load at 277-V ac.

G. Accessory function control modules shall be compatible with requirement of the accessory being controlled.

H. Digital Control Network:

1. Dimmers shall receive digital signals from digital network control stations that are linked to the dimmer cabinet with a common network data cable.
2. Functions of digital network control stations shall be set up at the dimmer cabinet's electronic controls that include indicated number and arrangement of scene presets, channels, and fade times.

I. Emergency Power Transfer Switch: Comply with UL 1008; factory prewired and pretested to automatically transfer load circuits from normal to emergency power supply when normal supply fails.

1. Transfer from normal to emergency supply when normal-supply voltage drops to 55 percent or less.
2. Retransfer immediately to normal on failure of emergency supply and after an adjustable time-delay of 10 to 90 seconds on restoration of normal supply while emergency supply is available.
3. Integrated Fault-Current Rating: Same value as listed for the panel.
4. Test Switch: Simulate failure of normal supply to test controls associated with transfer scheme.
5. Fabricate and test dimmer boards to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."

2.10 MANUAL SWITCHES AND PLATES

A. Switches: Modular, momentary push-button, low-voltage type.

1. Color: White unless otherwise indicated; red when associated with emergency circuits.
2. Integral Pilot Light: Indicate when circuit is on. Use where indicated.
3. Locator Light: Internal illumination.

4. Wall Plates: Comply with requirements in Section 262726 "Wiring Devices" for materials, finish, and color. Use multigang plates if more than one switch is indicated at a location.
5. Legend: Engraved or permanently silk-screened on wall plate where indicated. Use designations indicated on Drawings.

2.11 CONDUCTORS AND CABLES

A. Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18, No. 22 or No. 24 AWG as directed. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14, No. 16 or No. 18 AWG as directed. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Twisted-Pair Data Cable: Category 5e, Category 6 or Category 6a as directed. Comply with requirements for twisted pair cabling in Section 260523 "Control-Voltage Electrical Power Cables."

E. Twisted-Pair Data Cable: Category 5e, Category 6 or Category 6a as directed. Comply with requirements for twisted pair cabling in Section 271513 "Communications Copper Horizontal Cabling."

PART 3 - EXECUTION

3.1 WIRING INSTALLATION

A. Comply with NECA 1.

B. Wiring Method:

1. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
2. Install unshielded, twisted-pair cable for control and signal transmission conductors, complying with Section 271513 "Communications Copper Horizontal Cabling."
3. Minimum conduit size shall be 3/4 inch (18 mm).

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

D. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.

E. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

F. Install dimmer cabinets for each zone.

G. Comply with requirements in Section 260553 "Identification for Electrical Systems" for identifying components and power and control wiring.

H. Label each dimmer module with a unique designation.

I. Label each scene control button with approved scene description.

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Continuity tests of circuits.
2. Operational Test: Set and operate controls to demonstrate their functions and capabilities in a methodical sequence that cues and reproduces actual operating functions.

    a. Include testing of dimming control equipment under conditions that simulate actual operational conditions. Record control settings, operations, cues, and functional observations.

3. Emergency Power Transfer: Test listed functions.

B. Dimming control components will be considered defective if they do not pass tests and inspections.

C. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.

D. Reports: Written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.

3.3 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain central dimming controls as directed.

END OF SECTION 260933

SECTION 260936 - MODULAR DIMMING CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes wall-box, multi-scene, modular dimming controls.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Detail assemblies of standard components, custom assembled for specific application on Project. Indicate dimensions, weights, arrangement of components, and clearance and access requirements.

1. Include elevation views of front panels of control and indicating devices and control stations.
2. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of wall-box multiscene dimming controls that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Cost to repair or replace any parts for two years from date of Substantial Completion.
2. Extended Warranty Period: Cost of replacement parts (materials only, f.o.b. the nearest shipping point to Project site), for eight years, that failed in service due to transient voltage surges.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 SYSTEM DESCRIPTION

A. Compatibility:

1. Dimming control components shall be compatible with luminaires, luminaires and ballasts or luminaires, ballasts, and transformers as directed.
2. Dimming control devices shall be compatible with lighting control system components specified in Section 260943.16 "Addressable-Luminaire Lighting Controls" and Section 260943.23 "Relay-Based Lighting Controls," and in Section 260923 "Lighting Control Devices."

B. Dimmers and Dimmer Modules: Comply with UL 508.

1. Audible Noise and RFI Suppression: Solid-state dimmers shall operate smoothly over their operating ranges without audible lamp or dimmer noise or RFI. Modules shall include integral or external filters to suppress audible noise and RFI.
2. Dimmer or Dimmer-Module Rating: Not less than 125 percent of connected load unless otherwise indicated.

C. Capacities: Unit shall be rated for 2400 W at 240-V ac and 2000 W at 120-V ac for up to 100 devices or zones.

D. Surge Protection: Withstand supply power surges without impairment to performance.

1. Panels: 6000 V, 3000 A, complying with IEEE C62.41.1 and IEEE C62.41.2.
2. Other System Devices: 6000 V, 3000 A, complying with IEEE C62.41.1 and IEEE C62.41.2.

E. Off Control Position: User-selected off position of any control point shall disconnect the load from line supply.

F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 WALL-BOX MULTISCENE DIMMING CONTROLS

A. Description: Factory-fabricated equipment providing manual dimming consisting of a wall-box-mounted master controller and indicated number of wall-box zone stations. Controls and dimmers shall be integrated for mounting in multigang wall box under a single wall plate. Each zone shall be adjustable to indicated number of scenes, which shall reside in the memory of zone controller.

B. Dimmers: Each zone shall be configurable to control the following loads:

1. Fluorescent lamps with electronic or magnetic ballasts as directed.

2. LED lamps.
3. Incandescent lamps.
4. Low-voltage lamps, derived with magnetic or electronic transformers as directed.
5. Non-dim, on-off switching only.

C. Dimmers: Regulate voltages to maintain a constant light level, with no visible flicker, when the source voltage varies plus or minus 2 percent of rms voltage.

D. Memory:

1. Retain preset scenes and fade rates through momentary (up to 3-second) power interruptions.
2. Retain preset scenes through power failures for at least seven days.

E. Device Plates: Style, material, and color shall comply with Section 262726 "Wiring Devices." Master-control cover plate shall be one piece.

F. Master controller shall include the following:

1. Cover-mounted switches, including master off, all bright, and selectors for each scene.
2. Cover-mounted LED indicator lights, one associated with each scene switch, and one for the master off switch.
3. Concealed switches and indicators for specified function.
4. A raise/lower switch for each zone for temporary adjustments of the zone, without altering scene values stored in memory.
5. Fade time indicated by digital display for current scene while fading.
6. Cover-mounted infrared receiver.

G. Infrared Transmitters: Wireless remote control for recalling each or four of the presets as directed. Operate up to 50 feet (15 m) within line of sight of the master controller.

2.4 CONDUCTORS AND CABLES

A. Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Class 2 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18, No. 22 or No. 24 AWG as directed. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size shall be 1/2 inch (13 mm).

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

D. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.

E. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.2 IDENTIFICATION

A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Label each dimmer module with a unique designation.

C. Label each scene control button with approved scene description.

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Continuity tests of circuits.
2. Operational Test: Set and operate controls to demonstrate their functions and capabilities in a methodical sequence that cues and reproduces actual operating functions.

    a. Include testing of modular dimming control equipment under conditions that simulate actual operational conditions. Record control settings, operations, cues, and functional observations.

B. Dimming control components will be considered defective if they do not pass tests and inspections.

C. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.

D. Reports: Written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.

3.4 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain modular dimming controls. Laptop portable computer shall be used in training.

END OF SECTION 260936

SECTION 260943.16 - ADDRESSABLE-LUMINAIRE LIGHTING CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes lighting controls for addressable luminaires, based on DALI digital controls.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Floor plans.
2. Address drawing.
3. Point list and data bus load.
4. Wire termination diagrams and schedules.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample warranty.

C. Software licenses and upgrades required by and installed for operation and programming of digital and analog devices.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On USB drive. Username and password for manufacturer's support website.
3. Device address list.
4. Printout of software application and graphic screens.
5. Adjustments of scene preset controls, adjustable fade rates, and fade overrides.
6. Operation of adjustable zone controls.
7. Testing and adjusting of panic and emergency power features.

1.5 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of lighting controls that fail in materials or workmanship within specified warranty period.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. DALI:

1. Components: Individually addressable devices (such as ballasts, relays, dimmers, and switches) that are operated from digital signals received through a DALI-compliant bus, from data-entry and -retrieval devices (such as computers, Internet portals, hand-held IR programming devices, wired Ethernet hubs, wireless IEEE 802.11 hubs, and digital communications device as directed. Devices also report status to data-entry and -retrieval devices though the bus.
2. Digital Control: Use peer-to-peer communication and distributed logic, where the failure of any single component shall be automatically isolated and not affect global system functions.

B. Ethernet LAN:

1. Provide an Ethernet LAN to connect controller/gateways to a PC running a Microsoft Windows operating system. Comply with requirements in Section 271513 "Communications Copper Horizontal Cabling."
2. Ethernet Protocols: Comply with and be compatible with 10/100 BaseT TCP/IP routers and networks.
3. TCP/IP Modem: Capable of maintaining a secure Internet connection using VPN or equivalent protocol.

C. Surge Protective Device: Factory installed as an integral part of control components or field-mounted surge protective device complying with UL 1449, SPD Type 2.

D. Operation: Input signal from digital signal sources switches or dims DALI devices associated with ballasts or luminaires, or switches field-deployed, DALI-compliant, control relays.

1. Each device and relay is connected to a digital data bus.
2. Each DALI device and relay has a digital address and can be operated by a digital signal.
3. Each device or relay can be assigned to any or all of 16 available groups connected to a single data bus.
4. Each dimming ballast may have as many as 16 preset lighting levels or scenes. Scenes can be programmed to ballasts and may be applied to groups.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

F. Comply with 47 CFR 15, Subparts A and B, for Class A digital devices.

G. Comply with protocol described in IEC 60929, Annexes E and G, for DALI lighting control devices, wiring, and computer hardware and software.

H. Comply with UL 916.

2.2 BUS POWER SUPPLY

A. Description: Supply power to data bus for 64 addressable devices, suitable for use with NFPA 70, Class 2 control circuit.

1. Primary Power: Field selectable, 120 and 277 V.
2. Power Supply: Regulated to maintain the operating voltage above 15-V dc under full load and rated for full charging load of 250 mA and a minimum maintained connected load of 190 mA.
3. Pilot Lights: Indicate data bus ground-fault and data bus traffic.

2.3 CONTROLLER/GATEWAYS

A. Description: DALI controller/gateways link the distributed data buses with an Ethernet network to provide computer configuration, control, analysis, and maintenance. Controller/gateways operate independently and continue to process local inputs and schedules when disconnected from the LAN. Controller/gateways shall provide local intelligence and features including the following:

1. Integrated real-time clock with automatic daylight savings adjustment and leap-year correction.
2. Integrated sunrise/sunset support based on the site location (latitude and longitude).
3. Automatic time schedules, to control groups for scheduled occupancy with support for holiday exceptions.
4. Two digital outputs for additional control and interlocking with external equipment such as fans, valves, and security panels.
5. Support one or two data bus(es) as directed.
6. Computer Monitoring and Configuration: The controller/gateway shall allow configuration, monitoring, and analysis from PCs on the Ethernet LAN.

B. Each data bus shall have the capacity to control 64 addressable devices, using NFPA 70, Class 2 control circuit.

1. Each data bus shall have the capacity to control up to 16 groups and scenes.
2. LED indicator lights for Ethernet status (link, send, and receive), power-on, and LAN failure.
3. Linking of switch and sensor inputs to relay and ballast outputs.
4. Viewing relay and ballast output status.
5. Controlling relay and ballast outputs.
6. Setting device addresses.
7. Assigning switch and sensor inputs and relay and ballast output modes.

C. Allow connection of the following DALI-compliant addressable devices:

1. Fluorescent luminaire switching and dimming, for linear and compact lamps.
2. Incandescent luminaire switching and dimming.
3. HID and HPS luminaire switching and dimming.
4. LED luminaire switching and dimming.
5. Occupancy and photoelectric sensors.
6. Emergency lighting interface complying with UL 924.

D. Stores system programming in nonvolatile memory.

1. Switch to enable or disable software programming.

2.4 USER INTERFACE

A. Workstations: A laptop PC, with Microsoft Windows operating system and lighting control system management software installed. With automatic backup.

1. Include documentation, storage media, and licensing for a minimum of five concurrent users.

B. Tablet Computer: Handheld, with custom graphical user-interface software, supplied by the controller/gateway supplier. The software shall provide for all DALI-protocol programming commands to be applied to the controller/gateway via a tethered connection.

C. Web Interface: As directed, Internet portal, with one or 10 unique username and password(s), and a custom graphical user interface, allowing DALI-protocol programming commands to be applied to the controller gateway via LAN or the Internet.

D. IR Programming Assistant: Handheld, with custom graphical user-interface software, supplied by the controller/gateway supplier to program the manual switches.

2.5 LIGHTING CONTROL SYSTEM MANAGEMENT SOFTWARE

A. The software shall provide for programming, configuring, and monitoring all devices connected to all data buses of the lighting control system, using application-specific software with Microsoft Windows-based, user-friendly software with graphical user-interface designed screens.

1. The software shall be object oriented with pop-up menus and built-in help screens. All specified features of the data-bus-connected devices and those associated with controller/gateways shall be included in the software.

2.6 LUMINAIRE SWITCHING AND DIMMING MODULES

A. Description: Comply with DALI exponential dimming curve calibrated for the connected lamp type, group, and scene settings, and with DALI light-level and configuration commands. Dimmer rise time shall be not less than 15 microseconds.

2.7 BALLAST SWITCHING AND DIMMING MODULES

A. Each ballast or group shall be addressable and shall include on-off, fade, dimming, scene settings, and other standard DALI control functions and as required to meet the sequence of operation.

B. Ballasts: Comply with requirements in Section 265116 "Fluorescent Interior Lighting" for ballasts for linear fluorescent lamps and Section 265123 "HID Interior Lighting" for ballasts for HID lamps; electronic programmed-start; and the following:

1. Starting Method: Programmed rapid start with anti-flash (turns on at previously set light level).
2. Dimming Range: 100 to 10 percent of rated lumens unless otherwise indicated.
3. Ballast Factor: 1.0 at full output; 0.01 at full dim.
4. Input Voltage Range: 108 to 305 V.

2.8 SENSORS

A. Comply with requirements in Section 260923 "Lighting Control Devices." All sensors shall be DALI-protocol compliant.

B. Indoor Occupancy Sensors: May be powered directly from the lighting control network or with a standalone power supply. Units powered with a standalone power supply shall interface with the lighting control system through an electrically isolated digital input.

2.9 RELAYS

A. Relays: Electrically operated, mechanically held single-pole switch, rated at 20 A at 277 V. Short-circuit current rating shall be not less than 5 kA. Pilot light indicates when relay is closed and latched. Control shall be by DALI digital data bus. Relay status shall be displayed when queried by lighting management software.

B. Relay Panel: A single enclosure with incoming lighting branch circuits, relays, and connection to the DALI digital control network.

1. Enclosure: NEMA 250, Type 1 unless otherwise indicated.
2. Barriers to separate low-voltage and line-voltage components.
3. Directory: Cover mounted, identifying each relay with its device address and naming the load controlled.

C. Individually Mounted Relays:

1. Enclosure: Standard outlet box or NEMA 250, Type 1 unless otherwise indicated.
2. Directory: Cover mounted, identifying each relay with its device address.

2.10 MANUAL SWITCHES AND PLATES

A. Connection Type: As directed, RS-485 protocol, Category 5 or Category 5e UTP cable, using RJ-45 connectors. Power shall be from the control unit.

B. Push-Button Switches: Modular, operating over the DALI digital data bus.

1. Each switch shall control the following functions, in coordination with programmed sequence of operation and related sensors:

a. On.
b. Off.
c. Dimming, increase light level.
d. Dimming, decrease light level.
e. Return to preset light level.

2. LED Pilot Lights: On to indicate that the control is active, or when the manual control is operated.
3. Match color and style specified in Section 262726 "Wiring Devices."
4. Integral IR receiver for programming.

C. Wall Plates: Single and multi-gang plates as specified in Section 262726 "Wiring Devices."

D. Legend: Engraved or permanently silk-screened on wall plate where indicated. Use designations indicated on Drawings.

2.11 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Class 2 Power Source: Not smaller than No. 12 AWG, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Class 2 Control Cables: As directed, Multiconductor cable with copper conductors not smaller than No. 18, No. 22 or No. 24 AWG, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cables: As directed, Multiconductor cable with copper conductors not smaller than No. 14, No. 16 or No. 18 AWG, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Digital and Multiplexed Signal Cables: UTP cable with copper conductors, complying with Category 5e or Category 6 for horizontal copper cable and with Section 271513 "Communications Copper Horizontal Cabling as directed."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental airspaces, including plenum ceilings.
2. Comply with requirements for cable trays specified in Section 260536 "Cable Trays for Electrical Systems."
3. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

C. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

D. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

E. Identify system components, wiring, cabling, boxes, cabinets, and terminals. Comply with identification requirements specified in Section 260553 "Identification for Electrical Systems."

F. Label each device cable within 6 inches (152 mm) of connection to bus power supply or termination block.

G. As directed, engage a factory-authorized service representative to perform or Perform startup service.

H. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Test each bus controller using local and remote controls.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

B. Field Test Reports:

1. Printed list of all points created from actual queries of all addressed control points to include lamps, ballasts, manual controls, and sensors.
2. Event log verifying the performance of all devices generating event messages to include occupancy sensors, control buttons, alarm messages, and any other change of value messages.

C. Lighting controls will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports, including a certified report that identifies bus controllers included and describes query results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.3 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.4 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain the control unit and operator interface.

END OF SECTION 260943.16

SECTION 260943.23 - RELAY-BASED LIGHTING CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes lighting control panels using mechanically held relays for switching.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For each relay panel and related equipment.

1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types and details for types other than NEMA 250, Type 1.
3. Detail wiring partition configuration, current, and voltage ratings.
4. Short-circuit current rating of relays.
5. Address Drawing: Reflected ceiling plan and floor plans, showing connected luminaires, address for each luminaire, and luminaire groups. Base plans on construction plans, using the same legend, symbols, and schedules.
6. Point List and Data Bus Load: Summary list of all control devices, sensors, ballasts, and other loads. Include percentage of rated connected load and device addresses.
7. Wire Termination Diagrams and Schedules: Coordinate nomenclature and presentation with Drawings and block diagram. Differentiate between manufacturer-installed and field-installed wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Software licenses and upgrades required by and installed for operation and programming of digital and analog devices.

C. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On USB drive. Or Username and password for manufacturer's support website as directed.

3. Device address list.
4. Printout of software application and graphic screens.
5. Testing and adjusting of panic and emergency power features.

1.5 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of standalone multipreset modular dimming controls that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Cost to repair or replace any parts for two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Sequence of Operations: Input signal from field-mounted manual switches, or digital signal sources, shall open or close one or more lighting control relays in the lighting control panels. Any combination of inputs shall be programmable to any number of control relays.

B. Surge Protective Device: Factory installed as an integral part of control components or field-mounted surge suppressors complying with UL 1449, SPD Type 2.

C. Electrical Components, Devices, and Accessories: Listed and labeled by a qualified testing agency and marked for intended location and application.

D. Comply with 47 CFR 15, Subparts A and B, for Class A digital devices.

E. Comply with UL 916.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Lighting control panels shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 or 1.0 as directed.

2.3 LIGHTING CONTROL RELAY PANELS

A. Description: Standalone lighting control panel using mechanically latched relays to control lighting and appliances.

B. Lighting Control Panel:

1. A single enclosure with incoming lighting branch circuits, control circuits, switching relays, and on-board timing and control unit.
2. A vertical barrier separating branch circuits from control wiring.

C. Control Unit: Contain the power supply and electronic control for operating and monitoring individual relays.

1. Timing Unit:

a. 365-day calendar, astronomical clock, and automatic adjustments for daylight savings and leap year.
b. Clock configurable for 12-hour (A.M./P.M.) or 24-hour format.
c. Four independent schedules, each having 24 time periods.
d. Schedule periods settable to the minute.
e. Day-of-week, day-of-month, day-of-year with one-time or repeating capability.
f. 10 special date periods.

2. Sequencing Control with Override:

a. Automatic sequenced on and off switching of selected relays at times set at the timing unit, allowing timed overrides from external switches.
b. Sequencing control shall operate relays one at a time, completing the operation of all connected relays in not more than 10 seconds.
c. Override control shall allow any relay connected to it to be switched on or off by a field-deployed manual switch or by an automatic switch, such as an occupancy sensor.
d. Override control "blink warning" shall warn occupants approximately five minutes before actuating the off sequence.

3. Nonvolatile memory shall retain all setup configurations. After a power failure, the controller shall automatically reboot and return to normal system operation, including accurate time of day and date.

D. Relays: Electrically operated, mechanically held single-pole switch, rated at 20 A at 277 V. Short-circuit current rating shall be not less than 5 kA. Control shall be three-wire, 24-V ac.

E. Relays: Electrically operated, mechanically held single-pole switch, rated at 20 A at 120-V tungsten, 30 A at 277-V ballast, 1.5 hp at 120 V, and 3 hp at 277 V. Short-circuit current rating shall be not less than 14 kA. Control shall be three-wire, 24-V ac.

F. Power Supply: NFPA 70, Class 2, sized for connected equipment, plus 20 percent spare capacity. Powered from a dedicated branch circuit of the panelboard that supplies power to the line side of the relays, sized to provide control power for the local panel-mounted relays, bus system, low-voltage inputs, field-installed occupancy sensors, and photo sensors.

G. Operator Interface:

1. Integral alphanumeric keypad and digital display, and intuitive drop-down menus to assist in programming.
2. Log and display relay on-time.
3. Connect relays to one or more time and sequencing schemes.

2.4 MANUAL SWITCHES AND PLATES

A. Push-Button Switches: Modular, momentary contact, three wire, for operating one or more relays and to override automatic controls.

1. Match color and style specified in Section 262726 "Wiring Devices."
2. Integral green LED pilot light to indicate when circuit is on.
3. Internal white LED locator light to illuminate when circuit is off.

B. Wall Plates: Single and multi-gang plates as specified in Section 262726 "Wiring Devices."

C. Legend: Engraved or permanently silk-screened on wall plate where indicated. Use designations indicated on Drawings.

2.5 FIELD-MOUNTED SIGNAL SOURCES

A. Daylight Harvesting Switching Controls: Comply with Section 260923 "Lighting Control Devices." Control power may be taken from the lighting control panel, and signal shall be compatible with the relays.

B. Indoor Occupancy Sensors and Extreme-Temperature Occupancy Sensors: Comply with Section 260923 "Lighting Control Devices." Control power may be taken from the lighting control panel, and signal shall be compatible with the relays.

2.6 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Class 2 Power Source: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cables: Multiconductor cable with copper conductors not smaller than No. 18, No. 22 or No. 24 AWG as directed. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cables: Multiconductor cable with copper conductors not smaller than No. 14, No. 16 or No. 18 AWG as directed. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Twisted-Pair Data Cable: Category 5e, Category 6 or Category 6a as directed. Comply with requirements for twisted pair cabling in Section 260523 "Control-Voltage Electrical Power Cables."

E. Twisted-Pair Data Cable: Category 5e, Category 6 or Category 6a as directed. Comply with requirements in Section 271513 "Communications Copper Horizontal Cabling."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental airspaces, including plenum ceilings.
2. Comply with requirements for cable trays specified in Section 260536 "Cable Trays for Electrical Systems."
3. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

C. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

D. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

E. Install panels and accessories according to NECA 407.

F. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

G. Mount top of trim 90 inches (2286 mm) above finished floor unless otherwise indicated.

H. Mount panel cabinet plumb and rigid without distortion of box.

I. As directed Engage a factory-authorized service representative to perform or Perform startup service.

J. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.2 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Create a directory to indicate loads served by each relay; incorporate Owner's final room designations. Obtain approval before installing. Use a PC or typewriter to create directory; handwritten directories are unacceptable.

C. Lighting Control Panel Nameplates: Label each panel with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

B. Acceptance Testing Preparation:

1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers described below and low-voltage surge arrestors. Certify compliance with manufacturer's test parameters.

    a. Circuit-Breaker Tests:

        1) Compare nameplate with Drawings and Specifications.
        2) Inspect physical and mechanical conditions.
        3) Inspect anchorage and alignment.
        4) Verify that the units are clean.
        5) Operate the circuit breaker to ensure smooth operation.
        6) Inspect bolted electrical connections for high resistance using one or more of the following methods:

            a) A low-resistance ohmmeter.
            b) Verify tightness of bolted electrical connections by calibrated torque wrench.
            c) Thermographic survey.

        7) Inspect operating mechanism, contacts, and arc chutes in unsealed units.
        8) Perform adjustments for final protective device settings according to the overcurrent protective device coordination study. Comply with requirements in Section 260573.16 "Coordination Studies."
        9) Perform insulation resistance tests for one minute on each pole, phase-to-phase, and phase-to-ground with the circuit breaker closed and across each pole using manufacturer's published data.
        10) Perform a contact/pole-resistance test.
        11) Perform insulation-resistance tests on control wiring with respect to ground. Applied potential shall be 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable. Test duration shall be for one minute. Follow manufacturer's written instructions for solid-state units.
        12) Determine long-time pickup and delay by primary current injection.
        13) Determine short-time pickup and delay by primary current injection.
        14) Determine ground-fault pickup and time delay by primary current injection.
        15) Determine instantaneous pickup by primary current injection.
        16) Test functions of the trip unit by means of secondary injection.
        17) Perform minimum pickup voltage tests on shunt trip and close coils according to manufacturer's published data.

18) Verify correct operation of auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, anti-pump function, and trip unit battery condition. Reset trip logs and indicators.
19) Verify operation of charging mechanism.

b. Surge Arrestor Tests:

1) Compare nameplate with the Contract Documents.
2) Inspect physical and mechanical conditions.
3) Inspect anchorage, alignment, grounding, and clearances.
4) Verify that the units are clean.
5) Inspect bolted electrical connections for high resistance using one or more of the following methods:

a) Low-resistance ohmmeter.
b) Verify tightness of bolted electrical connections by calibrated torque wrench.

6) Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.
7) Perform an insulation-resistance test on each arrestor, phase terminal-to-ground using voltage according to manufacturer written instructions.
8) Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding tests.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

C. Lighting control panel will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports, including a certified report that identifies lighting control panels and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.4 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain the control unit and operator interface.

END OF SECTION 260943.23

SECTION 261116.11 - SECONDARY UNIT SUBSTATIONS WITH SWITCHGEAR SECONDARY

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes secondary unit substations, each consisting of medium-voltage primary incoming section, transformer section, and low-voltage secondary switchgear section, with the following features:

1. As directed Indoor enclosure, Outdoor enclosure or Indoor and outdoor enclosures.
2. Medium-voltage, metal-clad switchgear section.
3. As directed Liquid-filled or Dry-type transformer as directed.

B. Related Requirements:

1. Section 260513 "Medium-Voltage Cables" for requirements for terminating cables in incoming section of substation.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.
2. Dimensioned plans and elevations showing major components and features.

    a. Include a plan view and cross section of equipment base, showing clearances, manufacturer's recommended workspace that accounts for breaker service and removal, and locations of penetrations for grounding and conduits.

3. One-line diagram.
4. Nameplate legends.
5. Short-time and short-circuit current ratings of secondary unit substations and components.
6. Ratings of individual protective devices.
7. Mimic-bus diagram.

C. Time-Current Characteristic Curves: For overcurrent protective devices.

D. Primary Fuses: Submit recommendations and size calculations.

1. Utility company's metering provisions with indication of approval by utility company.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings for Outdoor Installations:

1. Utilities site plan, drawn to scale, showing heavy equipment or truck access paths for maintenance and replacement.

B. Coordination Drawings for Indoor Installations:

1. Location plan, showing heavy equipment or truck access paths for maintenance and replacement.
2. Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved.
3. Dimensioned concrete base, outline of secondary unit substation, conduit entries, and grounding equipment locations.
4. Support locations, type of support, and weight on each support.
5. Location of lighting fixtures, sprinkler piping and heads, ducts, and diffusers.

C. Qualification Data: For testing agency.

D. Seismic Qualification Certificates: For transformer assembly, accessories, and components, from manufacturer.

E. Product certificates.

F. Factory test reports.

G. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA or the National Institute for Certification in Engineering Technologies to supervise on-site testing.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 SYSTEM DESCRIPTION

A. Description: Medium-voltage, primary incoming section; transformer section; and low-voltage secondary switchgear section; and including coordinated circuit breakers, fusible switches, and metering components.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with IEEE C2.

D. Comply with IEEE C37.121.

E. Comply with NFPA 70.

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: The secondary unit substations shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the secondary unit substation will remain in place without separation of any parts when subjected to the seismic forces specified and the secondary unit substation will be fully operational after the seismic event."
2. Component Importance Factor: As directed 1.5 or 1.0.
3. Component Amplification Factor: As directed 2.5.
4. Component Response Modification Factor: As directed 6.0.

2.4 MANUFACTURED UNITS

A. Indoor-Unit Arrangement: Single assembly.

B. Outdoor-Unit Arrangement: Single assembly.

1. Weatherproof, listed for installation outdoors, complying with IEEE C37.20.1.
2. Aisle-less Construction: Full-height doors in front of basic weatherproof equipment.

C. Connections between the primary device and transformer shall be cable or bus as directed, and between the transformer and secondary shall be flexible bus braid unless noted otherwise.

D. Indoor Enclosure: Steel.

E. Outdoor Enclosure: Weatherproof, aisle-less construction for outdoor service. Galvanized-steel, weatherproof construction; integral structural-steel base frame with factory-applied asphaltic undercoating.

1. Enclosure: Downward, rearward sloping roof; bolt-on rear covers or rear hinged doors for each section as directed, with provisions for padlocking.
2. Each compartment shall have the following features:

    a. Structural design and anchorage adequate to resist loads imposed by 125-mph (200-km/h) wind.
    b. Space heater operating at one-half or less of rated voltage, sized to prevent condensation, controlled by thermostats to maintain temperature of each section above expected dew point or manual switching of branch-circuit protective device as directed.
    c. Louvers equipped with insect and rodent screens and filters and arranged to permit air circulation while excluding rodents and exterior dust.
    d. Weatherproof ground-fault circuit interrupter (GFCI) duplex receptacle.
    e. Power for heaters, lights, and receptacles shall be provided by control power transformer or as indicated.

F. Skid Mounted: Mount each shipping group on an integral base frame as a complete weatherproof unit.

G. Unit Substation Enclosures Finish: Factory-applied finish in manufacturer's standard color, including under surfaces treated with corrosion-resistant undercoating.

H. Unit Substation Enclosures Finish: Factory-applied finish in manufacturer's standard gray over a rust-inhibiting primer on treated metal surface.

2.5 MEDIUM-VOLTAGE METAL-CLAD SWITCHGEAR SECTION

A. Metal-clad, circuit-breaker switchgear, complying with IEEE C37.20.2 and NEMA SG 4 and tested for compliance according to NEMA C 37.55.

1. Arc Resistant: Comply with IEEE C37.20.7, Type 1, Type 2, Type 1C or Type 2C as directed.

B. Ratings shall comply with IEEE C37.04, suitable for application in three-phase, 60-Hz, solidly grounded-neutral system.

1. System Voltage: 4.16 kV nominal; 4.76 kV maximum, 7.2 kV nominal; 15 kV maximum, 13.8 kV nominal; 15 kV maximum or 34.5 kV nominal; 38 kV maximum as directed.
2. Nominal Interrupting-Capacity Class: 250, 350, 500, 750 or 1000 MVA as directed.
3. Main-Bus Rating: 1200 A, 2000 A or 3000 A, continuous as directed.

C. Circuit Breakers: Electrically operated, drawout mounting; using three individual vacuum-sealed interrupter modules, and including the following features:

1. Designed to operate at rated voltage to interrupt fault current within its rating within three or five cycles of trip initiation as directed. For systems with X/R ratio of 17 or less, transient voltage during interruption shall not exceed twice the rated line-to-ground voltage of the system.
2. Contact-Wear Indicator: Readily accessible to field maintenance personnel.
3. Minimum of six Type A and six Type B spare contacts.

4. Interchangeability: Interchangeable with vacuum circuit breakers of same current and interrupting ratings.
5. Operating Mechanism: Electrically charged, mechanically and electrically trip-free, stored-energy operation.

D. Control Power:

1. 120 or 240-V ac for closing and tripping as directed.

E. Test Accessories: Relay and meter test plugs.

F. Circuit-Breaker Test Cabinet:

1. Separately mounted.
2. Containing push buttons for circuit-breaker closing and tripping, control relay, fuses, and secondary coupler with cable approximately 108 inches (2740 mm) long.
3. Include secondary devices for operating circuit breaker if removed from switchgear and moved near test cabinet.
4. Include provision for storage of test and maintenance accessories in cabinet.

G. Remote-Tripping Device: Wall-mounting emergency control station to open circuit breakers; located in red cast-metal box with break-glass operation.

H. Surge Arresters: Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor type, connected in each phase of incoming circuit and ahead of any disconnecting device.

I. Maintenance Tools: Furnish tools and miscellaneous items required for circuit-breaker test, inspection, maintenance, and operation.

1. Fuse-handling tool.
2. Extension rails, lifting device, transport or dockable dolly or mobile lift, and all other items necessary to remove circuit breaker from housing and transport to remote location.
3. Racking handle to move circuit breaker manually between "connected" and "disconnected" positions, and a secondary test coupler to permit testing of circuit breaker without removal from switchgear.

2.6 MEDIUM-VOLTAGE INSTRUMENTS SECTION

A. Instrument Transformers: Comply with IEEE C57.13.

1. Potential Transformers: Secondary voltage rating of 120 V and NEMA C 12.11 Accuracy Class of 0.3 with burdens of W, X, and Y.
2. Current Transformers: Burden and Accuracy Class suitable for connected relays, meters, and instruments.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems.

1. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.

2. Switch-selectable digital display with the following features:

    a. Phase Currents, Each Phase: Plus or minus 1 percent.
    b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
    c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
    d. Three-Phase Real Power: Plus or minus 2 percent.
    e. Three-Phase Reactive Power: Plus or minus 2 percent.
    f. Power Factor: Plus or minus 2 percent.
    g. Frequency: Plus or minus 0.5 percent.
    h. Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
    i. Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

3. Communications module suitable for remote monitoring of meter quantities and functions. Interface communication and metering requirements according to Section 260913 "Electrical Power Monitoring and Control."
4. Mounting: Display and control unit that is flush or semi-flush mounted in instrument compartment door.

C. Analog Instruments: Rectangular, 4-1/2 inches (115 mm) square, 1 percent accuracy, semi-flush mounting, with anti-parallax 250-degree scale and external zero adjustment.

1. Voltmeters: Cover an expanded scale range of normal voltage plus 10 percent.
2. Voltmeter Selector Switch: Rotary type with off position to provide readings of phase-to-phase and phase-to-neutral voltages.
3. Ammeters: Cover an expanded scale range of bus rating plus 10 percent.
4. Ammeter Selector Switch: Permits current reading in each phase and keeps current-transformer secondary circuits closed in off position.
5. Locate meter and selector switch on circuit-breaker compartment door for indicated feeder circuits only.
6. Watt-Hour Meters: Flush- or semi-flush-mounting type, 5 A, 120 V, three phase, three wire; with three elements, 15-minute indicating demand register, and provision for testing and adding pulse initiation.
7. Recording Demand Meter: Usable as totalizing relay or indicating and recording maximum demand meter with 15-minute interval.

    a. Operation: Counts and records a succession of pulses entering two channels.
    b. Housing: Drawout, back-connected case arranged for semi-flush mounting.

D. Overcurrent and Ground-Fault Protective Relays: Multifunctional, solid-state microprocessor-based, medium-voltage relay, for operation from the specified control power. Comply with IEEE C37.90.

1. Field-Selectable Relay Settings: Required by the overcurrent protective device coordination study and arc-flash study.
2. Primary Current-Transformer Ratings: Programmable from 5 to 5,000 A.
3. Phase and Ground Protection: Field-selectable curves from IEEE moderately inverse, very inverse, or extremely inverse.
4. Phase Instantaneous Overcurrent Trip Pickup Point: Field selectable as "none" or from 1.0 to 25 times current-transformer primary rating. Include discriminator circuit with

"on" and "off" switch, so that when phase instantaneous overcurrent has been programmed to "none," the discriminator circuit protects against currents exceeding 11 times current-transformer primary rating when the breaker is being closed and shall be deactivated after approximately eight cycles.

5. Contacts: Two, Form-A contacts, field selectable into contact pairs as follows and as required by the overcurrent protective device coordination study and arc-flash study:

    a. One contact assigned ANSI 51 phase and ANSI 51 ground, and the other contact assigned ANSI 50 phase and ANSI 50 ground.
    b. One contact assigned ANSI 51/50 phase, and the other contact assigned 51/50 ground.

6. Alphameric display to show the following parameters with metering accuracy not to exceed 2 percent of full scale:

    a. Individual phase currents.
    b. Ground current.
    c. Cause of trip.
    d. Magnitude and phase of current causing trip.
    e. Phase or ground indication.
    f. Peak current demand for each phase and ground since last reset.
    g. Current-transformer primary rating.
    h. Programmed phase and ground set points.

7. Communications module to transmit the following data according to Section 260913 "Electrical Power Monitoring and Control."

    a. Relay's metered and target data, such as currents, set points, cause of trip, magnitude of trip current, and open-close trip status.
    b. Ability to close and open the associated breaker with proper access code from remote location over the communication network when the relay is configured in remote open-close mode.

8. Relay alarm and trip contacts shall not change state if power is lost or an undervoltage occurs. These contacts shall only cause a trip on detection of an overcurrent or fault condition based on programmed settings. Provide a "protection off" alarm, which shall be normally energized when the relay is powered and the self-diagnostics indicates the unit is functional. On loss of power or relay failure, this alarm relay shall be de-energized providing a fail-safe protection off alarm.
9. The relay shall operate reliably solely from the breaker main current transformers during a fault condition, if the normally connected auxiliary ac voltage is not available, even after an extended power outage.
10. Mount the relay in a drawout case with a two-stage quick-release operation. The removal of the relay from the case shall disconnect the trip circuits and short the current-transformer secondaries before the unit control power is disconnected. When the relay is inserted into the case, control power connections shall be made before the trip circuits are activated. Include a self-shorting contact on the case terminal block to provide alarm indication and tripping of circuit breaker upon removal of the relay from the case.

E. Control Power Supply: Control power transformer supplies 120-V control circuits through secondary disconnect devices.

1. Dry-type transformers, in separate compartments for units larger than 3 kVA, including primary and secondary fuses.
2. Two control power transformers in separate compartments with necessary interlocking relays; each transformer connected to line side of associated main circuit breaker.

    a. Secondary windings connected through relay(s) to control bus to affect an automatic transfer scheme.
    b. Secondary windings connected through an internal automatic transfer switch to switchgear control power bus.

3. Control Power Fuses: Primary and secondary fuses provide current-limiting and overload protection.

F. Control Wiring: Factory installed, complete with bundling, lacing, and protection.

1. Conductors across Hinges and for Interconnections between Shipping Units: Flexible conductors for No. 8 AWG and smaller.
2. Conductors: Sized according to NFPA 70 for duty required.

2.7 LIQUID-FILLED TRANSFORMER SECTION

A. Description: IEEE C57.12.00 and UL 1062, liquid-filled, two-winding, secondary unit substation transformer.

B. Primary Incoming Section: Transformer cover-mounted bushings. The bushings shall meet thermal, mechanical, and dielectric requirements as specified for the transformer section.

C. Insulating Liquid: Mineral oil complying with ASTM D3487, Type II, and tested according to ASTM D117.

D. Insulation Temperature Rise: 55 deg C, based on an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C. Insulation system shall be rated to continuously allow an additional 12 percent kVA output, at 65 deg C temperature rise, without decreasing rated transformer life.

E. Insulation Temperature Rise: 65 deg C, based on an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C.

F. BIL: 60, 75, 95 or 110 kV as directed.

G. Full-Capacity Voltage Taps: Four nominal 2.5 percent taps, two above and two below rated primary voltage; with externally operable tap changer for de-energized use and with position indicator and padlock hasp.

H. Full-Capacity Voltage Taps: Four nominal 2.5 percent taps below rated primary voltage, with externally operable tap changer for de-energized use and with position indicator and padlock hasp.

I. Cooling System: Class ONAN, liquid cooled, Class ONAN/ONAF, liquid cooled, and with forced-air rating or Class ONAN/ONAF/ONAF, liquid cooled, and with provisions for future forced-air rating as directed. Cooling systems shall include auxiliary cooling equipment, automatic controls, and status indicating lights.

J. Impedance: Percent as directed.

K. Accessories: Grounding pads, lifting lugs, and provisions for jacking under base. Transformers shall have a steel base and frame allowing use of pipe rollers in any direction, and an insulated, low-voltage, neutral bushing with removable ground strap. Include the following additional accessories:

1. Liquid-level gage.
2. Pressure-vacuum gage.
3. Liquid temperature indicator.
4. Drain and filter valves.
5. Pressure-relief device.

2.8 DRY-TYPE TRANSFORMER SECTION

A. Description: IEEE C57.12.01, IEEE C57.12.50 or IEEE C57.12.51 as directed, and dry-type, two-winding, secondary unit substation transformer.

B. Primary Incoming Section: Transformer cover-mounted bushings. The bushings shall meet thermal, mechanical, and dielectric requirements as specified for the transformer section.

C. Style: Indoor, ventilated or Outdoor, ventilated as directed, cast coil/encapsulated coil, with primary and secondary windings individually cast in epoxy; with insulation system rated at 185 deg C with an 80 deg C average winding temperature rise above a maximum ambient temperature of 40 deg C.

D. Style: Indoor, ventilated or Outdoor, ventilated as directed, vacuum-pressure, impregnated type, and with insulation system rated at 220 deg C with an 80deg C average winding temperature rise above a maximum ambient temperature of 40 deg C.

E. Cooling System: Class AA, air cooled, complying with IEEE C57.12.01.

F. Cooling System: Class AFA, air cooled with forced-air rating, complying with IEEE C57.12.01.

1. Manual forced-air cooling system controls, including manual switch for fans, fan controller and associated power and control wiring, and power panel with current-limiting fuses.
2. Include mounting provision for fans.

G. Cooling System: Class AA/AFA, air cooled with provisions for future forced-air rating, complying with IEEE C57.12.01.

1. Automatic forced-air cooling system controls, including thermal sensors, fans, control wiring, temperature controller with test switch, power panel with current-limiting fuses, indicating lights, alarm, and alarm-silencing relay.

2. Include mounting provision for fans.

H. Cooling System: Class AFA, forced-air cooling, complying with IEEE C57.12.01.

1. Automatic forced-air cooling system controls, including thermal sensors, fans, control wiring, temperature controller with test switch, power panel with current-limiting fuses, indicating lights, alarm, and alarm-silencing relay.
2. Include cooling fans.

I. Insulation Materials: IEEE C57.12.01, rated 220 deg C.

1. Insulation Temperature Rise: As directed 80, 115 or 150 deg C, maximum rise above 40 deg C.

J. BIL: As directed 60, 75, 95 or 110 kV.

K. Full-Capacity Voltage Taps: Four nominal 2.5 percent taps, two above and two below rated primary voltage.

L. Full-Capacity Voltage Taps: Four nominal 2.5 percent taps below rated primary voltage.

M. Impedance: Percent as directed.

N. High-Temperature Alarm: Sensor at transformer with local audible and visual alarm and contacts for remote alarm.

2.9 SECONDARY DISTRIBUTION SECTION SWITCHGEAR

A. The secondary distribution section shall be drawout, fused or fused where indicated, low-voltage switchgear, complying with IEEE C37.20.1 and UL 1558.

1. Section barriers between main and tie circuit-breaker compartments shall be extended to rear of section.

B. Switchgear Structure:

1. Match and align the front and back of the switchgear.
2. Isolate line bus from load bus at each main and tie circuit breaker with bus isolation barriers.
3. Allow the following circuit-breaker functions to be performed when the compartment door is closed:

    a. Operate manual charging system.
    b. Open and close the circuit breaker.
    c. Examine and adjust the trip unit.
    d. Read the breaker nameplate.

4. Locate instrumentation transformers within the breaker cell and make front accessible and removable.

C. Switchgear Bus:

1. Use bus bars to connect compartments and vertical sections. Cable connections are not permitted.
2. Main Phase Bus: Uniform capacity the entire length of section.
3. Neutral Bus: As directed 50 or 100 percent of phase-bus ampacity, except as indicated. Equip bus with pressure-connector terminations for outgoing circuit neutral conductors. Include braces for neutral-bus extensions for busway feeders.
4. Vertical Section Bus Size: Comply with IEEE C37.20.1, including allowance for spare circuit breakers and spaces for future circuit breakers.
5. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent minimum conductivity, with copper feeder circuit-breaker line connections.
6. Phase- and Neutral-Bus Material: Silver- or tin-plated, high-strength, electrical-grade aluminum alloy, with copper or tin-plated aluminum circuit-breaker line connections.
7. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent minimum conductivity or tin-plated, high-strength, electrical-grade aluminum alloy.
8. Use silver-plated copper or tin-plated aluminum for connecting circuit-breaker line to aluminum bus.
9. Use copper for connecting circuit-breaker line to copper bus.
10. Contact Surfaces of Buses: Silver plated.
11. Feeder Circuit-Breaker Load Terminals: Silver-plated copper bus extensions equipped with pressure connectors for outgoing circuit conductors.
12. Ground Bus: Hard-drawn copper of 98 percent minimum conductivity, with pressure connector for feeder and branch-circuit ground conductors, minimum size 1/4-by-2 inches (6 by 50 mm).
13. Neutral bus equipped with pressure-connector terminations for outgoing circuit neutral conductors. Neutral-bus extensions for busway feeders are braced.
14. Neutral Disconnect Link: Bolted, uninsulated, 1/4-by-2-inch (6-by-50-mm) copper bus, arranged to connect neutral bus to ground bus.
15. Provide for future extensions from either end of main phase, neutral, and ground bus by means of predrilled bolt-holes and connecting links.

D. Circuit-Breaker Compartment:

1. Drawout Features: Circuit-breaker mounting assembly equipped with a racking mechanism to position circuit breaker and hold it rigidly in "connected," "test," and "disconnected" positions. Include the following features:

    a. Interlocks: Prevent movement of circuit breaker to or from "connected" position when it is closed and prevent closure of circuit breaker unless it is in "connected," "test," or "disconnected" position.
    b. Circuit-Breaker Positioning: Permit the racking of an open circuit breaker to or from "connected," "test," and "disconnected" positions only when the compartment door is closed unless live parts are covered by a full dead-front shield. Permit the manual withdrawal of an open circuit breaker to a position for removal from the structure. When the compartment door is open, status for connection devices for different positions includes the following:

        1) Test Position: Primary disconnects disengaged, and secondary disconnect devices and ground contact engaged.
        2) Disconnected Position: Primary and secondary devices and ground contact disengaged.

2. Primary Disconnect: Mount on the stationary part of the compartment. The disconnect shall consist of a set of contacts extending to the rear through an insulating support barrier, and of corresponding moving finger contacts on the power circuit-breaker studs, which engage in only the "connected" position. The assembly shall provide multiple silver-to-silver full floating, spring-loaded, high-pressure-point contacts with uniform pressure on each finger. Load studs shall connect to bus extensions that terminate in solderless terminals in the rear cable compartment.
3. Secondary Disconnect: Floating terminals mounted on the stationary part of the compartment that engage mating contacts at the front of the breaker. Disconnecting devices shall be gold plated, and engagement shall be maintained in the "connected" and "test" positions.

E. Circuit Breakers:

1. Comply with IEEE C37.13 and UL 1066.
2. Ratings: For continuous, interrupting, and short-time current ratings for each circuit breaker; voltage and frequency ratings same as switchgear.
3. Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with the following features:

    a. Normal Closing Speed: Independent of both control and operator.
    b. Slow Closing Speed: Optional with operator for inspection and adjustment.
    c. Stored-Energy Mechanism: Manually charged, Electrically charged or Electrically charged, and the operator's choice of manual charging as directed.

        1) Operating Handle: One for each circuit breaker capable of manual operation.
        2) Electric Close Button: One for each electrically operated circuit breaker.

    d. Operation counter.

4. Trip Devices: Solid-state, overcurrent trip-device system consisting of one or two current transformers or sensors per phase, a release mechanism, and the following features:

    a. Functions: Long-time-delay, short-time-delay, and instantaneous-trip functions, independent of each other in both action and adjustment.
    b. Temperature compensation that ensures accuracy and calibration stability from minus 5 to plus 40 deg C.
    c. Field-adjustable, time-current characteristics.
    d. Current Adjustability: Dial settings and rating plugs on trip units, or sensors on circuit breakers, or a combination of these methods.
    e. Three bands, minimum, for long-time- and short-time-delay functions; marked "minimum," "intermediate," and "maximum."
    f. Pickup Points:

        1) Five minimum, for long-time- and short-time-trip functions. Equip short-time-trip function for switchable I-squared-t operation.
        2) Five minimum, for instantaneous-trip functions.

    g. Ground-fault protection with at least three short-time-delay settings and three trip-time-delay bands; adjustable current pickup.

1) Arrange to provide protection for three-wire circuit or system.
2) Arrange to provide protection for four-wire circuit or system.
3) Arrange to provide protection for four-wire, double-ended substation.

5. Trip Indication: Labeled, battery-powered lights or mechanical targets on trip device to indicate type of fault.
6. Auxiliary Contacts:

   a. Contacts and switches required for normal circuit-breaker operation, sufficient for interlocking and remote indication of circuit-breaker position.
   b. Spare auxiliary switches, at least two, unless other quantity is indicated. Each switch shall consist of two Type A and two Type B contacts wired through secondary disconnect devices to a terminal block in stationary circuit-breaker compartment.

7. Arc Chutes: Readily removable from associated circuit breaker when it is in "disconnected" position and arranged to permit inspection of contacts without removing circuit breaker from switchgear.
8. Padlocking Provisions: For installing at least three padlocks on each circuit breaker to secure its enclosure and prevent movement of drawout mechanism.

F. Mechanical Interlocking of Circuit Breakers: Uses a mechanical tripping lever or equivalent design and electrical interlocks.

G. Key Interlocks: Arranged to prevent opening or closing interlocked circuit breakers, except in a specified sequence. Include mountings and hardware for future installation of key interlocks.

H. Undervoltage Trip Devices: Instantaneous, with adjustable pickup voltage.

I. Undervoltage Trip Devices: Adjustable time-delay and pickup voltage.

J. Shunt-Trip Devices.

K. Fused Circuit Breakers: Circuit-breaker and fuse combinations complying with requirements for circuit breakers and trip devices.

1. Fuses: NEMA FU 1, Class L current limiting, sized to coordinate with and protect associated circuit breaker.
2. Circuit Breakers with Frame Size 1600 A and Smaller: Mount fuses on line side of associated circuit breaker, on a common drawout carriage, arranged so fuses are accessible only when circuit breaker is in "disconnected" position.
3. Circuit Breakers with Frame Sizes More than 1600 A: As directed Fuses and circuit breakers may or shall be installed in separate compartments on separate drawout mountings. Interlock fuse drawout element with associated power circuit breaker to prevent drawing out fuse element unless circuit breaker is in "open" position.
4. Open-Fuse Trip Device: Provide for a positive means of tripping and holding circuit breaker in "open" position when a fuse opens. Indicate open-fuse status at front of circuit breaker or fuse drawout element.

L. Indicating Lights: To indicate circuit breaker is open or closed, for main and bus tie circuit breakers interlocked either with each other or with external devices.

2.10 LOW-VOLTAGE INSTRUMENT SECTION

A. Instrument Transformers: Comply with IEEE C57.13.

1. Potential Transformers: Secondary voltage rating of 120 V and NEMA C 12.11 Accuracy Class of 0.3 with burdens of W, X, and Y.
2. Current Transformers: Burden and Accuracy Class suitable for connected relays, meters, and instruments.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems.

1. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.
2. Switch-selectable digital display with the following features:

    a. Phase Currents, Each Phase: Plus or minus 1 percent.
    b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
    c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
    d. Three-Phase Real Power: Plus or minus 2 percent.
    e. Three-Phase Reactive Power: Plus or minus 2 percent.
    f. Power Factor: Plus or minus 2 percent.
    g. Frequency: Plus or minus 0.5 percent.
    h. Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
    i. Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

3. Communications module suitable for remote monitoring of meter quantities and functions. Interface communication and metering requirements according to Section 260913 "Electrical Power Monitoring and Control."
4. Mounting: Display and control unit that is flush or semi-flush mounted in instrument compartment door.

C. Analog Instruments: Rectangular, 4-1/2 inches (115 mm) square, 1 percent accuracy, semi-flush mounting, with anti-parallax 250-degree scale and external zero adjustment.

1. Voltmeters: Cover an expanded scale range of normal voltage plus 10 percent.
2. Voltmeter Selector Switch: Rotary type with "off" position to provide readings of phase-to-phase and phase-to-neutral voltages.
3. Ammeters: Cover an expanded scale range of bus rating plus 10 percent.
4. Ammeter Selector Switch: Permits current reading in each phase and keeps current-transformer secondary circuits closed in "off" position.
5. Locate meter and selector switch on circuit-breaker compartment door for indicated feeder circuits only.
6. Watt-Hour Meters: Flush- or semi-flush-mounting type, 5 A, 120 V, three phase, three wire; with three elements, 15-minute indicating demand register, and provision for testing and adding pulse initiation.
7. Recording Demand Meter: Usable as totalizing relay or indicating and recording maximum demand meter with 15-minute interval.

a. Operation: Counts and records a succession of pulses entering two channels.
b. Housing: Drawout, back-connected case arranged for semi-flush mounting.

D. Relays: Comply with IEEE C37.90, types and settings as indicated; with test blocks and plugs.

E. Surge Suppression: Factory installed as an integral part of the low-voltage switchgear, complying with UL 1449 SPD, Type 1, with the following features and accessories:

1. Integral disconnect switch.
2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
3. Indicator light display for protection status.
4. Form-C contacts rated at 5-A 250-V ac, one N.O. and one N.C., for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
5. Surge counter.

F. Surge Suppression: Field-mounted surge suppressors complying with Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits." Include the following features and accessories:

1. Integral disconnect switch.
2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
3. Indicator light display for protection status.
4. Form-C contacts rated at 5-A 250-V ac, one N.O. and one N.C., for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
5. Surge counter.

G. Control Power Supply: From the medium-voltage instruments section.

H. Control Power Supply: Control power transformer supplying 120-V control circuits through secondary disconnect devices.

I. Control Wiring: Factory installed, complete with bundling, lacing, and protection; and complying with the following:

1. Flexible conductors for No. 8 AWG and smaller, for conductors across hinges and for conductors for interconnections between shipping units.
2. Conductors sized according to NFPA 70 for duty required.

J. Maintenance Tools: Furnish tools and miscellaneous items required for circuit-breaker and switchgear test, inspection, maintenance, and operation.

1. Racking handle to manually move circuit breaker between "connected" and "disconnected" positions.

2. Portable test set for testing all functions of circuit-breaker, solid-state trip devices without removal from switchgear.
3. Relay and meter test plugs suitable for testing switchgear meters and switchgear class relays.
4. Circuit-Breaker Removal Apparatus: Portable, floor-supported, roller-base, elevating carriage arranged for moving circuit breakers in and out of compartments.
5. Circuit-Breaker Removal Apparatus: Overhead-circuit-breaker lifting device, track mounted at top front of switchgear and complete with hoist and lifting yokes matching each size of drawout circuit breaker installed.
6. Spare-Fuse Cabinet: Identified and compartmented steel box or cabinet with lockable door.
7. Storage for Manual: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.

2.11 IDENTIFICATION DEVICES

A. Compartment Nameplates: Engraved, laminated-plastic or metal nameplate for each compartment, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 260553 "Identification for Electrical Systems."

2.12 SOURCE QUALITY CONTROL

A. Factory Tests: Perform design and routine tests according to standards specified for components. Conduct transformer tests according to IEEE C57.12.90. Conduct switchgear and switchboard tests according to NEMA C 37.51.

B. Factory Tests: Perform the following factory-certified tests on each secondary unit substation:

1. Resistance measurements of all windings on the rated voltage connection and on tap extreme connections.
2. Ratios on the rated voltage connection and on tap extreme connections.
3. Polarity and phase relation on the rated voltage connection.
4. No-load loss at rated voltage on the rated voltage connection.
5. Exciting current at rated voltage on the rated voltage connection.
6. Impedance and load loss at rated current on the rated voltage connection and on tap extreme connections.
7. Applied potential.
8. Induced potential.
9. Temperature Test: If a transformer is supplied with auxiliary cooling equipment to provide more than one rating, test at lowest kVA Class ONAN or Class AA rating and highest kVA Class ONAF or Class AFA rating.

    a. Temperature test is not required if a record of a temperature test on an essentially duplicate unit is available.

10. Owner will witness all required factory tests. Notify Architect at least 14 days before date of tests and indicate their approximate duration.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with applicable portions of NECA 1, NECA 400, NECA 410, NECA 430, and NEMA SG 11.

B. Install secondary unit substations on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed

C. Verify that ground connections are in place and that requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at secondary unit substation location.

D. Comply with requirements for vibration isolation and seismic control devices specified in Section 260529 "Hangers and Supports for Electrical Systems" and Section 260548 "Vibration and Seismic Controls for Electrical Systems."

E. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

3.2 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Install the number of signs required to be readable from each accessible side, but space the signs a maximum of 30 ft. (9 m) apart.
2. Install arc-flash warning labels specified in Section 260573 "Overcurrent Protective Device Arc-Flash Study."

B. Operating Instructions: Place printed operating instructions for secondary unit substations, including key interlocking, control sequences, elementary single-line diagram, and emergency procedures with the maintenance materials.

3.3 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

1. At Interior Locations: For grounding to grounding electrodes, use bare copper cable not smaller than No. 4/0 AWG. Bond surge arrester and neutrals directly to the transformer enclosure and then to the grounding electrode system with bare copper conductors. Keep leads as short as practicable with no kinks or sharp bends. Make joints in grounding conductors and loops by exothermic weld or compression connector.
2. At Exterior Locations:

a. For counterpoise, use tinned bare copper cable not smaller than No. 4/0 AWG, buried not less than 30 inches (765mm) below grade interconnecting the grounding electrodes. Bond surge arrester and neutrals directly to the transformer enclosure and then to the grounding electrode system with bare copper conductors, sized as shown. Keep lead lengths as short as practicable with no kinks or sharp bends.
b. Fence and equipment connections shall not be smaller than No. 4 AWG. Ground fence at each gate post and corner post and at intervals not exceeding 10 ft. (3050 mm). Bond each gate section to the fence post using 1/8 by 1 inch (3 by 25 mm) tinned flexible braided copper strap and clamps.
c. Make joints in grounding conductors and loops by exothermic weld or compression connector.

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 CLEANING

A. After completing equipment installation and before energizing, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish. Vacuum interiors of secondary unit substation sections.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: As directed Owner will engage or Engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

C. General Field Testing Requirements:

1. Comply with the provisions of NFPA 70B Ch. "Testing and Test Methods."
2. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.
3. After installing secondary unit substation but before primary is energized, verify that grounding system at the substation is tested at the specified value or less.
4. After installing secondary unit substation and after electrical circuitry has been energized, test for compliance with requirements.
5. Visual and Mechanical Inspection:

a. Verify equipment nameplate data complies with Contract Documents.
b. Inspect bolted electrical connections for high resistance using one of the following two methods:

1) Use a low-resistance ohmmeter to compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.

6. Remove and replace malfunctioning units and retest.
7. Prepare test and inspection reports. Record as-left set points of all adjustable devices.

D. Switchgear Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, grounding, and required area clearances.
c. Verify the unit is clean and shipping bracing, loose parts, and documentation shipped inside cubicles have been removed.
d. Verify that fuse and circuit-breaker sizes and types correspond to Drawings and coordination study as well as to the address of the circuit breaker that is used to identify it in microprocessor-communication software.
e. Verify that current and voltage-transformer ratios correspond to Drawings.
f. Confirm correct operation and sequencing of electrical and mechanical interlock systems.

1) Attempt closure on locked-open devices. Attempt to open locked-closed devices.
2) Make key exchange with devices operated in off-normal positions.

g. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
h. Inspect insulators for evidence of physical damage or contaminated surfaces.
i. Verify correct barrier and shutter installation and operation.
j. Exercise all active components.
k. Inspect mechanical indicating devices for correct operation.
l. Verify that filters are in place and vents are clear.
m. Inspect control power transformers as follows:

1) Inspect for physical damage, cracked insulation, broken leads, connection tightness, defective wiring, and overall general condition.
2) Verify that primary- and secondary-fuse or circuit-breaker ratings match Drawings and comply with manufacturer's recommendations.
3) Verify correct functioning of drawout disconnecting and grounding contacts and interlocks.

2. Electrical Tests:

a. Perform dc voltage insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground, for one minute. If the temperature of the bus is other than plus or minus 20 deg. C, adjust the resulting resistance as provided in NETA ATS, Table 100.11.

1) Insulation-resistance values of bus insulation shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.1.
2) Do not proceed to the dielectric-withstand-voltage tests until insulation-resistance levels are raised above minimum values.

b. Perform a dielectric-withstand-voltage test on each bus section, each phase-to-ground with phases not under test grounded, according to manufacturer's published data. If manufacturer has no recommendation for this test, it shall be conducted according to NETA ATS, Table 100.2. Apply the test voltage for one minute.

1) If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric-withstand-voltage test, the test specimen is considered to have passed the test.

c. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential shall be 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable. Test duration shall be one minute. For units with solid-state components or control devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.

1) Minimum insulation-resistance values of control wiring shall not be less than 2 megohms.

d. Voltage Transformers:

1) Perform secondary wiring integrity test. Verify correct potential at all devices.
2) Verify secondary voltages by energizing the primary winding with system voltage.

e. Perform current-injection tests on the entire current circuit in each section of switchgear.

1) Perform current tests by secondary injection with magnitudes such that a minimum current of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.
2) Perform current tests by primary injection with magnitudes such that a minimum of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.

f. Verify operation of space heaters.
g. Perform phasing checks on double-ended or dual-source switchgear to ensure correct bus phasing from each source.

E. Medium-Voltage Vacuum Circuit Breaker Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, grounding, and required clearances.
c. Verify that maintenance devices such as special tools and gages specified by the manufacturer are available for servicing and operating the breaker.
d. Verify the unit is clean.
e. Perform mechanical operation tests on operating mechanism according to manufacturer's published data.
f. Measure critical distances on operating mechanism as recommended by the manufacturer. Critical distances of the operating mechanism shall be according to manufacturer's published data.
g. Verify cell fit and element alignment.
h. Verify racking mechanism operation.
i. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
j. Record as-found and as-left operation counter reading. Operation counter shall advance one digit per close-open cycle.

2. Electrical Tests:

a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to ground with switch closed, and across each open pole. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Insulation-resistance values shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than this table or manufacturer's recommendations. Dielectric-withstand-voltage tests shall not proceed until insulation-resistance levels are raised above minimum values.
b. Perform a contact/pole-resistance test. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value. Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in manufacturer's published data. If manufacturer's published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
c. Perform minimum pickup voltage tests on trip and close coils according to manufacturer's published data. Minimum pickup voltage of the trip and close coils shall comply with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.20.
d. Verify correct operation of any auxiliary features, such as electrical close and trip operation, trip-free operation, and anti-pump function. Auxiliary features shall operate according to manufacturer's published data.
e. Trip circuit breaker by operation of each protective device. Reset all trip logs and indicators.
f. Perform vacuum bottle integrity (dielectric-withstand-voltage) test across each vacuum bottle, with the contacts in the "open" position according to manufacturer's published data. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the vacuum bottle integrity test, the test specimen is considered to have passed the test.
g. Perform a dielectric-withstand-voltage test according to manufacturer's published data. If no evidence of distress or insulation failure is observed by the end of the

total time of voltage application during the dielectric-withstand-voltage test, the test specimen is considered to have passed the test.

h. Verify operation of heaters.

F. Instrument Transformer Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Verify correct connection of transformers with system requirements.
c. Verify that adequate clearances exist between primary and secondary circuit wiring.
d. Verify the unit is clean.
e. Verify that required grounding and shorting connections provide contact.
f. Verify correct operation of transformer withdrawal mechanism and grounding operation.
g. Verify correct primary- and secondary-fuse sizes for voltage transformers.
h. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

2. Electrical Tests of Current Transformers:

a. Perform insulation-resistance test of each current transformer and its secondary wiring with respect to ground at 1000-V dc for one minute. For units with solid-state components that cannot tolerate the applied voltage, comply with manufacturer's recommendations. Insulation-resistance values of instrument transformers shall not be less than values shown in NETA ATS, Table 100.5.
b. Perform a polarity test of each current transformer according to IEEE C57.13.1. Polarity results shall agree with transformer markings.
c. Perform a ratio-verification test using the voltage or current method according to IEEE C57.13.1. Ratio errors shall comply with IEEE C57.13.
d. Perform an excitation test on transformers used for relaying applications according to IEEE C57.13.1. Excitation results shall match the curve supplied by the manufacturer or shall comply with IEEE C57.13.1.
e. Measure current circuit burdens at transformer terminals according to IEEE C57.13.1. The measured burdens shall match the instrument transformer Accuracy Class rating.
f. Verify that current-transformer secondary circuits are grounded and have only one grounding point according to IEEE C57.13.3.

3. Electrical Tests of Voltage and Potential Transformers:

a. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply the test voltage for one minute according to NETA ATS, Table 100.5. For units with solid-state components that cannot tolerate the applied voltage, follow manufacturer's recommendations. Insulation-resistance values of instrument transformers shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5.
b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Test voltages shall be applied for one minute according to NETA ATS,

Table 100.5. Insulation-resistance values of the transformers shall not be less than values shown in NETA ATS, Table 100.5.

c. Perform a polarity test on each transformer to verify the polarity marks or H(1)-X(1) relationship. Polarity results shall agree with transformer markings.
d. Perform a turns-ratio test on all tap positions. Ratio errors shall not exceed the tolerances specified in IEEE C57.13.
e. Measure voltage circuit burdens at transformer terminals. Measured burdens shall be compared to instrument transformer ratings. The measured burdens shall match the instrument transformer Accuracy Class rating.
f. Verify that voltage-transformer secondary circuits are grounded and have only one grounding point according to IEEE C57.13.3.

G. Microprocessor-Based Protective Relay Field Tests:

1. Visual and Mechanical Inspection:

a. Record model number, style number, serial number, firmware revision, software revision, and rated control voltage.
b. Verify operation of light-emitting diodes, display, and targets.
c. Record passwords for each access level.
d. Clean the front panel and remove foreign material from the case.
e. Check tightness of connections.
f. Verify that the frame is grounded according to manufacturer's instructions.
g. Set the relay according to results in Section 260573.16 "Coordination Studies" and in Section 260573.19 "Arc-Flash Hazard Analysis."
h. Download settings from the relay. Print a copy of the settings for the report and compare the settings to those specified in the coordination study.

2. Electrical Tests:

a. Perform insulation-resistance tests from each circuit to the grounded frame according to manufacturer's published data.
b. Apply voltage or current to analog inputs and verify correct registration of the relay meter functions.
c. Functional Operation: Check functional operation of each element used in the protection scheme as follows:

1) Timing Relay:

a) Determine time delay.
b) Verify operation of instantaneous contacts.

2) Volts/Hertz Relay:

a) Determine pickup frequency at rated voltage.
b) Determine pickup frequency at a second voltage level.
c) Determine time delay.

3) Sync Check Relay:

a) Determine closing zone at rated voltage.

b) Determine maximum voltage differential that permits closing at zero degrees.
c) Determine live line, live bus, dead line, and dead bus set points.
d) Determine time delay.
e) Verify dead bus/live line, dead line/live bus, and dead bus/dead line control functions.

4) Undervoltage Relay:

a) Determine dropout voltage.
b) Determine time delay.
c) Determine time delay at a second point on the timing curve for inverse time relays.

5) Directional Power Relay:

a) Determine minimum pickup at maximum torque angle.
b) Determine closing zone.
c) Determine maximum torque angle.
d) Determine time delay.
e) Verify time delay at a second point on the timing curve for inverse time relays.

6) Temperature (RTD) Relay:

a) Determine trip resistance.
b) Determine reset resistance.

7) Instantaneous Overcurrent Relay:

a) Determine pickup.
b) Determine dropout.
c) Determine time delay.

8) Time Overcurrent:

a) Determine minimum pickup.
b) Determine time delay at two points on the time current curve.

9) Overvoltage Relay:

a) Determine overvoltage pickup.
b) Determine time delay to close the contact with sudden application of 120 percent of pickup.

10) Transformer Sudden Pressure Relay:

a) Determine rate-of-rise or the pickup level of suddenly applied pressure according to manufacturer's published data.
b) Verify operation of the 63 FPX seal-in circuit.
c) Verify trip circuit to remote operating device.

11) Ground Detector Relay:

a) Determine maximum impedance to ground causing relay pickup.

12) Directional Overcurrent Relay:

a) Determine directional unit minimum pickup at maximum torque angle.
b) Determine closing zone.
c) Determine maximum torque angle.
d) Plot operating characteristics.
e) Determine overcurrent unit pickup.
f) Determine overcurrent unit time delay at two points on the time current curve.

13) Differential:

a) Determine operating unit pickup.
b) Determine the operation of each restraint unit.
c) Determine slope.
d) Determine harmonic restraint.
e) Determine instantaneous pickup.

d. Control Verification:

1) Functional Tests:

a) Check operation of all active digital inputs.
b) Check output contacts or SCRs, preferably by operating the controlled device, such as circuit breaker, auxiliary relay, or alarm.
c) Check internal logic functions used in protection scheme.
d) Upon completion of testing, reset min/max recorders, communications statistics, fault counters, sequence-of-events recorder, and event records.

2) In-Service Monitoring: After the equipment is initially energized, measure magnitude and phase angle of inputs and verify expected values.

H. Liquid-Filled Transformer Section Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect impact recorder prior to unloading
c. Test dew point of tank gases if applicable.
d. Inspect anchorage, alignment, and grounding.
e. Verify the presence of PCB content labeling.
f. Verify removal of any shipping bracing after placement.
g. Verify the bushings are clean.

h. Verify that alarm, control, and trip settings on temperature and level indicators are set and operate within manufacturer's recommended settings.
i. Verify that cooling fans and pumps operate correctly and have appropriate overcurrent protection.
j. Verify that liquid level in tanks and bushings is within manufacturer's published tolerances.
k. Perform specific inspections and mechanical tests recommended by the manufacturer.
l. Verify presence of transformer surge arresters and that their ratings are as specified.
m. Verify that as-left tap connections are as specified.
n. Verify the presence of surge arresters and that their ratings are as specified.

2. Electrical Tests:

a. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index; the value of the index shall not be less than 1.0.
b. Measure core insulation resistance at 500-V dc if the core is insulated and the core ground strap is removable. Core insulation-resistance values shall not be less than 1 megohm at 500-V dc.
c. Perform turns-ratio tests at tap positions. Turns-ratio test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If the test fails, replace the transformer.
d. Perform an excitation-current test on each phase. The typical excitation-current test data pattern for a three-legged core transformer is two similar current readings and one lower current reading. Investigate and correct if the test shows a different pattern.
e. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.
f. Remove a sample of insulating liquid according to ASTM D923. Insulating liquid values shall comply with NETA ATS, Table 100.4. Sample shall be tested for the following:

1) Dielectric Breakdown Voltage: ASTM D877 or ASTM D1816.
2) Acid Neutralization Number: ASTM D974.
3) Interfacial Tension: ASTM D971.
4) Color: ASTM D1500.
5) Visual Condition: ASTM D1524.
6) Water in Insulating Liquids: ASTM D1533.

g. Remove a sample of insulating liquid according to ASTM D923 and perform dissolved-gas analysis according to IEEE C57.104 or ASTM D3612.

I. Small Dry-Type Transformer Section Field Tests:

1. Visual and Mechanical Inspection.

a. Inspect physical and mechanical condition.

b. Inspect anchorage, alignment, and grounding.
c. Verify that resilient mounts are free and that any shipping brackets have been removed.
d. Verify the unit is clean.
e. Perform specific inspections and mechanical tests recommended by the manufacturer.
f. Verify that as-left tap connections are as specified.
g. Verify the presence of surge arresters and that their ratings are as specified.

2. Electrical Tests:

a. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index; the value of the index shall not be less than 1.0.
b. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

J. Large Dry-Type Transformer Section Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, and grounding.
c. Verify that resilient mounts are free and that any shipping brackets have been removed.
d. Verify the unit is clean.
e. Verify that alarm, control, and trip settings on temperature and level indicators are set and operate within manufacturer's recommended settings.
f. Verify that cooling fans operate and that fan motors have correct overcurrent protection.
g. Perform specific inspections and mechanical tests recommended by the manufacturer.
h. Verify that as-left tap connections are as specified.
i. Verify the presence of surge arresters and that their ratings are as specified.

2. Electrical Tests:

a. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index; the value of the index shall not be less than 1.0.
b. Measure core insulation resistance at 500-V dc if the core is insulated and the core ground strap is removable. Core insulation-resistance values shall not be less than 1 megohm at 500-V dc.
c. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

K. Metering Device Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect cover gasket, cover glass, condition of spiral spring, disk clearance, contacts, and case shorting contacts, as applicable.
c. Verify the unit is clean.
d. Verify freedom of movement, end play, and alignment of rotating disk(s).

2. Electrical Tests:

a. Verify accuracy of meters at cardinal points. Meter accuracy shall be according to manufacturer's published data.
b. Calibrate meters according to manufacturer's published data. Calibration results shall be within manufacturer's published tolerances.
c. Verify instrument multipliers. Instrument multipliers shall be according to system design specifications.
d. Verify that current-transformer and voltage-transformer secondary circuits are intact. Test results shall confirm the integrity of the secondary circuits of current and voltage transformers.

3.6 DEMONSTRATION

A. As directed Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain systems.

END OF SECTION 261116.11

SECTION 261116.12 - SECONDARY UNIT SUBSTATIONS WITH SWITCHBOARDS SECONDARY

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes secondary unit substations, each consisting of medium-voltage primary incoming section, transformer section, and low-voltage secondary switchboard section, with the following features:

1. As directed, Indoor enclosure, Outdoor enclosure or Indoor and outdoor enclosures.
2. Medium-voltage, metal-enclosed switchgear section.
3. As directed, Liquid-filled or Dry-type transformer.

B. Related Requirements:

1. Section 260513 "Medium-Voltage Cables" for requirements for terminating cables in incoming section of substation.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.
2. Dimensioned plans and elevations showing major components and features.

    a. Include a plan view and cross section of equipment base, showing clearances, manufacturer's recommended workspace that accounts for breaker service and removal, and locations of penetrations for grounding and conduits.

3. One-line diagram.
4. Nameplate legends.
5. Short-time and short-circuit current ratings of secondary unit substations and components.
6. Ratings of individual protective devices.

C. Design Data:

1. Time-Current Characteristic Curves: For overcurrent protective devices.
2. Primary Fuses: Submit recommendations and size calculations.
3. Utility company's metering provisions with indication of approval by utility company.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings.

1. Outdoor Installations:

a. Include utilities site plan, drawn to scale, showing heavy equipment or truck access paths for maintenance and replacement.
b. Dimensioned concrete base, outline of secondary unit substation, conduit entries, and grounding equipment locations.
c. Support locations, type of support, and weight on each support.

2. Indoor Installations:

a. Location plan, showing heavy equipment or truck access paths for maintenance and replacement.
b. Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved.
c. Dimensioned concrete base, outline of secondary unit substation, conduit entries, and grounding equipment locations.
d. Support locations, type of support, and weight on each support.
e. Location of luminaires, sprinkler piping and heads, ducts, and diffusers.

B. Qualification Data: For testing agency.

C. Seismic Qualification Data: Certificates, for transformer assembly, accessories, and components, from manufacturer.

D. Product certificates.

E. Factory test reports.

F. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA or the National Institute for Certification in Engineering Technologies to supervise on-site testing.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 SYSTEM DESCRIPTION

A. Description: Medium-voltage, primary incoming section; transformer section; and low-voltage secondary switchgear section; and including coordinated circuit breakers, fusible switches, and metering components.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with IEEE C2.

D. Comply with IEEE C37.121.

E. Comply with NFPA 70.

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: The secondary unit substations shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the secondary unit substation will remain in place without separation of any parts when subjected to the seismic forces specified and the secondary unit substation will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 or 1.0 as directed.
3. Component Amplification Factor: 2.5.
4. Component Response Modification Factor: 6.0.

2.4 MANUFACTURED UNITS

A. Indoor Unit Arrangement: Single assembly.

B. Outdoor Unit Arrangement: Single assembly.

1. Weatherproof, listed for installation outdoors, complying with IEEE C37.20.1.
2. Aisleless Construction: Full-height doors in front of basic weatherproof equipment.

C. Connections between the primary device and transformer shall be cable or bus as directed, and between the transformer and secondary shall be flexible bus braid unless noted otherwise.

D. Indoor Enclosure: Steel.

E. Outdoor Enclosure: Weatherproof, galvanized steel, listed for installation outdoors, complying with IEEE C37.20.1. Aisleless, full-height doors, with provisions for padlocking, in front of

basic weatherproof equipment. Integral structural-steel base frame with factory-applied asphaltic undercoating.

1. Each compartment shall have the following features:

   a. Structural design and anchorage adequate to resist loads imposed by 125-mph (200-km/h) wind.
   b. Space heater operating at one-half or less of rated voltage, sized to prevent condensation, controlled by thermostats to maintain temperature of each section above expected dew point.
   c. Louvers equipped with insect and rodent screens and filters and arranged to permit air circulation while excluding rodents and exterior dust.
   d. Weatherproof ground-fault circuit interrupter duplex receptacle.
   e. Power for heaters and receptacles shall be provided by control power transformer or as indicated.
   f. Skid Mounted: Mount each shipping group on an integral base frame as a complete weatherproof unit.

F. Unit Substation Enclosures Finish: Factory-applied finish in manufacturer's standard gray over a rust-inhibiting primer on treated metal surface.

2.5 MEDIUM-VOLTAGE TERMINAL COMPARTMENT SECTION

A. Primary Incoming Section: Terminal assembly with adequate space for incoming-cable terminations and surge arresters, complying with NEMA SG4 and meeting thermal, mechanical, and dielectric requirements specified for the transformer section.

B. Ratings: Suitable for application in three-phase, 60-Hz, solidly grounded-neutral system.

C. System Voltage: As directed, 4.16 kV nominal; 4.76 kV maximum, 7.2 kV nominal; 15 kV maximum, 13.8 kV nominal; 15 kV maximum or 34.5 kV nominal; 38 kV maximum.

D. Surge Arresters: Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor type, connected in each phase of incoming circuit and ahead of any disconnecting device.

2.6 MEDIUM-VOLTAGE METAL-ENCLOSED SWITCHGEAR SECTION

A. Metal-enclosed, air-interrupter switchgear, with or without fuses as directed, complying with IEEE C37.20.3.

1. Switchgear shall be arc-resistant, complying with IEEE C37.20.7, Type 1A, Type 2A, Type 1C or Type 2C as directed.

B. Ratings: Comply with IEEE C37.04; and suitable for application in three-phase, 60-Hz, solidly grounded-neutral system.

1. System Voltage: 4.16 kV nominal; 4.76 kV maximum, 7.2 kV nominal; 15 kV maximum, 13.8 kV nominal; 15 kV maximum or 34.5 kV nominal; 38 kV maximum as directed.

2. Design Level of Available-Source Fault Current: Integrated short-circuit rating consistent with value of fault current indicated.
3. Main-Bus Rating: As directed, 600, 1200 or 2000 A, continuous.

C. Interrupter Switches: Stationary, gang operated, and suitable for application at maximum short-circuit rating of integrated switchgear assembly.

1. Rating: As directed, 600 or 1200-A continuous duty and load break.
2. Two-Time Duty-Cycle Fault Closing: As directed, 25,000 or 40,000 asymmetrical amperes.
3. Switch Action: No external arc and no significant quantities of ionized gas released into the enclosure.
4. Switch Construction: Supported entirely by interior framework of structure, with copper switchblades and stored-energy operating mechanism.
5. Phase Barriers: Full length of switchblades and fuses for each pole; designed for easy removal; allow visual inspection of switch components if barrier is in place.
6. Protective Shields: Cover live components and terminals.

    a. Fuse Mounts: Single-frame mounted and de-energized when switch is open.

7. Mechanical Interlock: Prevent opening switch compartment door unless switchblades are open, and prevent closing switch if door is open. Interlock air-interrupter switch with transformer secondary main circuit breaker, preventing switch from being opened or closed unless secondary main circuit breaker is open.
8. Window: Permits viewing switch-blade positions when door is closed.
9. Accessory Set: Tools and miscellaneous items required for interrupter switchgear test, inspection, maintenance, and operation. Include fuse-handling tool as recommended by switchgear manufacturer.

D. Fuses: Sizes recommended by secondary unit substation manufacturer, considering fan cooling, temperature-rise specification, and cycle loading.

1. Current-Limiting Fuses: Full-range, fast-replaceable, current-limiting type that will operate without explosive noise or expulsion of gas, vapor, or foreign matter from tube.
2. Expulsion Fuses: Furnished in disconnect-type mountings and renewable with replacement fuse units. Gases emitted on interruption are controlled and silenced by chambers designed for that purpose.
3. Indicator integral with each fuse to show when it has blown.
4. Spares: Include three fuses in use and three spare fuses in storage clips in each switch.

E. Surge Arresters: Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor type, with ratings as indicated, connected in each phase of incoming circuit and ahead of any disconnecting device.

2.7 MEDIUM-VOLTAGE INSTRUMENTS SECTION

A. Instrument Transformers: Comply with IEEE C57.13.

1. Potential and Current Transformers: Burden and Accuracy Class suitable for connected meters.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems.

1. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.
2. Switch-selectable digital display with the following features:

    a. Phase Currents, Each Phase: Plus or minus 1 percent.
    b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
    c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
    d. Three-Phase Real Power: Plus or minus 2 percent.
    e. Three-Phase Reactive Power: Plus or minus 2 percent.
    f. Power Factor: Plus or minus 2 percent.
    g. Frequency: Plus or minus 0.5 percent.
    h. Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.

3. Communications module suitable for remote monitoring of meter quantities and functions. Interface communication and metering requirements according to Section 260913 "Electrical Power Monitoring and Control."
4. Mounting: Display and control unit that is flush or semi-flush mounted in instrument compartment door.

C. Analog Instruments: Rectangular, 4-1/2 inches (115 mm) square, 1 percent accuracy, semi-flush mounting, with anti-parallax 250-degree scale and external zero adjustment.

1. Voltmeters: Cover an expanded scale range of normal voltage plus 10 percent.
2. Voltmeter Selector Switch: Rotary type with off position to provide readings of phase-to-phase and phase-to-neutral voltages.
3. Ammeters: Cover an expanded scale range of bus rating plus 10 percent.
4. Ammeter Selector Switch: Permits current reading in each phase and keeps current-transformer secondary circuits closed in off position.
5. Locate meter and selector switch on circuit-breaker compartment door for indicated feeder circuits only.
6. Watt-Hour Meters: Flush- or semi-flush-mounting type, 5 A, 120 V, three phase, three wire; with three elements, 15-minute indicating demand register, and provision for testing and adding pulse initiation.
7. Recording Demand Meter: Usable as totalizing relay or indicating and recording maximum demand meter with 15-minute interval.

    a. Operation: Counts and records a succession of pulses entering two channels.
    b. Housing: Drawout, back-connected case arranged for semi-flush mounting.

2.8 LIQUID-FILLED TRANSFORMER SECTION

A. Description: IEEE C57.12.00 and UL 1062, liquid-filled, two-winding, secondary unit substation transformer.

B. Insulating Liquid: Mineral oil complying with ASTM D3487, Type II, and tested according to ASTM D117.

C. Insulation Temperature Rise: 55 deg C, based on an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C. Insulation system shall be rated to continuously allow an additional 12-percent kVA output, at 65 deg C temperature rise, without decreasing rated transformer life.

D. Insulation Temperature Rise: 65 deg C, based on an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C.

E. BIL: As directed, 60, 75, 95 or 110 kV as directed.

F. Full-Capacity Voltage Taps: Four nominal 2.5 percent taps, two above and two below rated primary voltage; with externally operable tap changer for de-energized use and with position indicator and padlock hasp.

G. Cooling System: Class ONAN, liquid cooled, Class ONAN/ONAF, liquid cooled, and with forced-air rating or Class ONAN/ONAF/ONAF, liquid cooled, and with provisions for future forced-air rating as directed. Cooling systems shall include auxiliary cooling equipment, automatic controls, and status indicating lights.

H. Impedance: Percent as directed.

I. Accessories: Grounding pads, lifting lugs, and provisions for jacking under base. Transformers shall have a steel base and frame allowing use of pipe rollers in any direction, and an insulated, low-voltage, neutral bushing with removable ground strap. Include the following additional accessories:

1. Liquid-level gage.
2. Pressure-vacuum gage.
3. Liquid temperature indicator.
4. Drain and filter valves.
5. Pressure-relief device.

2.9 DRY-TYPE TRANSFORMER SECTION

A. Description: IEEE C57.12.01, IEEE C57.12.50 or IEEE C57.12.51, and dry-type, two-winding, secondary unit substation transformer as directed.

B. Primary Incoming Section: Transformer cover-mounted bushings. The bushings shall meet thermal, mechanical, and dielectric requirements as specified for the transformer section.

C. Style: As directed, Indoor, ventilated, Outdoor, ventilated or Totally enclosed, nonventilated, cast coil/encapsulated coil, with primary and secondary windings individually cast in epoxy; with insulation system rated at 185 deg C with an 80 deg C average winding temperature rise above a maximum ambient temperature of 40 deg C.

D. Style: AS directed, Indoor, ventilated, Outdoor, ventilated or Totally enclosed, nonventilated, vacuum-pressure, impregnated type, and with insulation system rated at 220 deg C with an 80 deg C average winding temperature rise above a maximum ambient temperature of 40 deg C.

E. Cooling System: Class AA, air cooled, complying with IEEE C57.12.01.

F. Cooling System: Class AFA, air cooled with forced-air rating, complying with IEEE C57.12.01.

1. Manual forced-air cooling system controls, including manual switch for fans, fan controller and associated power and control wiring, and power panel with current-limiting fuses.
2. Include mounting provision for fans.

G. Cooling System: Class AA/FA, air cooled with provisions for future forced-air rating, complying with IEEE C57.12.01.

1. Automatic forced-air cooling system controls, including thermal sensors, fans, control wiring, temperature controller with test switch, power panel with current-limiting fuses, indicating lights, alarm, and alarm-silencing relay.
2. Include mounting provision for fans.

H. Cooling System: Class AFA, forced-air cooling, complying with IEEE C57.12.01.

1. Automatic forced-air cooling system controls, including thermal sensors, fans, control wiring, temperature controller with test switch, power panel with current-limiting fuses, indicating lights, alarm, and alarm-silencing relay.
2. Include cooling fans.

I. Insulation Materials: IEEE C57.12.01, rated 220 deg C.

1. Insulation Temperature Rise: As directed, 80, 115 or 150 deg C, maximum rise above 40 deg C.

J. BIL: 60, 75, 95 or 110 kV as directed.

K. Full-Capacity Voltage Taps: Four nominal 2.5 percent taps, two above and two below rated primary voltage.

L. Impedance: Percent as directed.

M. High-Temperature Alarm: Sensor at transformer with local audible and visual alarm and contacts for remote alarm.

2.10 SECONDARY DISTRIBUTION SECTION SWITCHBOARD

A. The secondary distribution section shall be drawout, fused or fused where indicated, low-voltage switchgear, complying with NEMA PB 2 and UL 891.

B. Switchboard Structure: Front and rear accessible.

1. Match and align the front or front and rear of the switchgear as directed.
2. Comply with UL requirements for service entrance equipment.

C. Switchboard Bus:

1. Use bus bars to connect compartments and vertical sections. Cable connections are not permitted.
2. Main Phase Bus: Uniform capacity the entire length of section.
3. Neutral Bus: As directed, 50 or 100 percent of phase-bus ampacity, except as indicated. Equip bus with pressure-connector terminations for outgoing circuit neutral conductors. Include braces for neutral-bus extensions for busway feeders.
4. Vertical Section Bus: Extend to spaces for future circuit breakers.
5. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent minimum conductivity, with copper feeder circuit-breaker line connections.
6. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent minimum conductivity or tin-plated, high-strength, electrical-grade aluminum alloy.
7. Ground Bus: Hard-drawn copper of 98 percent minimum conductivity, with pressure connector for feeder and branch-circuit ground conductors, minimum size 1/4-by-2 inches (6 by 50 mm).
8. Neutral bus equipped with pressure-connector terminations for outgoing circuit neutral conductors. Neutral-bus extensions for busway feeders are braced.
9. Neutral Disconnect Link: Bolted, uninsulated, 1/4-by-2-inch (6-by-50-mm) copper bus, arranged to connect neutral bus to ground bus.

D. Switchboard Arrangement:

1. Main Disconnect Device(s): As directed, Bolted pressure switches, ICCBs, MCCBs or Fusible switches.
2. Feeder Protective Devices: As directed, Bolted pressure switches, ICCBs, MCCBs or Fusible switches.

E. Bolted Pressure Switches: As directed, Fixed-mounted, manually operated, electrically tripped, or fusible, bolted pressure contact switch. Comply with UL 977.

1. Stored energy deadfront mechanism, compressed and released by the operating handle; switching action shall be independent of the speed of the operating handle.
2. Indication whether the switch is open or closed, and provisions for padlocking the operating handle.
3. With fuse clips and fuses for UL 248 Class L time-delay fuses.
4. Electrically tripped switches shall include:

    a. Ground-fault protection, with adjustable time delay and test panel.
    b. Single-phase protection, tripping the switch on loss of a source phase.
    c. Blown fuse protection, tripping the switch on a blown fuse, with blown fuse indication.

F. ICCBs: As directed, Fixed or Drawout-mounted, manually or electrically operated air-circuit breakers. Comply with UL 1066.

1. With "close" and "open" push buttons and red and green lighted breaker position indicators. Charging time of the motor operator shall not exceed 8 seconds. Operator power shall be from a control power transformer internal to the switchboard.
2. Solid-state monitoring and tripping system to provide system status monitoring, adjustable time-current protection, and shunt trip.

a. Interchangeable current sensors and timing circuits for adjustable time-current protection settings and status signals.
b. LED indicators or display, with manual reset, to show cause of automatic trip.
c. Display panel to indicate that the status of the system circuitry is fully operational or give fault location based on automatic diagnosis.
d. Trip the circuit breaker when closing on a fault.
e. Time-current adjustments to achieve protective-device coordination as follows:

1) Adjustable long-delay pickup and time.
2) Individual adjustments for short-delay pickup, time, and I-squared-t setting.
3) Adjustable instantaneous pickup.
4) Individually adjustable ground-fault pickup and time, with I-squared-t setting or ground alarm as directed.

f. With built-in connector to test the breaker settings. Provide one test set.
g. Battery backup for informational displays after automatic trip, with battery status indicator.

G. MCCBs (to 1600 A): Fixed-mounted, manually operated air-circuit breakers. Comply with UL 489.

1. With quick-make, quick-break, over-center switching mechanism that is mechanically trip-free, and its position is shown by the position of the handle. With manual push-to-trip push button.
2. Solid-state monitoring and tripping system to provide system status monitoring, adjustable time-current protection, and shunt trip.

a. Interchangeable current sensors and timing circuits for adjustable time-current protection settings and status signals.
b. With trip-setting dials or interchangeable plugs to establish the continuous trip of the circuit breaker. Plugs shall not be interchangeable between frames, and the breaker may not be closed without the plug. With neutral ground-fault sensor.
c. Time-current adjustments to achieve protective-device coordination as follows:

1) Adjustable long-time delay.
2) Adjustable short-time setting and delay to shape the time-current curve.
3) Adjustable instantaneous setting.
4) Individually adjustable ground-fault setting and time delay.

d. With built-in connector to test the long-time delay, instantaneous, and ground-fault functions of the breaker. Provide one test set for testing the installed circuit breakers 225-ampere frame and higher.
e. With built-in digital ammeter display, showing load current and tripping cause.

H. MCCBs (1600 to 2500 A): Fixed-mounted, manually operated air-circuit breakers. Comply with UL 489.

1. With quick-make, quick-break, over-center switching mechanism that is mechanically trip-free, and its position is shown by the position of the handle. With manual push-to-trip push button.

2. Solid-state monitoring and tripping system to provide system status monitoring, adjustable time-current protection, and shunt trip.

    a. Interchangeable current sensors and timing circuits for adjustable time-current protection settings and status signals.
    b. LED indicators or display, with manual reset, to show reasons of automatic trip.
    c. Display panel to indicate that the status of the system circuitry is fully operational, or give fault location based on automatic diagnosis.
    d. Trip the circuit breaker when closing on a fault.
    e. Time-current adjustments to achieve protective-device coordination as follows:

        1) Adjustable long-delay pickup and time.
        2) Individual adjustments for short-delay pickup, time, and I-squared-t setting.
        3) Adjustable instantaneous pickup.
        4) Individually adjustable ground-fault pickup and time, with I-squared-t setting or ground alarm.

    f. One test kit to test each trip function.
    g. Battery backup for informational displays after automatic trip, with battery status indicator.

I. Fusible Switches: Fixed-mounted, manually operated, electrically tripped, fusible, quick-make, quick-break switch. Comply with UL 98.

1. Indication whether the switch is open or closed, and provisions for padlocking the operating handle.
2. With fuse clips and fuses.
3. Electrically tripped switches shall include:

    a. Shunt trip.
    b. Ground-fault protection, with adjustable time delay and test panel.
    c. Single-phase protection, tripping the switch on loss of a source phase.
    d. Blown fuse protection, tripping the switch on a blown fuse, with blown fuse indication.

2.11 LOW-VOLTAGE INSTRUMENTS SECTION

A. Instrument Transformers: Comply with IEEE C57.13.

1. Potential Transformers: Secondary voltage rating of 120 V and NEMA C 12.11 Accuracy Class of 0.3 with burdens of W, X, and Y.
2. Current Transformers: Burden and Accuracy Class suitable for connected relays, meters, and instruments.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems.

1. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.
2. Switch-selectable digital display with the following features:

a. Phase Currents, Each Phase: Plus or minus 1 percent.
b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
d. Three-Phase Real Power: Plus or minus 2 percent.
e. Three-Phase Reactive Power: Plus or minus 2 percent.
f. Power Factor: Plus or minus 2 percent.
g. Frequency: Plus or minus 0.5 percent.
h. Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
i. Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

3. Communications module suitable for remote monitoring of meter quantities and functions. Interface communication and metering requirements according to Section 260913 "Electrical Power Monitoring and Control."
4. Mounting: Display and control unit that is flush or semi-flush mounted in instrument compartment door.

C. Analog Instruments: Rectangular, 4-1/2 inches (115 mm) square, 1 percent accuracy, semi-flush mounting, with anti-parallax 250-degree scale and external zero adjustment.

1. Voltmeters: Cover an expanded scale range of normal voltage plus 10 percent.
2. Voltmeter Selector Switch: Rotary type with "off" position to provide readings of phase-to-phase and phase-to-neutral voltages.
3. Ammeters: Cover an expanded scale range of bus rating plus 10 percent.
4. Ammeter Selector Switch: Permits current reading in each phase and keeps current-transformer secondary circuits closed in "off" position.
5. Locate meter and selector switch on circuit-breaker compartment door for indicated feeder circuits only.
6. Watt-Hour Meters: Flush- or semi-flush-mounting type, 5 A, 120 V, three phase, three wire; with three elements, 15-minute indicating demand register, and provision for testing and adding pulse initiation.
7. Recording Demand Meter: Usable as totalizing relay or indicating and recording maximum demand meter with 15-minute interval.

a. Operation: Counts and records a succession of pulses entering two channels.
b. Housing: Drawout, back-connected case arranged for semi-flush mounting.

D. Relays: Comply with IEEE C37.90, types and settings as indicated; with test blocks and plugs.

E. Surge Suppression: Factory installed as an integral part of the low-voltage switchgear, complying with UL 1449 SPD, Type 1, with the following features and accessories:

1. Integral disconnect switch.
2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
3. Indicator light display for protection status.
4. Form-C contacts rated at 5 A and 250-V ac, one N.O. and one N.C., for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.

5. Surge counter.

F. Control Power Supply: Control power transformer supplying 120-V control circuits through secondary disconnect devices.

G. Control Wiring: Factory installed, complete with bundling, lacing, and protection; and complying with the following:

1. Flexible conductors for No. 8 AWG and smaller, for conductors across hinges and for conductors for interconnections between shipping units.
2. Conductors sized according to NFPA 70 for duty required.

H. Maintenance Tools: Furnish tools and miscellaneous items required for circuit-breaker and switchgear test, inspection, maintenance, and operation.

1. Racking handle to manually move circuit breaker between "connected" and "disconnected" positions.
2. Portable test set for testing all functions of circuit-breaker, solid-state trip devices without removal from switchboard.
3. Relay and meter test plugs suitable for testing switchgear meters and switchgear class relays.
4. Circuit-Breaker Removal Apparatus: Portable, floor-supported, roller-base, elevating carriage arranged for moving circuit breakers in and out of compartments.
5. Spare-Fuse Cabinet: Identified and compartmented steel box or cabinet with lockable door.
6. Storage for Manual: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.

2.12 IDENTIFICATION DEVICES

A. Compartment Nameplates: Engraved, laminated-plastic or metal nameplate for each compartment, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 260553 "Identification for Electrical Systems."

2.13 SOURCE QUALITY CONTROL

A. Factory Tests: Perform design and routine tests according to standards specified for components. Conduct transformer tests according to IEEE C57.12.90. Conduct switchgear and switchboard tests according to NEMA C37.51.

B. Factory Tests: Perform the following factory-certified tests on each secondary unit substation:

1. Resistance measurements of all windings on the rated voltage connection and on tap extreme connections.
2. Ratios on the rated voltage connection and on tap extreme connections.
3. Polarity and phase relation on the rated voltage connection.
4. No-load loss at rated voltage on the rated voltage connection.
5. Exciting current at rated voltage on the rated voltage connection.

6. Impedance and load loss at rated current on the rated voltage connection and on tap extreme connections.
7. Applied potential.
8. Induced potential.
9. Temperature Test: If a transformer is supplied with auxiliary cooling equipment to provide more than one rating, test at lowest kVA Class ONAN or Class AA rating and highest kVA Class ONAF or Class AFA rating.

    a. Temperature test is not required if a record of a temperature test on an essentially duplicate unit is available.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with applicable portions of NECA 1, NECA 400, NECA 410, NECA 430, and NEMA SG 11.

B. Install secondary unit substations on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.

C. Comply with requirements for vibration isolation and seismic control devices specified in Section 260529 "Hangers and Supports for Electrical Systems" and Section 260548.16 "Seismic Controls for Electrical Systems."

D. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

3.2 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Install the number of signs required to be readable from each accessible side but space the signs a maximum of 30 ft. (9 m) apart.
2. Install arc-flash warning labels specified in Section 260573.19 "Arc-Flash Hazard Analysis."

B. Operating Instructions: Place printed operating instructions for secondary unit substations, including key interlocking, control sequences, elementary single-line diagram, and emergency procedures with the maintenance materials.

3.3 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

1. At Interior Locations: For grounding to grounding electrodes, use bare copper cable not smaller than No. 4/0 AWG. Bond surge arrester and neutrals directly to the transformer enclosure and then to the grounding electrode system with bare copper conductors. Keep leads as short as practicable with no kinks or sharp bends. Make joints in grounding conductors and loops by exothermic weld or compression connector.
2. At Exterior Locations:

    a. For counterpoise, use tinned bare copper cable not smaller than No. 4/0 AWG, buried not less than 30 inches (765 mm) below grade interconnecting the grounding electrodes. Bond surge arrester and neutrals shall directly to the transformer enclosure and then to the grounding electrode system with bare copper conductors, sized as shown. Keep lead lengths as short as practicable with no kinks or sharp bends.
    b. Fence and equipment connections shall not be smaller than No. 4 AWG. Ground fence at each gate post and corner post and at intervals not exceeding 10 ft. (3050 mm). Bond each gate section to the fence post using 1/8 by 1 inch (3 by 25 mm) tinned flexible braided copper strap and clamps.
    c. Make joints in grounding conductors and loops by exothermic weld or compression connector.

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 CLEANING

A. After completing equipment installation and before energizing, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish. Vacuum interiors of secondary unit substation sections.

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

B. General Field Testing Requirements:

1. Comply with the provisions of NFPA 70B Ch. "Testing and Test Methods."
2. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.
3. After installing secondary unit substation but before primary is energized, verify that grounding system at the substation is tested at the specified value or less.
4. After installing secondary unit substation and after electrical circuitry has been energized, test for compliance with requirements.
5. Visual and Mechanical Inspection:

    a. Verify equipment nameplate data complies with Contract Documents.
    b. Inspect bolted electrical connections for high resistance using one of the following two methods:

1) Use a low-resistance ohmmeter to compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.

6. Remove and replace malfunctioning units and retest.
7. Prepare test and inspection reports. Record as-left set points of all adjustable devices.

C. Switchgear Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, grounding, and required area clearances.
c. Verify the unit is clean and shipping bracing, loose parts, and documentation shipped inside cubicles have been removed.
d. Verify that fuse and circuit-breaker sizes and types correspond to Drawings and coordination study as well as the address of the circuit breaker that is used to identify it in microprocessor-communication software.
e. Verify that current and voltage-transformer ratios correspond to Drawings.
f. Confirm correct operation and sequencing of electrical and mechanical interlock systems.

1) Attempt closure on locked-open devices. Attempt to open locked-closed devices.
2) Make key exchange with devices operated in off-normal positions.

g. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
h. Inspect insulators for evidence of physical damage or contaminated surfaces.
i. Verify correct barrier and shutter installation and operation.
j. Exercise all active components.
k. Inspect mechanical indicating devices for correct operation.
l. Verify that filters are in place and vents are clear.
m. Inspect control power transformers as follows:

1) Inspect for physical damage, cracked insulation, broken leads, connection tightness, defective wiring, and overall general condition.
2) Verify that primary- and secondary-use or circuit-breaker ratings match Drawings and comply with manufacturer's recommendations.
3) Verify correct functioning of drawout disconnecting and grounding contacts and interlocks.

2. Electrical Tests:

a. Perform dc voltage insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground, for one minute. If the temperature of the bus is other than plus or minus 20 deg. C, adjust the resulting resistance as provided in NETA ATS Table 100.11.

1) Insulation-resistance values of bus insulation shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.1.
2) Do not proceed to the dielectric-withstand-voltage tests until insulation-resistance levels are raised above minimum values.

b. Perform a dielectric-withstand-voltage test on each bus section, each phase-to-ground with phases not under test grounded, according to manufacturer's published data. If manufacturer has no recommendation for this test, it shall be conducted according to NETA ATS, Table 100.2. Apply the test voltage for one minute.

1) If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric-withstand-voltage test, the test specimen is considered to have passed the test.

c. Voltage Transformers:

1) Perform secondary wiring integrity test. Verify correct potential at all devices.
2) Verify secondary voltages by energizing the primary winding with system voltage.

d. Perform current-injection tests on the entire current circuit in each section of switchgear.

1) Perform current tests by secondary injection with magnitudes such that a minimum current of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.
2) Perform current tests by primary injection with magnitudes such that a minimum of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.

e. Verify operation of space heaters.
f. Perform phasing checks on double-ended or dual-source switchgear to ensure correct bus phasing from each source.

D. Instrument Transformer Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Verify correct connection of transformers with system requirements.
c. Verify that adequate clearances exist between primary and secondary circuit wiring.

d. Verify the unit is clean.
e. Verify that all required grounding and shorting connections provide contact.
f. Verify correct operation of transformer withdrawal mechanism and grounding operation.
g. Verify correct primary- and secondary-fuse sizes for voltage transformers.
h. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

2. Electrical Tests of Current Transformers:

a. Perform insulation-resistance test of each current transformer and its secondary wiring with respect to ground at 1000-V dc for one minute. For units with solid-state components that cannot tolerate the applied voltage, comply with manufacturer's recommendations. Insulation-resistance values of instrument transformers shall not be less than values shown in NETA ATS, Table 100.5.
b. Perform a polarity test of each current transformer according to IEEE C57.13.1. Polarity results shall agree with transformer markings.
c. Perform a ratio-verification test using the voltage or current method according to IEEE C57.13.1. Ratio errors shall comply with IEEE C57.13.
d. Perform an excitation test on transformers used for relaying applications according to IEEE C57.13.1. Excitation results shall match the curve supplied by the manufacturer or shall comply with IEEE C57.13.1.
e. Measure current circuit burdens at transformer terminals according to IEEE C57.13.1. The measured burdens shall match the instrument transformer Accuracy Class rating.
f. Verify that current-transformer secondary circuits are grounded and have only one grounding point according to IEEE C57.13.3.

3. Electrical Tests of Voltage and Potential Transformers:

a. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply the test voltage for one minute according to NETA ATS, Table 100.5. For units with solid-state components that cannot tolerate the applied voltage, follow manufacturer's recommendations. Insulation-resistance values of instrument transformers shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5.
b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Test voltages shall be applied for one minute according to NETA ATS, Table 100.5. Insulation-resistance values of the transformers shall not be less than values shown in NETA ATS, Table 100.5
c. Perform a polarity test on each transformer to verify the polarity marks or H(1)-X(1) relationship. Polarity results shall agree with transformer markings.
d. Perform a turns-ratio test on all tap positions. Ratio errors shall not exceed the tolerances specified in IEEE C57.13.
e. Measure voltage circuit burdens at transformer terminals. Measured burdens shall be compared to instrument transformer ratings. The measured burdens shall match the instrument transformer Accuracy Class rating.
f. Verify that voltage-transformer secondary circuits are grounded and have only one grounding point according to IEEE C57.13.3.

E. Microprocessor-Based Protective Relay Field Tests:

1. Visual and Mechanical Inspection:

a. Record model number, style number, serial number, firmware revision, software revision, and rated control voltage.
b. Verify operation of light-emitting diodes, display, and targets.
c. Record passwords for each access level.
d. Clean the front panel and remove foreign material from the case.
e. Check tightness of connections.
f. Verify that the frame is grounded according to manufacturer's instructions.
g. Set the relay according to results in Section 260573.16 "Coordination Studies" and in Section 260573.19 "Arc-Flash Hazard Analysis."
h. Download settings from the relays. Print a copy of the settings for the report and compare the settings to those specified in the coordination study.

2. Electrical Tests:

a. Perform insulation-resistance tests from each circuit to the grounded frame according to manufacturer's published data.
b. Apply voltage or current to all analog inputs and verify correct registration of the relay meter functions.
c. Functional Operation: Check functional operation of each element used in the protection scheme.

F. Liquid-Filled Transformer Section Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect impact recorder prior to unloading.
c. Test dew point of tank gases if applicable.
d. Inspect anchorage, alignment, and grounding.
e. Verify the presence of PCB content labeling.
f. Verify removal of any shipping bracing after placement.
g. Verify the bushings are clean.
h. Verify that alarm, control, and trip settings on temperature and level indicators are set and operate within manufacturer's recommended settings.
i. Verify that cooling fans and pumps operate correctly and have appropriate overcurrent protection.
j. Verify that liquid level in tanks and bushings is within manufacturer's published tolerances.
k. Perform specific inspections and mechanical tests recommended by the manufacturer.
l. Verify presence of transformer surge arresters and that their ratings are as specified.
m. Verify that as-left tap connections are as specified.
n. Verify the presence of surge arresters and that their ratings are as specified.

G. Dry-Type Transformer Section Field Tests:

1. Visual and Mechanical Inspection:

    a. Inspect physical and mechanical condition.
    b. Inspect anchorage, alignment, and grounding.
    c. Verify that resilient mounts are free and that any shipping brackets have been removed.
    d. Verify the unit is clean.
    e. Perform specific inspections and mechanical tests recommended by the manufacturer.
    f. Verify that as-left tap connections are as specified.
    g. Verify the presence of surge arresters and that their ratings are as specified.

H. Insulated-Case/Molded-Case Air-Circuit-Breaker Field Tests:

1. Visual and Mechanical Inspection:

    a. Inspect physical and mechanical condition.
    b. Inspect anchorage and alignment.
    c. Verify the unit is clean.
    d. Operate the circuit breaker to ensure smooth operation.
    e. Inspect operating mechanism, contacts, and arc chutes in unsealed units.
    f. Perform adjustments for final protective-device settings according to the coordination study. Set the protective devices according to results in Section 260573.16 "Coordination Studies" and in Section 260573.19 "Arc-Flash Hazard Analysis."

2. Electrical Tests:

    a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to ground with the circuit breaker closed, and across each open pole. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Insulation-resistance values shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Values of insulation resistance less than this table or manufacturer's recommendations shall be investigated.
    b. Perform a contact/pole-resistance test. Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data. If manufacturer's published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
    c. Determine long-time pickup and delay by primary current injection. Ground-fault pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band, including adjustment factors.
    d. Determine short-time pickup and delay by primary current injection. Short-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
    e. Determine ground-fault pickup and time delay by primary current injection. Ground-fault pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.

f. Determine instantaneous pickup by primary current injection. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.8.
g. Perform minimum pickup voltage tests on shunt trip and close coils according to manufacturer's published data. Minimum pickup voltage of the shunt trip and close coils shall conform to the manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.20.
h. Verify correct operation of auxiliary features, such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free operation, anti-pump function, and trip unit battery condition. Reset all trip logs and indicators. Auxiliary features shall operate according to manufacturer's published data.
i. Verify operation of charging mechanism. The charging mechanism shall operate according to manufacturer's published data.

I. Low-Voltage Ground-Fault Protection System Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect the components for damage and errors in polarity or conductor routing.

1) Verify that ground connection is made on the source side of the neutral disconnect link and on the source side of any ground-fault sensor.
2) Verify that the neutral sensors are connected with correct polarity on both primary and secondary.
3) Verify that phase conductors and the neutral pass through the sensor in the same direction for zero sequence systems.
4) Verify that grounding conductors do not pass through zero sequence sensors.
5) Verify that grounded conductor is solidly grounded.

b. Verify the unit is clean.
c. Operate the circuit breaker to ensure smooth operation.
d. Verify correct operation of functions of the self-test panel if provided.
e. Verify that the control power transformer has adequate capacity for the system.
f. Set pickup and time-delay settings according to "Quality Control" Article. Record appropriate operation and test sequences according to NFPA 70, "Services" Article, "Ground-Fault Protection Equipment" Section.

2. Electrical Tests:

a. Measure the system neutral-to-ground insulation resistance with the neutral disconnect link temporarily removed. Replace the neutral disconnect link after testing. System neutral-to-ground insulation resistance shall be a minimum of one megohm. Correct wiring until the minimum is achieved.
b. Perform ground-fault protective-device pickup tests using primary injection. Results of pickup test shall be greater than 90 percent of the ground-fault protective-device pickup setting and less than 1200 A or 125 percent of the pickup setting, whichever is smaller. Adjust or replace the device until these parameters are achieved.

c. For summation-type systems utilizing phase and neutral current transformers, verify correct polarities by applying current to each phase-neutral current-transformer pair. This test also applies to MCCBs utilizing an external neutral current transformer. The ground-fault protective device shall operate when current direction is the same relative to polarity marks in the two current transformers. The ground-fault protective device shall not operate when current direction is opposite relative to polarity marks in the two current transformers.
d. Measure time delay of the ground-fault protective device at a value equal to or greater than 150 percent of the pickup value. Relay timing shall be according to manufacturer's published data but shall be no longer than one second at 3000 A according to NFPA 70, "Services" Article, "Ground-Fault Protection Equipment" Section.
e. Verify reduced control voltage tripping capability is 55 percent for ac systems and 80 percent for dc systems. Replace the ground-fault system if the reduced control voltage tripping requirement is not achieved, and retest.
f. Verify blocking capability of zone interlock systems. Results of zone-blocking tests shall be according to manufacturer's published data and design specifications.

J. Metering Device Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect cover gasket, cover glass, condition of spiral spring, disk clearance, contacts, and case shorting contacts, as applicable.
c. Verify the unit is clean.
d. Verify freedom of movement, end play, and alignment of rotating disk(s).

2. Electrical Tests:

a. Verify accuracy of meters at all cardinal points. Meter accuracy shall be according to manufacturer's published data.
b. Calibrate meters according to manufacturer's published data. Calibration results shall be within manufacturer's published tolerances.
c. Verify all instrument multipliers. Instrument multipliers shall be according to system design specifications.
d. Verify that current-transformer and voltage-transformer secondary circuits are intact. Test results shall confirm the integrity of the secondary circuits of current and voltage transformers.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain systems.

END OF SECTION 261116.12

SECTION 261116.13 - SECONDARY UNIT SUBSTATIONS WITH MOTOR CONTROL CENTER SECONDARY

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes secondary unit substations, each consisting of medium-voltage primary incoming section, transformer section, and low-voltage secondary MCC section, with the following features:

1. Indoor enclosure, Outdoor enclosure or Indoor and outdoor enclosures as directed.
2. Medium-voltage, MCC section.
3. As directed, Liquid-filled or Dry-type transformer.

B. Related Requirements:

1. Section 260513 "Medium-Voltage Cables" for requirements for terminating cables in incoming section of substation.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.
2. Dimensioned plans and elevations showing major components and features.

    a. Include a plan view and cross section of equipment base, showing clearances, manufacturer's recommended workspace that accounts for breaker service and removal, and locations of penetrations for grounding and conduits.

3. One-line diagram.
4. Nameplate legends.
5. Short-time and short-circuit current ratings of secondary unit substations and components.
6. Ratings of individual protective devices.
7. For the motor-control secondary section, submit manufacturer's standard drawings complying with the requirements of UL 845.

    a. Manufacturer's production drawings as defined in UL 845.
    b. Schematic and Connection Wiring Diagrams: For power, signal, and control wiring for each installed controller.
    c. Nameplate legends.
    d. Vertical and horizontal bus capacities.

e. Features, characteristics, ratings, and factory settings of each installed unit.

C. Design Data:

1. Time-Current Characteristic Curves: For overcurrent protective devices.
2. Primary Fuses: Submit recommendations and size calculations.
3. Utility company's metering provisions with indication of approval by utility company.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:

1. Outdoor Installations:

a. Utilities site plan, drawn to scale, showing heavy equipment or truck access paths for maintenance and replacement.
b. Dimensioned concrete base, outline of secondary unit substation, conduit entries, and grounding equipment locations.
c. Support locations, type of support, and weight on each support.

2. Indoor Installations:

a. Location plan, showing heavy equipment or truck access paths for maintenance and replacement.
b. Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
c. Dimensioned concrete base, outline of secondary unit substation, conduit entries, and grounding equipment locations.
d. Support locations, type of support, and weight on each support.

B. Qualification Data: For testing agency.

C. Seismic Qualification Data: Certificates, for transformer assembly, accessories, and components, from manufacturer.

D. Product certificates.

E. Factory test reports.

F. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA or the National Institute for Certification in Engineering Technologies to supervise on-site testing.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 SYSTEM DESCRIPTION

A. Description: Medium-voltage, primary incoming section; transformer section; and low-voltage MCC section; and including coordinated circuit breakers, fusible switches, and metering components.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with IEEE C2.
3. Comply with IEEE C37.121.
4. Comply with NFPA 70.

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: The secondary unit substations shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the secondary unit substation will remain in place without separation of any parts when subjected to the seismic forces specified and the secondary unit substation will be fully operational after the seismic event."
2. Component Importance Factor: As directed, 1.5 or 1.0.
3. Component Amplification Factor: 2.5.
4. Component Response Modification Factor: 6.0.

2.4 MANUFACTURED UNITS

A. Indoor Unit Arrangement: Single assembly, with the secondary section MCC complying with NEMA 250, Type 1, NEMA 250, Type 1 (gasketed) or NEMA 250, Type 12 construction as directed.

B. Outdoor Unit Arrangement: Single assembly.

1. Weatherproof, listed for installation outdoors, with primary and transformer sections complying with IEEE C37.20.1, and the MCC section complying with NEMA 250, Type 3R.

2. Aisleless Construction: Full-height doors in front of basic weatherproof equipment.

C. Connections between the primary device and transformer shall be cable or bus as directed, and between the transformer and secondary shall be flexible bus braid unless noted otherwise.

D. Indoor Enclosure: Steel.

E. Outdoor Enclosure: Weatherproof, galvanized steel, listed for installation outdoors, complying with IEEE C37.20.1. Aisleless, full-height doors, with provisions for padlocking, in front of basic weatherproof equipment. Integral structural-steel base frame with factory-applied asphaltic undercoating.

1. Each compartment shall have the following features:

a. Structural design and anchorage adequate to resist loads imposed by 125-mph (200-km/h) wind.
b. Space heater operating at one-half or less of rated voltage, sized to prevent condensation, controlled by thermostats to maintain temperature of each section above expected dew point.
c. Louvers equipped with insect and rodent screens and filters and arranged to permit air circulation while excluding rodents and exterior dust.
d. Weatherproof ground-fault circuit interrupter (GFCI) duplex receptacle.
e. Power for heaters and receptacles shall be provided by control power transformer or as indicated.
f. Skid Mounted: Mount each shipping group on an integral base frame as a complete weatherproof unit.

F. Unit Substation Enclosures Finish: Factory-applied finish in manufacturer's standard gray over a rust-inhibiting primer on treated metal surface.

2.5 MEDIUM-VOLTAGE TERMINAL COMPARTMENT SECTION

A. Primary Incoming Section: Terminal assembly with adequate space for incoming-cable terminations and surge arresters, complying with NEMA SG 4 and meeting thermal, mechanical, and dielectric requirements specified for the transformer section.

B. Ratings: Suitable for application in three-phase, 60-Hz, solidly grounded-neutral system.

C. System Voltage: 4.16 kV nominal; 4.76 kV maximum, 7.2 kV nominal; 15 kV maximum, 13.8 kV nominal; 15 kV maximum or 34.5 kV nominal; 38 kV maximum as directed.

D. Surge Arresters: Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor type, connected in each phase of incoming circuit and ahead of any disconnecting device.

2.6 MEDIUM-VOLTAGE METAL-ENCLOSED SWITCHGEAR SECTION

A. Metal-enclosed, air-interrupter switchgear, with or without fuses as directed, complying with IEEE C37.20.3.

1. Switchgear shall be arc-resistant, complying with IEEE C37.20.7, Type 1A, Type 2A, Type 1C or Type 2C as directed.

B. Ratings: Comply with IEEE C37.04; and suitable for application in three-phase, 60-Hz, solidly grounded-neutral system.

1. System Voltage: 4.16 kV nominal; 4.76 kV maximum, 7.2 kV nominal; 15 kV maximum, 13.8 kV nominal; 15 kV maximum or 34.5 kV nominal; 38 kV maximum as directed.
2. Design Level of Available-Source Fault Current: Integrated short-circuit rating consistent with value of fault current indicated.
3. Main-Bus Rating: As directed, 600, 1200 or 2000 A, continuous as directed.

C. Interrupter Switches: Stationary, gang operated, and suitable for application at maximum short-circuit rating of integrated switchgear assembly.

1. Rating: As directed, 600 or 1200-A continuous duty and load break.
2. Two-Time Duty-Cycle Fault Closing: As directed, 25,000 or 40,000 asymmetrical amperes.
3. Switch Action: No external arc and no significant quantities of ionized gas released into the enclosure.
4. Switch Construction: Supported entirely by interior framework of structure, with copper switchblades and stored-energy operating mechanism.
5. Phase Barriers: Full length of switchblades and fuses for each pole; designed for easy removal; allow visual inspection of switch components if barrier is in place.
6. Protective Shields: Cover live components and terminals.

    a. Fuse Mounts: Single-frame mounted and de-energized when switch is open.

7. Mechanical Interlock: Prevent opening switch compartment door unless switchblades are open, and prevent closing switch if door is open. Interlock air-interrupter switch with transformer secondary main circuit breaker, preventing switch from being opened or closed unless secondary main circuit breaker is open.
8. Window: Permits viewing switch-blade positions when door is closed.
9. Accessory Set: Tools and miscellaneous items required for interrupter switchgear test, inspection, maintenance, and operation. Include fuse-handling tool as recommended by switchgear manufacturer.

D. Fuses: Sizes recommended by secondary unit substation manufacturer, considering fan cooling, temperature-rise specification, and cycle loading.

1. Current-Limiting Fuses: Full-range, fast-replaceable, current-limiting type that will operate without explosive noise or expulsion of gas, vapor, or foreign matter from tube.
2. Expulsion Fuses: Furnished in disconnect-type mountings and renewable with replacement fuse units. Gases emitted on interruption are controlled and silenced by chambers designed for that purpose.
3. Indicator integral with each fuse to show when it has blown.
4. Spares: Include three fuses in use and three spare fuses in storage clips in each switch.

E. Surge Arresters: Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor type, with ratings as indicated, connected in each phase of incoming circuit and ahead of any disconnecting device.

2.7 MEDIUM-VOLTAGE INSTRUMENTS SECTION

A. Instrument Transformers: Comply with IEEE C57.13.

1. Potential and Current Transformers: Burden and Accuracy Class suitable for connected meters.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems.

1. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.
2. Switch-selectable digital display with the following features:

    a. Phase Currents, Each Phase: Plus or minus 1 percent.
    b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
    c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
    d. Three-Phase Real Power: Plus or minus 2 percent.
    e. Three-Phase Reactive Power: Plus or minus 2 percent.
    f. Power Factor: Plus or minus 2 percent.
    g. Frequency: Plus or minus 0.5 percent.
    h. Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.

3. Communications module suitable for remote monitoring of meter quantities and functions. Interface communication and metering requirements according to Section 260913 "Electrical Power Monitoring and Control."
4. Mounting: Display and control unit that is flush or semi-flush mounted in instrument compartment door.

C. Analog Instruments: Rectangular, 4-1/2 inches (115 mm) square, 1 percent accuracy, semi-flush mounting, with anti-parallax 250-degree scale and external zero adjustment.

1. Voltmeters: Cover an expanded scale range of normal voltage plus 10 percent.
2. Voltmeter Selector Switch: Rotary type with off position to provide readings of phase-to-phase and phase-to-neutral voltages.
3. Ammeters: Cover an expanded scale range of bus rating plus 10 percent.
4. Ammeter Selector Switch: Permits current reading in each phase and keeps current-transformer secondary circuits closed in off position.
5. Locate meter and selector switch on circuit-breaker compartment door for indicated feeder circuits only.
6. Watt-Hour Meters: Flush- or semi-flush-mounting type, 5 A, 120 V, three phase, three wire; with three elements, 15-minute indicating demand register, and provision for testing and adding pulse initiation.
7. Recording Demand Meter: Usable as totalizing relay or indicating and recording maximum demand meter with 15-minute interval.

    a. Operation: Counts and records a succession of pulses entering two channels.
    b. Housing: Drawout, back-connected case arranged for semi-flush mounting.

2.8 LIQUID-FILLED TRANSFORMER SECTION

A. Description: IEEE C57.12.00 and UL 1062, liquid-filled, two-winding, secondary unit substation transformer.

B. Insulating Liquid: Mineral oil complying with ASTM D3487, Type II, and tested according to ASTM D117.

C. Insulation Temperature Rise: 55 deg C, based on an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C. Insulation system shall be rated to continuously allow an additional 12-percent kVA output, at 65 deg C temperature rise, without decreasing rated transformer life.

D. Insulation Temperature Rise: 65 deg C, based on an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C.

E. BIL: As directed, 60, 75, 95 or 110 kV.

F. Full-Capacity Voltage Taps: Four nominal 2.5 percent taps, two above and two below rated primary voltage, with externally operable tap changer for de-energized use and with position indicator and padlock hasp.

G. Cooling System: As directed, Class ONAN, liquid cooled, Class ONAN/ONAF, liquid cooled, and with forced-air rating or Class ONAN/ONAF/ONAF, liquid cooled, and with provisions for future forced-air rating. Cooling systems shall include auxiliary cooling equipment, automatic controls, and status indicating lights.

H. Impedance: Percent as directed.

I. Accessories: Grounding pads, lifting lugs, and provisions for jacking under base. Transformers shall have a steel base and frame allowing use of pipe rollers in any direction, and an insulated, low-voltage, neutral bushing with removable ground strap. Include the following additional accessories:

1. Liquid-level gage.
2. Pressure-vacuum gage.
3. Liquid temperature indicator.
4. Drain and filter valves.
5. Pressure-relief device.

2.9 DRY-TYPE TRANSFORMER SECTION

A. Description: As directed, IEEE C57.12.01, IEEE C57.12.50 or IEEE C57.12.51, and dry-type, two-winding, secondary unit substation transformer.

B. Primary Incoming Section: Transformer cover-mounted bushings. The bushings shall meet thermal, mechanical, and dielectric requirements as specified for the transformer section.

C. Style: As directed, Indoor, ventilated, Outdoor, ventilated or Totally enclosed, nonventilated, cast coil/encapsulated coil, with primary and secondary windings individually cast in epoxy;

with insulation system rated at 185 deg C with an 80 deg C average winding temperature rise above a maximum ambient temperature of 40 deg C.

D. Style: As directed, Indoor, ventilated, Outdoor, ventilated or Totally enclosed, nonventilated, vacuum-pressure, impregnated type, and with insulation system rated at 220 deg C with an 80 deg C average winding temperature rise above a maximum ambient temperature of 40 deg C.

E. Cooling System: Class AA, air cooled, complying with IEEE C57.12.01.

F. Cooling System: Class AFA, air cooled with forced-air rating, complying with IEEE C57.12.01.

1. Manual forced-air cooling system controls, including manual switch for fans, fan controller and associated power and control wiring, and power panel with current-limiting fuses.
2. Include mounting provision for fans.

G. Cooling System: Class AA/FA, air cooled with provisions for future forced-air rating, complying with IEEE C57.12.01.

1. Automatic forced-air cooling system controls, including thermal sensors, fans, control wiring, temperature controller with test switch, power panel with current-limiting fuses, indicating lights, alarm, and alarm-silencing relay.
2. Include mounting provision for fans.

H. Cooling System: Class AFA, forced-air cooling, complying with IEEE C57.12.01.

1. Automatic forced-air cooling system controls, including thermal sensors, fans, control wiring, temperature controller with test switch, power panel with current-limiting fuses, indicating lights, alarm, and alarm-silencing relay.
2. Include cooling fans.

I. Insulation Materials: IEEE C57.12.01, rated 220 deg C.

1. Insulation Temperature Rise: As directed, 80, 115 or 150 deg C, maximum rise above 40 deg C.

J. BIL: As directed, 60, 75, 95 or 110 kV.

K. Full-Capacity Voltage Taps: Four nominal 2.5 percent taps, two above and two below rated primary voltage.

L. Impedance: Percent as directed.

M. High-Temperature Alarm: Sensor at transformer with local audible and visual alarm and contacts for remote alarm.

2.10 SECONDARY DISTRIBUTION SECTION MCC

A. MCC: Combination motor controllers, complying with NEMA ICS 18 and UL 845.

1. Wiring: NEMA ICS 18, As directed, Class I, Class I-S, Type A, Type B, for starters larger than Size 3, Type B-D, for starter Size 3 and smaller, Type B-T, for starter Size 3 and smaller or Type C.
2. Wiring: NEMA ICS 18, Class II, Class II-S, Type B, for starters larger than Size 3, Type B-D, for starter Size 3 and smaller, Type B-T, for starter Size 3 and smaller or Type C.
3. Short-Circuit Current Rating for Each Unit: As directed, Combination series rated or Fully rated; 22, 42, 65 or 100 kA.
4. Short-Circuit Current Rating of MCC: Combination series rated or Fully rated with its main overcurrent device; 22, 42, 65 or 100 kA.

B. MCC Structure: Front and rear accessible.

1. Match and align the front or front and rear of the MCC as directed.
2. Comply with UL requirements for service entrance equipment.

C. MCC Bus:

1. Use bus bars to connect compartments and vertical sections. Cable connections are prohibited.
2. Main Phase Bus: Uniform capacity the entire length of section.
3. Neutral Bus: As directed, 50 or 100 percent of phase-bus ampacity, except as indicated. Equip bus with pressure-connector terminations for outgoing circuit neutral conductors.
4. Vertical Section Bus: Extend to spaces for future controllers.
5. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent minimum conductivity, with copper feeder circuit-breaker line connections.
6. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent minimum conductivity or tin-plated, high-strength, electrical-grade aluminum alloy.
7. Ground Bus: Hard-drawn copper of 98 percent minimum conductivity, with pressure connector for ground conductors, minimum size 1/4-by-2 inches (6 by 50 mm).
8. Neutral Disconnect Link: Bolted, uninsulated, 1/4-by-2-inch (6-by-50-mm) copper bus, arranged to connect neutral bus to ground bus.

D. MCC Main Disconnect Device: As directed, Bolted pressure switch, fixed mounted, manually operated, electrically tripped, or fusible, bolted pressure contact switch. Comply with UL 977.

1. Stored energy deadfront mechanism, compressed and released by the operating handle; switching action shall be independent of the speed of the operating handle.
2. Indication whether the switch is open or closed, and provisions for padlocking the operating handle.
3. With fuse clips and fuses for UL 248 Class L time-delay fuses.
4. Electrically tripped switches shall include:

    a. Ground-fault protection, with adjustable time delay and test panel.
    b. Single-phase protection, tripping the switch on loss of a source phase.
    c. Blown fuse protection, tripping the switch on a blown fuse, with blown fuse indication.
    d. Operator power shall be from the supply internal to the MCC.

E. MCC Main Disconnect Device: As directed, Insulated case circuit breaker, fixed or drawout mounted, manually or electrically operated air-circuit breaker. Comply with UL 1066.

1. With "close" and "open" push buttons and red and green lighted breaker position indicators. Charging time of the motor operator shall not exceed 8 seconds. Operator power shall be from the supply internal to the MCC.
2. Solid-state monitoring and tripping system to provide system status monitoring, adjustable time-current protection, and shunt trip.

    a. Interchangeable current sensors and timing circuits for adjustable time-current protection settings and status signals.
    b. LED indicators or display, with manual reset, to show cause of automatic trip.
    c. Display panel to indicate that the status of the system circuitry is fully operational, or give fault location based on automatic diagnosis.
    d. Trip the circuit breaker when closing on a fault.
    e. Time-current adjustments to achieve protective-device coordination as follows:

        1) Adjustable long-delay pickup and time.
        2) Individual adjustments for short-delay pickup, time, and I-squared-t setting.
        3) Adjustable instantaneous pickup.
        4) Individually adjustable ground-fault pickup and time, with I-squared-t setting or ground alarm as directed.

    f. With built-in connector to test the breaker settings. Provide one test set.
    g. Battery backup for informational displays after automatic trip, with battery status indicator.

F. MCC Main Disconnect Device: MCCB (to 1600 A), fixed mounted, manually operated air-circuit breaker. Comply with UL 489.

1. With quick-make, quick-break, over-center switching mechanism that is mechanically trip-free, and its position is shown by the position of the handle. With manual push-to-trip push button.
2. Solid-state monitoring and tripping system to provide system status monitoring, adjustable time-current protection, and shunt trip.

    a. Interchangeable current sensors and timing circuits for adjustable time-current protection settings and status signals.
    b. With trip-setting dials or interchangeable plugs to establish the continuous trip of the circuit breaker. Plugs shall not be interchangeable between frames, and the breaker may not be closed without the plug. With neutral ground-fault sensor.
    c. Time-current adjustments to achieve protective-device coordination as follows:

        1) Adjustable long-time delay.
        2) Adjustable short-time setting and delay to shape the time-current curve.
        3) Adjustable instantaneous setting.
        4) Individually adjustable ground-fault setting and time delay.

    d. With built-in connector to test the long-time delay, instantaneous, and ground-fault functions of the breaker. Provide one test set for testing the installed circuit breakers 225-ampere frame and higher.
    e. With built-in digital ammeter display, showing load current and tripping cause.

G. MCC Main Disconnect Device: Fusible switch; fixed-mounted, manually operated, electrically tripped, quick-make, quick-break switch. Comply with UL 98.

1. Indication whether the switch is open or closed, and provisions for padlocking the operating handle.
2. With fuse clips and fuses.
3. Electrically tripped switches shall include:

    a. Shunt trip.
    b. Ground-fault protection, with adjustable time delay and test panel.
    c. Single-phase protection, tripping the switch on loss of a source phase.
    d. Blown fuse protection, tripping the switch on a blown fuse, with blown fuse indication.
    e. Operator power shall be from the supply internal to the MCC.

H. Full-Voltage Magnetic Controllers: Electrically held, full voltage, NEMA ICS 2, general purpose, Class A.

1. Configurations: Non-reversing and reversing.

I. Reduced-Voltage Magnetic Controllers: Electrically held, NEMA ICS 2, general purpose, Class A; closed transition; adjustable time delay on transition.

1. Configurations: Reduced voltage, electrically held.

    a. Wye-Delta Controller: Four contactors, with a three-phase starting resistor/reactor bank.
    b. Part-Winding Controller: Separate START and RUN contactors, field selectable for one-half or two-thirds winding start mode, with either six- or nine-lead motors; with separate overload relays for starting and running sequences.
    c. Autotransformer Reduced-Voltage Controller: Medium-duty service, with integral overtemperature protection; taps for starting at 50, 65, and 80 percent of line voltage; one RUN and two START contactors.

J. Reduced-Voltage, Solid-State Controllers: Comply with UL 508.

1. Description: An integrated unit with power SCRs, heat sink, microprocessor logic board, door-mounted digital display and keypad, bypass contactor, and overload relays.
2. Application: Suitable for use with NEMA MG 1 Design B, polyphase induction motors.
3. Configuration: Standard duty or Severe duty; nonreversible or reversible.
4. Starting Mode: As directed, Voltage ramping, Current limit, Torque control, Torque control with voltage boost; field selectable.
5. Stopping Mode: As directed, Coast to stop, Adjustable torque deceleration, Adjustable braking; field selectable.
6. Surge Suppression: Factory installed as an integral part of the controller, SPD complying with UL 1449 as Type 2, or SPD complying with UL 1449, Type 4, suitable for use in a Type 2 application.
7. Bypass Contactor: Operates automatically to bypass the SCRs when the motor has reached rated speed and full voltage is applied to motor. Solid-state controller protective features shall remain active when the bypass relay is in the bypass mode.

    a. Bypass Contactor: Manufacturer's standard product.
    b. Bypass Contactor Coils: Pressure-encapsulated type; manufacturer's standard operating voltage, matching control power or line voltage, depending on contactor size and line-voltage rating. Provide coil with SPD.

8. Adjustable acceleration-rate control using voltage or current ramp, and adjustable starting torque control with up to 400 percent current limitation for 20 seconds.
9. SCR Bridge: At least two SCRs per phase, for stable and smooth acceleration with or without external feedback as directed, from the motor or driven equipment.
10. Keypad: Front accessible; for programming the controller parameters, functions, and features; shall be manufacturer's standard and include not less than the following functions:

    a. Adjusting motor full-load amperes, as a percentage of the controller's rating.
    b. Adjusting current limitation on starting, as a percentage of the motor full-load current rating.
    c. Adjusting linear acceleration and deceleration ramps, in seconds.
    d. Setting initial torque, as a percentage of the nominal motor torque.
    e. Adjusting torque limit, as a percentage of the nominal motor torque.
    f. Adjusting maximum start time, in seconds.
    g. Adjusting voltage boost, as a percentage of the nominal supply voltage.
    h. Selecting stopping mode and adjusting parameters.
    i. Selecting motor thermal-overload protection class between 5 and 30.
    j. Activating and deactivating protection modes.
    k. Selecting or activating communications modes.

11. Digital display, front accessible; for showing motor, controller, and fault status; shall be manufacturer's standard and include not less than the following:

    a. Controller Condition: Ready, starting, running, stopping.
    b. Motor Condition: Amperes, voltage, power factor, power, and thermal state.
    c. Fault Conditions: Controller thermal fault, motor overload alarm and trip, motor underload, overcurrent, shorted SCRs, line or phase loss, phase reversal, and line frequency over or under normal.

12. Controller Diagnostics and Protection:

    a. Microprocessor-based thermal protection system for monitoring SCR and motor thermal characteristics and providing controller overtemperature and motor overload alarm and trip; settings selectable via the keypad.
    b. Protection from line-side reverse phasing; line-side and motor-side phase loss; motor jam, stall, and underload conditions; and line frequency over or under normal.

        1) Input isolation contactor that opens when the controller diagnostics detect a faulted solid-state component, or when the motor is stopped.
        2) Shunt trip that opens the disconnecting means when the controller diagnostics detect a faulted solid-state component.

13. Remote Output Features:

    a. All outputs prewired to terminal blocks.
    b. Form C status contacts that change state when controller is running.
    c. Form C alarm contacts that change state when a fault condition occurs.

14. Optional Features:

a. Analog output for field-selectable assignment of motor operating characteristics; 0- to 10-V dc or 4- to 20-mA dc as directed.
b. Two additional field-assignable Form C contacts for alarm outputs.
c. Full-voltage/BYPASS selector switch. Power contacts shall be totally enclosed, double break, and made of silver-cadmium oxide; and assembled to allow inspection and replacement without disturbing line or load wiring.

K. Multispeed Magnetic Controllers: Electrically held, full voltage, NEMA ICS 2, general purpose, Class A.

1. Configuration: Non-reversing; consequent pole or two winding as directed.

a. Two speed, with compelling relays to ensure that motor will start only at low speed.
b. Timer Relays: Accelerating, for properly timed acceleration through speeds lower than that selected.
c. Timer Relays: Decelerating, for automatically timed deceleration through each speed.

2. Configuration: Reversing; consequent pole or two winding as directed.

a. Two speed, with compelling relay to ensure that motor will start only at low speed.
b. Compelling relays shall ensure that motor starts only at low speed.
c. Timer Relays: Accelerating, for properly timed acceleration through speeds lower than that selected.
d. Timer Relays: Decelerating, for automatically timed deceleration through each speed.
e. Timer Relays: Anti-plugging, for a time delay when transferring from FORWARD to REVERSE and back.

L. Controller Disconnect and OCPD:

1. Fusible Disconnecting Means:

a. NEMA KS 1, heavy-duty, horsepower-rated fusible switch, with clips or bolt pads to accommodate Class J or Class L fuses as directed.
b. Lockable Handle: For three padlocks and interlocks with cover in closed position.
c. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.

2. MCP Disconnecting Means:

a. UL 489, with interrupting capacity complying with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
b. Lockable Handle: For three padlocks and interlocks with cover in closed position.
c. Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
d. As directed, N.C. or N.O. alarm contact that operates only when MCP has tripped.
e. Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.

M. Overload Relays:

1. Melting-Alloy Overload Relays:

    a. Inverse-time-current characteristic.
    b. As directed, Class 10, Class 20 or Class 30 tripping characteristic.
    c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.

2. Bimetallic Overload Relays:

    a. Inverse-time-current characteristic.
    b. As directed, Class 10, Class 20 or Class 30 tripping characteristic.
    c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
    d. Automatic resetting.

N. Control Power:

1. Control Circuits: As directed, 24 or 120-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT or control power source of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.

    a. CPT Spare Capacity: As directed, 50, 100 or 200 VA.

O. Control Wiring: Factory installed, complete with bundling, lacing, and protection; and complying with the following:

1. Flexible conductors for No. 8 AWG and smaller, for conductors across hinges and for conductors for interconnections between shipping units.
2. Conductors sized according to NFPA 70 for duty required.

P. Feeder-Tap Units

1. ICCBs: As directed, Fixed or Drawout-mounted, manually or electrically operated air-circuit breakers. Comply with UL 1066.

    a. With "close" and "open" push buttons and red and green lighted breaker position indicators. Charging time of the motor operator shall not exceed 8 seconds. Operator power shall be from a control power transformer internal to the switchboard.
    b. Solid-state monitoring and tripping system shall provide system status monitoring, adjustable time-current protection, and shunt trip.

        1) Interchangeable current sensors and timing circuits for adjustable time-current protection settings and status signals.
        2) LED indicators or display, with manual reset, to show cause of automatic trip.
        3) Display panel to indicate that the status of the system circuitry is fully operational or give fault location based on automatic diagnosis.
        4) Trip the circuit breaker when closing on a fault.
        5) Time-current adjustments to achieve protective-device coordination as follows:

a) Adjustable long-delay pickup and time.
b) Individual adjustments for short-delay pickup, time, and I-squared-t setting.
c) Adjustable instantaneous pickup.
d) Individually adjustable ground-fault pickup and time, with I-squared-t setting or ground alarm as directed.

6) Built-in connector tests breaker settings. Provide one test set.
7) Battery backup for informational displays after automatic trip, with battery status indicator.

2. MCCBs (to 1600 A): Fixed-mounted, manually operated air-circuit breakers, complying with UL 489.

a. Include quick-make, quick-break, over-center switching mechanism that is mechanically trip-free, and its position is shown by the position of the handle. Include manual push-to-trip push button.
b. Solid-state monitoring and tripping system to provide system status monitoring, adjustable time-current protection, and shunt trip.

1) Interchangeable current sensors and timing circuits for adjustable time-current protection settings and status signals.
2) Include trip-setting dials or interchangeable plugs to establish continuous trip of circuit breaker. Plugs shall not be interchangeable between frames, and circuit breaker may not be closed without the plug. With neutral ground-fault sensor.
3) Time-current adjustments to achieve protective-device coordination as follows:

a) Adjustable long-time delay.
b) Adjustable short-time setting and delay to shape the time-current curve.
c) Adjustable instantaneous setting.
d) Individually adjustable ground-fault setting and time delay.

4) With built-in connector to test the long-time delay, instantaneous, and ground-fault functions of the breaker. Provide one test set for testing the installed circuit breakers 225-ampere frame and higher.
5) With built-in digital ammeter and a digital display, showing tripping cause.

3. Fusible Switches: Fixed-mounted, manually operated, electrically tripped, fusible, quick-make, quick-break switch. Comply with UL 98.

a. Indication whether the switch is open or closed, and provisions for padlocking the operating handle.
b. Include fuse clips and fuses.
c. Electrically tripped switches shall include:

1) Shunt trip.
2) Ground-fault protection, with adjustable time delay and test panel.
3) Single-phase protection, tripping the switch on loss of a source phase.

4) Blown fuse protection, tripping the switch on a blown fuse, with blown fuse indication.

Q. Compartments: Modular; individual lift-off doors with concealed hinges and quick-captive screw fasteners. Interlocks on units require disconnecting means in off position before door can be opened or closed, except by operating a permissive release device.

R. Interchangeability: Compartments constructed to allow for removal of units without opening adjacent doors, disconnecting adjacent compartments, or disturbing operation of other units in MCC. Same-size compartments permit interchangeability and ready rearrangement of units, such as replacing three single units with a unit requiring three spaces, without cutting or welding.

S. Wiring Spaces:

1. Vertical wireways in each vertical section for vertical wiring to each unit compartment; supports to hold wiring in place.
2. Horizontal wireways in bottom and top of each vertical section for horizontal wiring between vertical sections; supports to hold wiring in place.

T. Auxiliary Devices:

1. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.

   a. Push Buttons, Pilot Lights, and Selector Switches: Heavy or Standard-duty, oiltight type.

      1) Push Buttons: As directed, Covered, Lockable, Recessed, Shielded, Shrouded or Unguarded types; maintained or momentary contact unless otherwise indicated.
      2) Pilot Lights: As directed, Incandescent, LED, Neon, Resistor or Transformer types; push to test.
      3) Selector Switches: Rotar type.

   b. Elapsed-Time Meters: Heavy duty with digital readout in hours; nonresettable; resettable.

2. Meters: Panel type, 2-1/2-inch (64-mm) minimum size with 90- or 120-degree scale and plus or minus 2 percent accuracy, with selector switches having an off position.
3. As directed, N.C., N.O. or Reversible N.C./N.O. contactor auxiliary contact(s).
4. Control Relays: Auxiliary and adjustable pneumatic or solid-state time-delay relays as directed.
5. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections and adjustable undervoltage, overvoltage, and time-delay settings.
6. Space heaters, with N.C. auxiliary contacts, to mitigate condensation in enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.
7. Sun shields, installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.
8. Cover gaskets, for NEMA 250, Type 1 enclosures.

9. Terminals, for connecting power-factor correction capacitors to line or load side of overload relays as directed.
10. Spare control-wiring terminal blocks; unwired; wired.

U. Maintenance Tools: Furnish tools and miscellaneous items required for circuit-breaker and switchgear test, inspection, maintenance, and operation.

1. Racking handle, to manually move circuit breaker between "connected" and "disconnected" positions.
2. Spare-Fuse Cabinet: Identified and compartmented steel box or cabinet with lockable door.
3. Storage for Manual: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.

2.11 LOW-VOLTAGE INSTRUMENTS SECTION

A. Instrument Transformers: Comply with IEEE C57.13.

1. Potential Transformers: Secondary voltage rating of 120 V and NEMA C12.11 Accuracy Class of 0.3 with burdens of W, X, and Y.
2. Current Transformers: Burden and Accuracy Class suitable for connected relays, meters, and instruments.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems.

1. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.
2. Switch-selectable digital display with the following features:

a. Phase Currents, Each Phase: Plus or minus 1 percent.
b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
d. Three-Phase Real Power: Plus or minus 2 percent.
e. Three-Phase Reactive Power: Plus or minus 2 percent.
f. Power Factor: Plus or minus 2 percent.
g. Frequency: Plus or minus 0.5 percent.
h. Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
i. Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

3. Communications module suitable for remote monitoring of meter quantities and functions. Interface communication and metering requirements according to Section 260913 "Electrical Power Monitoring and Control."
4. Mounting: Display and control unit that is flush or semi-flush mounted in instrument compartment door.

C. Analog Instruments: Rectangular, 4-1/2 inches (115 mm) square, 1 percent accuracy, semi-flush mounting, with anti-parallax 250-degree scale and external zero adjustment.

1. Voltmeters: Cover an expanded scale range of normal voltage plus 10 percent.
2. Voltmeter Selector Switch: Rotary type with "off" position to provide readings of phase-to-phase and phase-to-neutral voltages.
3. Ammeters: Cover an expanded scale range of bus rating plus 10 percent.
4. Ammeter Selector Switch: Permits current reading in each phase and keeps current-transformer secondary circuits closed in "off" position.
5. Locate meter and selector switch on circuit-breaker compartment door for indicated feeder circuits only.
6. Watt-Hour Meters: Flush- or semi-flush-mounting type, 5 A, 120 V, three phase, three wire; with three elements, 15-minute indicating demand register, and provision for testing and adding pulse initiation.
7. Recording Demand Meter: Usable as totalizing relay or indicating and recording maximum demand meter with 15-minute interval.

    a. Operation: Counts and records a succession of pulses entering two channels.
    b. Housing: Drawout, back-connected case arranged for semi-flush mounting.

D. Surge Suppression: Factory installed as an integral part of the low-voltage switchgear, complying with UL 1449 SPD, Type 1, with the following features and accessories:

1. Integral disconnect switch.
2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
3. Indicator light display for protection status.
4. Form-C contacts rated at 5 A and 250-V ac, one N.O. and one N.C., for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
5. Surge counter.

E. Maintenance Tools: Furnish tools and miscellaneous items required for circuit-breaker and switchgear test, inspection, maintenance, and operation.

1. Racking handle to manually move circuit breaker between "connected" and "disconnected" positions.
2. Spare-Fuse Cabinet: Identified and compartmented steel box or cabinet with lockable door.
3. Storage for Manual: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.

2.12 IDENTIFICATION DEVICES

A. Compartment Nameplates: Engraved, laminated-plastic or metal nameplate for each compartment, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 260553 "Identification for Electrical Systems."

2.13 SOURCE QUALITY CONTROL

A. Perform design and routine tests according to standards specified for components.

1. Conduct transformer tests according to IEEE C57.12.90.
2. Conduct primary switchgear tests according to ANSI C37.51.
3. Conduct routine tests of the completely assembled MCC, including the following:

    a. Dielectric Tests: Comply with NEMA ICS 1.
    b. Operational Tests:

        1) Verify correct operation of each circuit breaker, motor circuit Protector, magnetic contactor, and control devices, accessories and indicating lamps. The verification checks shall be made at rated voltage with power supplies to the main buses.
        2) Verify correct operation of magnetic contactors with power at 90 percent of rated voltage.

B. Perform the following factory-certified tests on each secondary unit substation:

1. Resistance measurements of all windings on the rated voltage connection and on tap extreme connections.
2. Ratios on the rated voltage connection and on tap extreme connections.
3. Polarity and phase relation on the rated voltage connection.
4. No-load loss at rated voltage on the rated voltage connection.
5. Exciting current at rated voltage on the rated voltage connection.
6. Impedance and load loss at rated current on the rated voltage connection and on tap extreme connections.
7. Applied potential.
8. Induced potential.
9. Temperature Test: If a transformer is supplied with auxiliary cooling equipment to provide more than one rating, test at lowest kVA Class ONAN or Class AA rating and highest kVA Class ONAF or Class AFA rating.

    a. Temperature test is not required if a record of a temperature test on an essentially duplicate unit is available.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with applicable portions of NECA 1, NECA 410, NECA 430, NEMA ICS 2.3, and NEMA SG 11.

B. Install secondary unit substations on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.

C. Comply with requirements for vibration isolation and seismic control devices specified in Section 260529 "Hangers and Supports for Electrical Systems" and Section 260548.16 "Seismic Controls for Electrical Systems."

D. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

3.2 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Install the number of signs required to be readable from each accessible side but space the signs a maximum of 30 ft. (9 m) apart.
2. Install arc-flash warning labels specified in Section 260574 "Overcurrent Protective Device Arc-Flash Study."

B. Operating Instructions: Place printed operating instructions for secondary unit substations, including key interlocking, control sequences, elementary single-line diagram, and emergency procedures with the maintenance materials.

3.3 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

1. At Interior Locations: For grounding to grounding electrodes, use bare copper cable not smaller than No. 4/0 AWG. Bond surge arrester and neutrals directly to the transformer enclosure and then to the grounding electrode system with bare copper conductors. Keep leads as short as practicable with no kinks or sharp bends. Make joints in grounding conductors and loops by exothermic weld or compression connector.
2. At Exterior Locations:

    a. For counterpoise use tinned bare copper cable not smaller than No. 4/0 AWG, buried not less than 24 inches (610 mm) below grade interconnecting the grounding electrodes. Bond surge arrester and neutrals shall directly to the transformer enclosure and then to the grounding electrode system with bare copper conductors, sized as shown. Keep lead lengths as short as practicable with no kinks or sharp bends.
    b. Fence and equipment connections shall not be smaller than No. 4 AWG. Ground fence at each gate post and corner post and at intervals not exceeding 10 ft. (3050 mm). Bond each gate section to the fence post using 1/8 by 1 inch (3 by 25 mm) tinned flexible braided copper strap and clamps.
    c. Make joints in grounding conductors and loops by exothermic weld or compression connector.

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 CLEANING

A. After completing equipment installation and before energizing, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish. Vacuum interiors of secondary unit substation sections.

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

B. General Field Testing Requirements:

1. Comply with the provisions of NFPA 70B Ch. "Testing and Test Methods."
2. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.
3. After installing secondary unit substation but before primary is energized, verify that grounding system at the substation is tested at the specified value or less.
4. After installing secondary unit substation and after electrical circuitry has been energized, test for compliance with requirements.
5. Visual and Mechanical Inspection:

    a. Verify equipment nameplate data complies with Contract Documents.
    b. Inspect bolted electrical connections for high resistance using one of the following two methods:

        1) Use a low-resistance ohmmeter to compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
        2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.

6. Remove and replace malfunctioning units and retest.
7. Prepare test and inspection reports. Record as-left set points of all adjustable devices.

C. Switchgear and MCC Field Tests:

1. Visual and Mechanical Inspection:

    a. Inspect physical and mechanical condition.
    b. Inspect anchorage, alignment, grounding, and required area clearances.
    c. Verify the unit is clean and shipping bracing, loose parts, and documentation shipped inside cubicles have been removed.
    d. Verify that fuse and circuit-breaker sizes and types correspond to Drawings and coordination study as well as the address of the circuit breaker that is used to identify it in microprocessor-communication software.
    e. Verify that current and voltage-transformer ratios correspond to Drawings.
    f. Confirm correct operation and sequencing of electrical and mechanical interlock systems.

        1) Attempt closure on locked-open devices. Attempt to open locked-closed devices.
        2) Make key exchange with devices operated in off-normal positions.

g. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
h. Inspect insulators for evidence of physical damage or contaminated surfaces.
i. Verify correct barrier and shutter installation and operation.
j. Exercise all active components.
k. Inspect mechanical indicating devices for correct operation.
l. Verify that filters are in place and vents are clear.
m. Inspect control power transformers as follows:

1) Inspect for physical damage, cracked insulation, broken leads, connection tightness, defective wiring, and overall general condition.
2) Verify that primary- and secondary-fuse or circuit-breaker ratings match Drawings and comply with manufacturer's recommendations.
3) Verify correct functioning of drawout disconnecting and grounding contacts and interlocks.

2. Electrical Tests:

a. Perform dc voltage insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground, for one minute. If the temperature of the bus is other than plus or minus 20 deg. C, adjust the resulting resistance as provided in NETA ATS Table 100.11.

1) Insulation-resistance values of bus insulation shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.1.
2) Do not proceed to the dielectric-withstand-voltage tests until insulation-resistance levels are raised above minimum values.

b. Perform a dielectric-withstand-voltage test on each bus section, each phase-to-ground with phases not under test grounded, according to manufacturer's published data. If manufacturer has no recommendation for this test, it shall be conducted to according to NETA ATS, Table 100.2. Apply the test voltage for one minute.

1) If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric-withstand-voltage test, the test specimen is considered to have passed the test.

c. Voltage Transformers:

1) Perform secondary wiring integrity test. Verify correct potential at all devices.
2) Verify secondary voltages by energizing the primary winding with system voltage.

d. Perform current-injection tests on the entire current circuit in each section of switchgear.

1) Perform current tests by secondary injection with magnitudes such that a minimum current of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.
2) Perform current tests by primary injection with magnitudes such that a minimum of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.

e. Verify operation of space heaters.
f. Perform phasing checks on double-ended or dual-source switchgear to ensure correct bus phasing from each source.

D. Instrument Transformer Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Verify correct connection of transformers with system requirements.
c. Verify that adequate clearances exist between primary and secondary circuit wiring.
d. Verify the unit is clean.
e. Verify that all required grounding and shorting connections provide contact.
f. Verify correct operation of transformer withdrawal mechanism and grounding operation.
g. Verify correct primary- and secondary-fuse sizes for voltage transformers.
h. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

2. Electrical Tests of Current Transformers:

a. Perform insulation-resistance test of each current transformer and its secondary wiring with respect to ground at 1000-V dc for one minute. For units with solid-state components that cannot tolerate the applied voltage, comply with manufacturer's recommendations. Insulation-resistance values of instrument transformers shall not be less than values shown in NETA ATS, Table 100.5.
b. Perform a polarity test of each current transformer according to IEEE C57.13.1. Polarity results shall agree with transformer markings.
c. Perform a ratio-verification test using the voltage or current method according to IEEE C57.13.1. Ratio errors shall comply with IEEE C57.13.
d. Perform an excitation test on transformers used for relaying applications according to IEEE C57.13.1. Excitation results shall match the curve supplied by the manufacturer or shall comply with IEEE C57.13.1.
e. Measure current circuit burdens at transformer terminals according to IEEE C57.13.1. The measured burdens shall match the instrument transformer Accuracy Class rating.
f. Verify that current-transformer secondary circuits are grounded and have only one grounding point according to IEEE C57.13.3.

3. Electrical Tests of Voltage and Potential Transformers:

a. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply the test voltage for one minute according to NETA ATS, Table 100.5. For units with solid-state components that cannot tolerate the applied

voltage, follow manufacturer's recommendations. Insulation-resistance values of instrument transformers shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5.

b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Test voltages shall be applied for one minute according to NETA ATS, Table 100.5. Insulation-resistance values of the transformers shall not be less than values shown in NETA ATS, Table 100.5

c. Perform a polarity test on each transformer to verify the polarity marks or H(1)-X(1) relationship. Polarity results shall agree with transformer markings.

d. Perform a turns-ratio test on all tap positions. Ratio errors shall not exceed the tolerances specified in IEEE C57.13.

e. Measure voltage circuit burdens at transformer terminals. Measured burdens shall be compared to instrument transformer ratings. The measured burdens shall match the instrument transformer Accuracy Class rating.

f. Verify that voltage-transformer secondary circuits are grounded and have only one grounding point according to IEEE C57.13.3.

E. Liquid-Filled Transformer Section Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect impact recorder prior to unloading.
c. Test dew point of tank gases if applicable.
d. Inspect anchorage, alignment, and grounding.
e. Verify the presence of PCB content labeling.
f. Verify removal of any shipping bracing after placement.
g. Verify the bushings are clean.
h. Verify that alarm, control, and trip settings on temperature and level indicators are set and operate within manufacturer's recommended settings.
i. Verify that cooling fans and pumps operate correctly and have appropriate overcurrent protection.
j. Verify that liquid level in tanks and bushings is within manufacturer's published tolerances.
k. Perform specific inspections and mechanical tests recommended by the manufacturer.
l. Verify presence of transformer surge arresters and that their ratings are as specified.
m. Verify that as-left tap connections are as specified.
n. Verify the presence of surge arresters and that their ratings are as specified.

F. Dry-Type Transformer Section Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, and grounding.
c. Verify that resilient mounts are free and that any shipping brackets have been removed.
d. Verify the unit is clean.

e. Perform specific inspections and mechanical tests recommended by the manufacturer.
f. Verify that as-left tap connections are as specified.
g. Verify the presence of surge arresters and that their ratings are as specified.

G. Low-Voltage Motor Controller Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect anchorage, alignment, grounding, and clearances.
b. Verify the unit is clean.
c. Inspect contactors:

1) Verify mechanical operation.
2) Verify contact gap, wipe, alignment, and pressure are according to manufacturer's published data.

d. Motor-Running Protection:

1) Verify overload element rating is correct for its application.
2) If motor-running protection is provided by fuses, verify correct fuse rating.

e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

2. Electrical Tests:

a. As directed, for contactor and circuit breaker, perform or Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to ground with switch closed, and across each open pole. Insulation-resistance values shall comply with manufacturer's published data or NETA ATS Table 100.1. In the absence of manufacturer's published data, comply with Table 100.5. Investigate and correct values of insulation resistance less than this table or manufacturer's recommendations.
b. Test circuit breakers as follows:

1) Operate the circuit breaker to ensure smooth operation.
2) Perform a contact/pole-resistance test. Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data. If manufacturer's published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.

c. Perform operational tests by initiating control devices. Control devices shall perform according to system design requirements.

H. Insulated-Case/Molded-Case Air-Circuit-Breaker Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage and alignment.

c. Verify the unit is clean.
d. Operate the circuit breaker to ensure smooth operation.
e. Inspect operating mechanism, contacts, and arc chutes in unsealed units.
f. Perform adjustments for final protective-device settings according to the coordination study. Set the protective devices according to results in Section 260573 "Overcurrent Protective Device Coordination Study" and in Section 260574 "Overcurrent Protective Device Arc-Flash Study."

2. Electrical Tests:

a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to ground with the circuit breaker closed, and across each open pole. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Insulation-resistance values shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Values of insulation resistance less than this table or manufacturer's recommendations shall be investigated.
b. Perform a contact/pole-resistance test. Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data. If manufacturer's published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
c. Determine long-time pickup and delay by primary current injection. Ground-fault pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band, including adjustment factors.
d. Determine short-time pickup and delay by primary current injection. Short-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
e. Determine ground-fault pickup and time delay by primary current injection. Ground-fault pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
f. Determine instantaneous pickup by primary current injection. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.8.
g. Perform minimum pickup voltage tests on shunt trip and close coils according to manufacturer's published data. Minimum pickup voltage of the shunt trip and close coils shall conform to the manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.20.
h. Verify correct operation of auxiliary features, such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free operation, anti-pump function, and trip unit battery condition. Reset all trip logs and indicators. Auxiliary features shall operate according to manufacturer's published data.
i. Verify operation of charging mechanism. The charging mechanism shall operate according to manufacturer's published data.

I. Low-Voltage Ground-Fault Protection System Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect the components for damage and errors in polarity or conductor routing.

1) Verify that ground connection is made on the source side of the neutral disconnect link and on the source side of any ground-fault sensor.
2) Verify that the neutral sensors are connected with correct polarity on both primary and secondary.
3) Verify that phase conductors and the neutral pass through the sensor in the same direction for zero sequence systems.
4) Verify that grounding conductors do not pass through zero sequence sensors.
5) Verify that grounded conductor is solidly grounded.

b. Verify the unit is clean.
c. Operate the circuit breaker to ensure smooth operation.
d. Verify correct operation of functions of the self-test panel if provided.
e. Verify that the control power transformer has adequate capacity for the system.
f. Set pickup and time-delay settings according to "Quality Control" Article. Record appropriate operation and test sequences according to NFPA 70, "Services" Article, "Ground-Fault Protection Equipment" Section.

2. Electrical Tests:

a. Measure the system neutral-to-ground insulation resistance with the neutral disconnect link temporarily removed. Replace the neutral disconnect link after testing. System neutral-to-ground insulation resistance shall be a minimum of 1 megohm. Correct wiring until the minimum is achieved.
b. Perform ground-fault protective-device pickup tests using primary injection. Results of pickup test shall be greater than 90 percent of the ground-fault protective-device pickup setting and less than 1200 A or 125 percent of the pickup setting, whichever is smaller. Adjust or replace the device until these parameters are achieved.
c. For summation-type systems utilizing phase and neutral current transformers, verify correct polarities by applying current to each phase-neutral current-transformer pair. This test also applies to MCCBs utilizing an external neutral current transformer. The ground-fault protective device shall operate when current direction is the same relative to polarity marks in the two current transformers. The ground-fault protective device shall not operate when current direction is opposite relative to polarity marks in the two current transformers.
d. Measure time delay of the ground-fault protective device at a value equal to or greater than 150 percent of the pickup value. Relay timing shall be according to manufacturer's published data but shall be no longer than one second at 3000 A according to NFPA 70, "Services" Article, "Ground-Fault Protection Equipment" Section.
e. Verify reduced control voltage tripping capability is 55 percent for ac systems and 80 percent for dc systems. Replace the ground-fault system if the reduced control voltage tripping requirement is not achieved, and retest.
f. Verify blocking capability of zone interlock systems. Results of zone-blocking tests shall be according to manufacturer's published data and design specifications.

J. Metering Device Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect cover gasket, cover glass, condition of spiral spring, disk clearance, contacts, and case shorting contacts, as applicable.
c. Verify the unit is clean.
d. Verify freedom of movement, end play, and alignment of rotating disk(s).

2. Electrical Tests:

a. Verify accuracy of meters at all cardinal points. Meter accuracy shall be according to manufacturer's published data.
b. Calibrate meters according to manufacturer's published data. Calibration results shall be within manufacturer's published tolerances.
c. Verify all instrument multipliers. Instrument multipliers shall be according to system design specifications.
d. Verify that current-transformer and voltage-transformer secondary circuits are intact. Test results shall confirm the integrity of the secondary circuits of current and voltage transformers.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain systems.

END OF SECTION 261116.13

SECTION 261213 - LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes liquid-filled, medium-voltage substation transformers, with primary and secondary bushings within or without air-terminal enclosures.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For liquid-filled, medium-voltage transformers.

1. Include plans and elevations showing major components and features.

a. Include a plan view and cross section of equipment base, showing clearances, manufacturer's recommended workspace, and locations of penetrations for grounding and conduits.

2. Include details of equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include single-line diagram.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings for Outdoor Installations:

1. Utilities site plan, drawn to scale, showing heavy equipment or truck access paths for maintenance and replacement.

B. Coordination Drawings for Indoor Installations:

1. Location plan, showing heavy equipment or truck access paths for maintenance and replacement.
2. Dimensioned concrete base, outline of transformer, conduit entries, and grounding equipment locations.

C. Seismic Qualification Certificates: For transformer assembly, accessories, and components, from manufacturer.

D. Product certificates.

E. Source quality-control reports.

F. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with IEEE C2.

C. Comply with IEEE C57.12.00.

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: The transformers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the transformer will remain in place without separation of any parts when subjected to the seismic forces specified and the transformer will be fully operational after the seismic event."
2. Component Importance Factor: As directed, 1.5 or 1.0.
3. Component Amplification Factor: 2.5.
4. Component Response Modification Factor: 6.0.

B. Windings Material: As directed, Aluminum or Copper.

C. Surge Arresters: Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor type, connected in each phase of incoming circuit and ahead of any disconnecting device.

D. Winding Connections: The connection of windings and terminal markings shall comply with IEEE C57.12.70.

E. Insulation:

1. Transformer kVA Rating, when Indicated at 65 deg C Rise, Shall Be as Follows: The average winding temperature rise above ambient temperature shall not exceed 65 deg C and 80 deg C hottest-spot temperature rise at rated kVA when tested according to IEEE C57.12.90, using combination of connections and taps that give the highest average winding temperature rise.

F. Bushings shall comply with IEEE C57.19.01 requirements for impulse and low-frequency insulation levels.

G. Tap Changer: External, for de-energized operation.

H. Mounting: An integral skid mounting frame, suitable to allow skidding or rolling of transformer in any direction, and with provision for anchoring frame to pad.

I. Insulating Liquids:

1. Mineral Oil: ASTM D3487, Type II, and tested for compliance with ASTM D117.

J. Capacities and Characteristics:

1. Location: As directed, Indoors or Outdoors.
2. Additional IEEE Standards: Comply with IEEE C57.12.10 or IEEE C57.12.36 as directed.
3. Altitude: As directed.
4. Connections:

    a. Primary: Air-filled terminal cabinet for cable connection, Throat for busway connection, Terminals for close connection to a primary switch or Open wire as directed.
    b. Secondary: Air-filled terminal cabinet for cable connection, Throat for busway connection or Open wire as directed.

5. Transformer Ratings. Comply with IEEE C57.12.00 for cooling class.

    a. Self-Cooled Rating, Class: As directed.
    b. Future Forced-Air-Cooled Rating, Class:

        1) Self-Cooled: As directed.
        2) Forced-Air Cooled: As directed.
        3) Make provision for future addition of forced-air-cooling equipment. The transformer bushings, leads, and related components shall be sized for the future equipment. Provide fan mounts, conduit supports, and terminal boxes.

    c. Impedance: Not less than 5.75 percent.
    d. Temperature Rise: 65 deg C or 55/65 deg C as directed.
    e. Coils Connection:

        1) High-Voltage Winding: Delta.
        2) Low-Voltage Winding: Wye.

    f. Voltage and BIL Ratings:

1) Nominal primary phase-to-phase voltage and BIL: 4160 V, 60 kV, 13,800 V, 95 kV or 34,500 kV, 125 kV as directed.
2) Nominal secondary voltage and BIL: 208Y/120 V, 45 kV or 480Y/277 V, 45 kV as directed.

6. Outdoor Transformer Enclosure Finish: Factory-applied finish in manufacturer's standard color, corrosion resistance complying with IEEE C57.12.28.
7. Indoor Transformer Enclosure Finish: Factory-applied finish in manufacturer's standard gray over a rust-inhibiting primer on treated metal surface.
8. Special Corrosion-Resistant Enclosure Finish: Factory-applied, corrosion-resistant finish in manufacturer's standard color that withstands 120 or 480 hours as directed, of exposure to salt-spray test specified in ASTM B117 without loss of paint or release of adhesion of paint primer coat to metal surface in excess of 1/16 inch (1.6 mm) from test mark. Scribed test mark and test evaluation shall be according to ASTM D1654 with a rating of not less than 7 according to Table 1 (Procedure A). Cut edges or otherwise damaged surfaces of hot-dip galvanized sheet steel, or mill-galvanized sheet steel shall be coated with a manufacturer's standard zinc-rich paint.
9. Taps: Two 2-1/2-percent, full-capacity taps above, and two 2-1/2-percent, full-capacity taps below rated voltage. Comply with IEEE C57.12.36 requirements.
10. Transformer Accessories:

    a. Drain and filter connection.
    b. Filling and top filter press connections.
    c. Pressure-vacuum gauge.
    d. Dial-type analog thermometer with alarm contacts.
    e. Magnetic liquid level indicator with high and low alarm contacts.
    f. Pressure-relief device set to operate at 10 psig, plus or minus 2 psig, and then automatically reseal when pressure drops to 6-psig minimum. Device flow shall be as recommended by manufacturer. With alarm contacts and a manual bleeder.
    g. At least four stainless-steel ground connection pads.
    h. Provisions for jacking, lifting, and towing.
    i. Machine-engraved nameplate made of anodized aluminum or stainless steel.
    j. Sudden pressure relay for remote alarm or trip when internal transformer pressure rises at field-set rate. As directed, Provide with or without seal-in delay.

2.4 CONTROL NETWORK

A. Controllers: Support serial MS/TP and Ethernet IP communications, and able to communicate directly via RS-485 serial networks and Ethernet 10Base-T networks as a native device.

2.5 WARNING LABELS AND SIGNS

A. Comply with requirements for labels and signs specified in Section 260553 "Identification for Electrical Systems."

1. Warning signs shall be made of baked enamel.
2. Equipment Identification Labels: Engraved, laminated-acrylic or -melamine label or Stenciled legend 4 inches (100 mm) high as directed.

2.6 SOURCE QUALITY CONTROL

A. Provide manufacturer's certificate verifying the transformer design tests comply with IEEE C57.12.90.

B. Perform the following factory-certified routine tests on each transformer for this Project:

1. Resistance.
2. Turns ratio, polarity, and phase relation.
3. Transformer no-load losses and excitation current at 100 percent of ratings.
4. Transformer impedance voltage and load loss.
5. Operation of all devices.
6. Control (auxiliary) and consumption losses.
7. Lightning impulse.
8. Low frequency.
9. Leak test.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Handling:

1. Handle transformers carefully. Do not subject transformers to impact, jolting, jarring, or rough handling.
2. Protect transformer termination compartments against entrance of dust, rain, and snow.
3. Transport transformers upright.

B. Examine areas and space conditions for compliance with requirements for liquid-filled, medium-voltage transformers and other conditions affecting performance of the Work.

C. Examine roughing-in of conduits and grounding systems to verify the following:

1. Wiring entries comply with layout requirements.
2. Entries are within conduit-entry tolerances specified by manufacturer, and no feeders will cross section barriers to reach load or line lugs.

D. Verify that ground connections are in place and that requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at transformer location.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install transformers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed

B. Transformer shall be installed level and plumb and shall tilt less than 1.5 degrees while energized.

C. Comply with requirements for vibration isolation and seismic control devices specified in Section 260529 "Hangers and Supports for Electrical Systems" and Section 260548.16 "Seismic Controls for Electrical Systems."

D. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

3.3 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

1. At Interior Locations: For grounding to grounding electrodes, use bare copper cable not smaller than No. 4/0 AWG. Bond surge arrester and neutrals directly to transformer enclosure and then to grounding electrode system with bare copper conductors. Keep leads as short as practicable, with no kinks or sharp bends. Make joints in grounding conductors and loops by exothermic weld or compression connector.
2. At Exterior Locations:

    a. For counterpoise, use tinned bare copper cable not smaller than No. 4/0 AWG, buried not less than 30 inches (765 mm) below grade interconnecting grounding electrodes. Bond surge arrester and neutrals directly to transformer enclosure and then to grounding electrode system with bare copper conductors. Keep lead lengths as short as practicable, with no kinks or sharp bends.
    b. Fence and equipment connections shall not be smaller than No. 4 AWG. Ground fence at each gate post and corner post and at intervals not exceeding 10 ft. (3050 mm.) Bond each gate section to fence post using 1/8 by 1 inch (3 by 25 mm) tinned flexible braided copper strap and clamps.
    c. Make joints in grounding conductors and loops by exothermic weld or compression connector.

3. Terminate all grounding and bonding conductors on a common equipment grounding terminal on transformer enclosure. Install supplemental terminal bars, lugs, and bonding jumpers as required to accommodate number of conductors for termination.
4. Complete transformer tank grounding and lightning arrester connections prior to making any other electrical connections.

B. Terminate medium-voltage cables in incoming section of substations according to Section 260513 "Medium-Voltage Cables."

3.4 SIGNS AND LABELS

A. Comply with installation requirements for labels and signs specified in Section 260553 "Identification for Electrical Systems."

B. Install warning signs as required to comply with 29 CFR 1910.269.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: As directed, Owner will engage or Engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. General Field-Testing Requirements:

a. Comply with provisions of NFPA 70B, Ch. "Testing and Test Methods."
b. After installing transformer but before primary is energized, verify that grounding system at substation is tested at specified value or less.

3.6 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain systems.

END OF SECTION 261213

SECTION 261216 - DRY-TYPE, MEDIUM-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes dry-type, medium-voltage transformers.

1.2 DEFINITIONS

A. VPI: Vacuum Pressure Impregnation.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For dry-type, medium-voltage transformers.

1. Include plans and elevations showing major components and features.
2. Include single-line diagram.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For transformer assembly, accessories, and components, from manufacturer.

B. Source quality-control reports.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with IEEE C2.

C. Comply with IEEE C57.12.01.

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: The transformers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the transformer will remain in place without separation of any parts when subjected to the seismic forces specified and the transformer will be fully operational after the seismic event."
2. Component Importance Factor: As directed, 1.5 or 1.0.
3. Component Amplification Factor: 2.5.
4. Component Response Modification Factor: 6.0.

B. Windings Material: As directed, Aluminum or Copper.

C. Surge Arresters: Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor type, connected in each phase of incoming circuit and ahead of any disconnecting device.

D. Cooling Systems: Comply with IEEE C57.12.01 for cooling class.

1. Self-Cooled Rating, Class: As directed.
2. Future Forced-Air-Cooled Rating, Class:

    a. Self-Cooled: As directed.
    b. Forced-Air Cooled: As directed.
    c. Make provision for future addition of forced-air-cooling equipment. The transformer bushings, leads, and related components shall be sized for the future equipment. Provide fan mounts, conduit supports, and terminal boxes.

E. Coils Insulation Systems:

1. Primary and secondary coil assemblies shall be manufactured using polyester VPI system.

F. Winding Connections: Connection of windings and terminal markings shall comply with IEEE C57.12.70.

G. Bushings shall comply with IEEE C57.19.01 requirements for impulse and low-frequency insulation levels.

H. Tap Changer: External, for de-energized operation.

I. Enclosure:

1. Provide with provisions for lifting and anchoring frame to concrete pad.
2. With an integral skid-mounting frame, suitable to allow skidding or rolling of transformer in any direction.
3. Indoor Transformer Enclosure Finish: Factory-applied finish in manufacturer's standard gray over a rust-inhibiting primer on treated metal surface.
4. Taps: Two 2-1/2-percent, full-capacity taps above and two 2-1/2-percent, full-capacity taps below rated voltage. Comply with IEEE C57.12.36 requirements.

J. Sound level shall comply with requirements of NEMA TR 1.

K. Capacities and Characteristics:

1. Enclosure: Ventilated power transformer, NEMA 250 Type 1 enclosure.
2. Additional IEEE Standards: Comply with IEEE C57.12.50, IEEE C57.12.51 or IEEE C57.12.55 as directed.
3. Comply with UL 1562 listing requirements.
4. Service Conditions: The transformers shall be suitable for operation under service conditions specified as usual service conditions in IEEE C57.12.01, except for the following:

    a. Altitude: As directed.

5. Connections:

    a. Primary: As directed, air-filled terminal cabinet for cable connection, Throat for busway connection or Terminals for close connection to a primary switch.
    b. Secondary: As directed, air-filled terminal cabinet for cable connection or Throat for busway connection.

6. Transformer Ratings.

    a. Impedance: Not less than 5.75 percent.
    b. Temperature Rise: 150 deg C.
    c. Coils Connection:

        1) High-Voltage Winding: Delta.
        2) Low-Voltage Winding: Wye.

    d. Voltage and BIL Ratings:

        1) Nominal primary phase-to-phase voltage and BIL: As directed, 4160 V, 30 kV, 13 800 V, 60 kV or 34 500 kV, 150 kV.
        2) Nominal secondary voltage and BIL: As directed, 208Y/120 V, 10 kV or 480Y/277 V, 10 kV.

7. Taps: Two 2-1/2-percent, full-capacity taps above and two 2-1/2-percent, full-capacity taps below rated voltage. Comply with IEEE C57.12.51 requirements.
8. Transformer Accessories:

    a. Dial-type analog thermometer with alarm contacts.
    b. At least four stainless-steel ground connection pads.
    c. Provisions for jacking, lifting, and towing.
    d. Machine-engraved nameplate made of anodized aluminum or stainless steel.

2.4 CONTROL NETWORK

A. Controllers: Support serial MS/TP and Ethernet IP communications, and able to communicate directly via RS-485 serial networks and Ethernet 10Base-T networks as a native device.

2.5 WARNING LABELS AND SIGNS

A. Comply with requirements for labels and signs specified in Section 260553 "Identification for Electrical Systems."

1. Warning signs shall be made of baked enamel.
2. Equipment Identification Labels: As directed, Engraved, laminated-acrylic or -melamine label or Stenciled legend 4 inches (100 mm) high.

2.6 SOURCE QUALITY CONTROL

A. Provide manufacturer's certificate that the transformer design tests comply with IEEE C57.12.91.

B. Perform the following factory-certified routine tests on each transformer 500 kVA and less for this Project:

1. Turns ratio, polarity, and phase relation on rated voltage connection.
2. Transformer no-load losses and excitation current at 100 percent of ratings. This test may be based on a statistical sample.
3. Applied voltage and induced voltage.
4. Partial discharge.

C. Perform the following factory-certified tests on each transformer 500 kVA and larger for this Project. Reports shall comply with the minimum information requirements of IEEE C57.12.01:

1. Resistance measurements of all windings on rated voltage tap and at tap extremes.
2. Turns ratio, polarity, and phase relation on rated voltage connection.
3. Transformer no-load losses and excitation current at 100 percent of ratings.
4. Impedance voltage and load loss at rated current and rated frequency on rated voltage connection and at tap extremes.
5. Applied voltage and induced voltage.
6. Partial discharge.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Pre-Installation Checks:

1. Verify removal of any shipping bracing after placement.

B. Verify that ground connections are in place and that requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at transformer location.

C. Install transformers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.

D. Transformer shall be installed level and plumb and shall tilt less than 1.5 degrees while energized.

E. Comply with requirements for vibration isolation and seismic control devices specified in Section 260529 "Hangers and Supports for Electrical Systems" and Section 260548.16 "Seismic Controls for Electrical Systems."

F. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

3.2 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

1. For grounding to grounding electrodes, use bare copper cable not smaller than No. 4/0 AWG. Bond surge arrester and neutrals directly to transformer enclosure and then to grounding electrode system with bare copper conductors. Keep leads as short as practicable, with no kinks or sharp bends. Make joints in grounding conductors and loops by exothermic weld or compression connector.
2. Terminate all grounding and bonding conductors on a common equipment grounding terminal on transformer enclosure. Install supplemental terminal bars, lugs, and bonding jumpers as required to accommodate number of conductors for termination.
3. Complete transformer tank grounding and lightning arrester connections prior to making any other electrical connections.

B. Terminate medium-voltage cables in incoming section of substations according to Section 260513 "Medium-Voltage Cables."

3.3 SIGNS AND LABELS

A. Comply with installation requirements for labels and signs specified in Section 260553 "Identification for Electrical Systems."

B. Install warning signs as required to comply with 29 CFR 1910.269.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. General Field-Testing Requirements:

a. Comply with provisions of NFPA 70B, Ch. "Testing and Test Methods."
b. After installing transformer but before primary is energized, verify that grounding system at substation is tested at specified value or less.

3.5 DEMONSTRATION

A. Train owner's maintenance personnel to adjust, operate, and maintain systems.

END OF SECTION 261216

SECTION 261219 - PAD-MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes pad-mounted, liquid-filled, medium-voltage distribution transformers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For pad-mounted, liquid-filled, medium-voltage transformers.

1. Include plans and elevations showing major components and features.
2. Include single-line diagram.
3. Manufacturer's published time-current curves of the transformer high-voltage fuses, with transformer damage curve, inrush curve, and thru fault current indicated.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For transformer assembly, accessories, and components, from manufacturer.

B. Source quality-control reports.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with IEEE C2.

C. Comply with IEEE C57.12.00.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: The transformers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the transformer will remain in place without separation of any parts when subjected to the seismic forces specified and the transformer will be fully operational after the seismic event."
2. Component Importance Factor: As directed, 1.5 or 1.0.
3. Component Amplification Factor: 2.5.
4. Component Response Modification Factor: 6.0.

B. Windings Material: As directed, Aluminum or Copper.

C. Surge Arresters: Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor type, fully shielded, separable-elbow type, suitable for plugging into the inserts provided in the high-voltage section of the transformer. Connected in each phase of incoming circuit and ahead of any disconnecting device.

D. Winding Connections: The connection of windings and terminal markings shall comply with IEEE C57.12.70.

E. Insulation: Transformer kVA rating shall be as follows: The average winding temperature rise above a 30 deg C ambient temperature shall not exceed 65 deg C and 80 deg C hottest-spot temperature rise at rated kVA when tested according to IEEE C57.12.90, using combination of connections and taps that give the highest average winding temperature rise.

F. Tap Changer: External handle, for de-energized operation.

G. Enclosure Integrity: Comply with IEEE C57.12.28 for pad-mounted enclosures that contain energized electrical equipment in excess of 600 V that may be exposed to the public.

H. Mounting: An integral skid mounting frame, suitable to allow skidding or rolling of transformer in any direction, and with provision for anchoring frame to pad.

I. Insulating Liquids:

1. Mineral Oil: ASTM D3487, Type II, and tested for compliance with ASTM D117.

J. Corrosion Protection:

1. Transformer coating system shall be factory applied, complying with requirements of IEEE C57.12.28 or IEEE C57.12.29 as directed, in manufacturer's standard color green.
2. Fabricate front sill, hood, and tank base of single-compartment transformers from stainless steel according to ASTM A167, Type 304 or 304L, not less than No. 13 U.S. gage, complying with requirements of IEEE C57.12.28 or IEEE C57.12.29 as directed, standard color green.
3. Base and Cabinets of Two Compartment Transformers: Fabricate from stainless steel according to ASTM A167, Type 304 or 304L, not less than No. 13 U.S. gage. Coat transformer with manufacturer's standard green color coating complying with requirements of IEEE C57.12.28 or IEEE C57.12.29 as directed, in manufacturer's standard color green.

2.3 SINGLE-PHASE, PAD-MOUNTED TRANSFORMERS

A. Description: Oil-filled, two-winding, 60-Hz, 65 deg C rise above a 30 deg C average ambient, self-cooled transformer.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with IEEE C57.12.25.

B. Compartment Construction:

1. Single compartment for high- and low-voltage sections, clamshell style, with provision for padlocking hinged cover and single-point latching.
2. Individual compartments for high- and low-voltage sections, formed by steel isolating barriers that extend full height and depth of compartments. With hinged, lift-off doors, with a stop in the open position, three-point latching, and provision for padlocking.
3. As directed, Provide Type 1 or Type 2 terminal arrangement.

C. Primary Fusing: Designed and rated to provide thermal protection of transformer by sensing overcurrent and high liquid temperature.

1. 150-kV BIL current-limiting fuses, conforming to the requirements of IEEE C37.47.
2. Interrupting Rating: 50,000 root mean square (rms) A symmetrical at the system voltage.
3. Fuse Assembly: Bayonet-type, liquid-immersed, expulsion fuses in series with liquid-immersed, partial-range, current-limiting fuses. Bayonet fuse shall sense both high currents and high oil temperatures to provide transformer with thermal protection.
4. Provide bayonet fuse assembly with an oil retention valve and an external drip shield inside the housing to eliminate or minimize oil spills. Valve shall close when fuse holder is removed.
5. Provide a conspicuously displayed warning adjacent to the bayonet fuse(s), cautioning against removing or inserting fuses unless transformer has been de-energized and tank pressure has been released.

D. High-Voltage Section: Dead-front design.

1. To connect primary cable, use separable insulated connectors; coordinated with and complying with requirements of Section 260513 "Medium-Voltage Cables." Bushings shall be one-piece units, with ampere and BIL ratings the same as connectors.
2. Bushing inserts and feed-through inserts:

    a. Conform to requirements of IEEE 386.
    b. Rated at 200 A, with voltage class matching connectors. Provide a parking stand near each bushing well. Parking stands shall be with insulated standoff bushings for parking of energized load-break elbow connectors on parking stands.
    c. Provide insulated protective caps for insulating and sealing out moisture from unused bushing inserts and insulated standoff bushings.

3. Bushing wells configured for loop-feed application.
4. Access to liquid-immersed fuses.
5. Dead-front surge arrester(s).
6. Tap-changer operator.
7. Ground pad.

E. Low-Voltage Section:

1. Bushings with spade terminals drilled for terminating the number of conductors indicated on the Drawings, and the lugs that comply with requirements of Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
2. Metering: Coordinated with and complying with requirements of Section 262713 "Electricity Metering." As directed, Install or Make provision for the installation by providing mounting space, brackets, and cable and conduit routing as well as the following:

    a. Sensors.
    b. BAS interface.
    c. Kilowatt-hour meter.
    d. Kilowatt-hour demand meter.

F. Capacities and Characteristics:

1. Power Rating (kVA): As directed.
2. Voltage Ratings: As directed, primary voltage V -240/120 or 480/240 V.
3. Transformer BIL (kV): Comply with IEEE C57.12.25 requirements.
4. Minimum Tested Impedance (Percent at 85 deg C): As directed, 1.25, 2.1, 3.0 or 3.2.

G. Transformer Accessories:

1. Drain and filter connection.
2. Filling and top filter press connections.
3. Pressure-vacuum gauge.
4. Dial-type analog thermometer with alarm contacts.
5. Magnetic liquid level indicator with high and low alarm contacts.
6. Automatically resetting pressure-relief device. Device flow shall be as recommended by manufacturer. With alarm contacts and a manual bleeder.
7. Stainless-steel ground connection pads.

8. Machine-engraved nameplate made of anodized aluminum or stainless steel.
9. Sudden pressure relay for remote alarm or trip when internal transformer pressure rises at field-set rate. Provide with or without seal-in delay.

2.4 THREE-PHASE TRANSFORMERS

A. Description:

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with IEEE C57.12.26.

B. Compartment Construction:

1. Single-Compartment Construction: Clamshell style, with provision for padlocking, hinged cover, and single-point latching.
2. Double-Compartment Construction: Individual compartments for high- and low-voltage sections, formed by steel isolating barriers that extend full height and depth of compartments, with hinged, lift-off doors and three-point latching, with a stop in the open position and provision for padlocking.

C. Primary Fusing: Designed and rated to provide thermal protection of transformer by sensing overcurrent and high liquid temperature.

1. 150-kV BIL current-limiting fuses, conforming to requirements of IEEE C37.47.
2. Interrupting Rating: 50,000 rms A symmetrical at system voltage.
3. Fuse Assembly: Bayonet-type, liquid-immersed, expulsion fuses in series with liquid-immersed, partial-range, current-limiting fuses. Bayonet fuse shall sense both high currents and high oil temperature to provide thermal protection to the transformer. Connect current-limiting fuses ahead of radial-feed load-break switch.
4. Provide bayonet fuse assembly with an oil retention valve and an external drip shield inside the housing to eliminate or minimize oil spills. Valve shall close when fuse holder is removed and an external drip shield is installed.
5. Provide a conspicuously displayed warning adjacent to bayonet fuse(s), cautioning against removing or inserting fuses unless transformer has been de-energized and tank pressure has been released.

D. High-Voltage Section: Dead-front design.

1. To connect primary cable, use separable insulated connectors; coordinated with and complying with requirements of Section 260513 "Medium-Voltage Cables." Bushings shall be one-piece units, with ampere and BIL ratings the same as connectors.
2. Bushing inserts and feed-through inserts:

    a. Conform to the requirements of IEEE 386.
    b. Rated at 200 A, with voltage class matching connectors. Provide a parking stand near each bushing well. Parking stands shall be equipped with insulated standoff bushings for parking of energized load-break elbow connectors on parking stands.

c. Provide insulated protective caps for insulating and sealing out moisture from unused bushing inserts and insulated standoff bushings.

3. Bushing wells configured for loop-feed application.
4. Access to liquid-immersed fuses.
5. Dead-front surge arresters.
6. Tap-changer operator.
7. Load-Break Switch:

   a. Radial-feed, liquid-immersed type with voltage class and BIL matching that of separable connectors, with a continuous current rating and load-break rating of 200 or 300 amperes as directed, and a make-and-latch rating of 12 kA rms symmetrical.
   b. Loop-feed sectionalizing switches, using three two-position, liquid-immersed-type switches for closed transition loop-feed and sectionalizing operation. Voltage class and BIL shall match that of separable connectors, with a continuous current rating and load-break rating of 200 or 300 amperes as directed, and a make-and-latch rating of 12 kA rms symmetrical. Switch operation shall be as follows:

      1) Position I: Line A connected to line B and both lines connected to the transformer.
      2) Position II: Transformer connected to line A only.
      3) Position III: Transformer connected to line B only.
      4) Position IV: Transformer disconnected and line A not connected to line B.
      5) Position V: Transformer disconnected and line A connected to line B.

8. Ground pad.

E. Low-Voltage Section:

1. Bushings with spade terminals drilled for terminating the number of conductors indicated on the Drawings, and the lugs that comply with requirements of Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
2. Metering: Coordinated with and complying with requirements of Section 262713 "Electricity Metering." As directed, Install or Make provision for the installation by providing mounting space, brackets, and cable and conduit routing as well as the following:

   a. Sensors.
   b. BAS interface.
   c. Kilowatt-hour meter.
   d. Kilowatt-hour demand meter.

F. Capacities and Characteristics:

1. Power Rating (kVA): As directed.
2. Voltage Ratings: Primary voltage V -208Y/120 or 480Y/277 V as directed.
3. Taps: Comply with IEEE C57.12.26 requirements.
4. Transformer BIL (kV): Comply with IEEE C57.12.26 requirements.
5. Minimum Tested Impedance (Percent at 85 deg C): As directed, 2.50, 2.87, 4.03 or 5.75.

G. Transformer Accessories:

1. Drain and filter connection.
2. Filling and top filter press connections.
3. Pressure-vacuum gauge.
4. Dial-type analog thermometer with alarm contacts.
5. Magnetic liquid level indicator with high and low alarm contacts.
6. Automatically resetting pressure-relief device. Device flow shall be as recommended by manufacturer. With alarm contacts and a manual bleeder.
7. Stainless-steel ground connection pads.
8. Machine-engraved nameplate, made of anodized aluminum or stainless steel.
9. Sudden pressure relay for remote alarm or trip when internal transformer pressure rises at field-set rate. As directed, Provide with or without seal-in delay.

2.5 SERVICE CONDITIONS

A. Transformers shall be suitable for operation under service conditions specified as usual service conditions in IEEE C57.12.00.

1. Altitude: As directed.

2.6 CONTROL NETWORK

A. Controllers: Support serial MS/TP and Ethernet IP communications, and able to communicate directly via RS-485 serial networks and Ethernet 10Base-T networks as a native device.

2.7 WARNING LABELS AND SIGNS

A. Comply with requirements for labels and signs specified in Section 260553 "Identification for Electrical Systems."

1. High-Voltage Warning Label: Provide self-adhesive warning signs on outside of high-voltage compartment door(s). Sign legend shall be "DANGER HIGH VOLTAGE" printed in two lines of nominal 2-inch- (50-mm)-high letters. The word "DANGER" shall be in white letters on a red background and the words "HIGH VOLTAGE" shall be in black letters on a white background.
2. Arc Flash Warning Label: Provide self-adhesive warning signs on outside of high-voltage compartment door(s), warning of potential electrical arc flash hazards and appropriate personal protective equipment required.

2.8 SOURCE QUALITY CONTROL

A. Provide manufacturer's certificate that the transformer design tests comply with IEEE C57.12.90.

1. Perform the following factory-certified routine tests on each transformer for this Project:

a. Resistance.

b. Turns ratio, polarity, and phase relation.
c. Transformer no-load losses and excitation current at 100 percent of ratings.
d. Transformer impedance voltage and load loss.
e. Operation of all devices.
f. Lightning impulse.
g. Low frequency.
h. Leak.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and space conditions for compliance with requirements for pad-mounted, liquid-filled, medium-voltage transformers and other conditions affecting performance of the Work.

B. Examine roughing-in of conduits and grounding systems to verify the following:

1. Wiring entries comply with layout requirements.
2. Entries are within conduit-entry tolerances specified by manufacturer, and no feeders will cross section barriers to reach load or line lugs.

C. Examine concrete bases for suitable conditions for transformer installation.

D. Verify that ground connections are in place and that requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at transformer location.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install transformers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.

B. Comply with requirements for vibration isolation and seismic control devices specified in Section 260529 "Hangers and Supports for Electrical Systems" and Section 260548.16 "Seismic Controls for Electrical Systems."

C. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and IEEE C2.

3.3 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

1. For counterpoise, use tinned bare copper cable not smaller than No. 4/0 AWG, buried not less than 30 inches (765 mm) below grade interconnecting the grounding electrodes. Bond surge arrester and neutrals directly to transformer enclosure and then to grounding electrode system with bare copper conductors, sized as shown. Keep lead lengths as short as practicable, with no kinks or sharp bends.
2. Fence and equipment connections shall not be smaller than No. 4 AWG. Ground fence at each gate post and corner post and at intervals not exceeding 10 ft. (3050 mm). Bond each gate section to fence post using 1/8 by 1 inch (3 by 25 mm) tinned flexible braided copper strap and clamps.
3. Make joints in grounding conductors and loops by exothermic weld or compression connector.
4. Terminate all grounding and bonding conductors on a common equipment grounding terminal on transformer enclosure.
5. Complete transformer tank grounding and lightning arrester connections prior to making any other electrical connections.

B. Terminate medium-voltage cables in incoming section of transformers according to Section 260513 "Medium-Voltage Cables."

3.4 SIGNS AND LABELS

A. Comply with installation requirements for labels and signs specified in Section 260553 "Identification for Electrical Systems."

B. Install warning signs as required to comply with 29 CFR 1910.269.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: As directed, Owner will engage or Engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. General Field-Testing Requirements:

   a. Comply with provisions of NFPA 70B Ch. "Testing and Test Methods."
   b. After installing transformer but before primary is energized, verify that grounding system at the transformer is tested at specified value or less.

3.6 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain systems.

END OF SECTION 261219

SECTION 261323 - MEDIUM-VOLTAGE, METAL-ENCLOSED SWITCHGEAR

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes indoor and outdoor metal-enclosed interrupter switchgear.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For medium-voltage, metal-enclosed switchgear.

1. Include a tabulation of installed devices with features and ratings.
2. Include dimensioned plans and elevations, showing dimensions, shipping sections, and weights of each assembled section. Elevations shall show major components, features, and mimic bus diagram.
3. Include a plan view and cross section of equipment base showing clearances, manufacturer's recommended work space, and locations of penetrations for grounding and conduits. Show location of anchor bolts and leveling channels.
4. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, and location and size of each field connection.
5. Locate accessory and spare equipment storage.
6. Include single-line diagram.
7. Include control power wiring diagrams.
8. Include batteries, battery rack, equipment base, and room layout.
9. Include copy of nameplate.
10. Ratings of the assembled switchgear:

    a. Voltage.
    b. Continuous current.
    c. Short-circuit rating.
    d. BIL.

11. Utility company's metering provisions with indication of approval by utility company.
12. Design Calculations: Signed and sealed by a qualified professional engineer. Calculate requirements for selecting seismic restraints.
13. Wiring Diagrams: For each switchgear assembly include the following:

    a. Power, signal, and control wiring.
    b. Three-line diagrams of current and future secondary circuits showing device terminal numbers and internal diagrams.
    c. Schematic control diagrams.
    d. Diagrams showing connections of component devices and equipment.
    e. Schematic diagrams showing connections to remote devices including SCADA remote terminal unit.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings.

1. Outdoor Installations:

a. Utilities site plan, drawn to scale, showing heavy equipment or truck access paths for maintenance and replacement.
b. Dimensioned concrete base, outline of the switchgear, conduit entries, and grounding equipment locations.

2. Indoor Installations:

a. Dimensioned concrete base, outline of the switchgear, conduit entries, and grounding equipment locations.
b. Support locations, type of support, and weight on each support. Locate structural supports for structure-supported raceways, cable trays, busways, overhead hoists and seismic anchors as directed.
c. Location of lighting fixtures, sprinkler piping and heads, ducts, and diffusers.

B. Qualification Data: For professional engineer and testing agency.

C. Seismic Qualification Data: Certificates, for switchgear and control power, accessories, and components, from manufacturer.

D. Product certificates.

E. Source quality-control reports.

F. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in "Field Quality Control" Article.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Manufactured Unit: Metal-enclosed switchgear, designed for application in solidly grounded neutral, ungrounded or impedance-grounded system as directed.

B. Switchgear Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with IEEE C37.20.3.

2.2 MANUFACTURERS

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: The switchgear shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means the switchgear will remain in place without separation of any parts when subjected to the seismic forces specified and the switchgear will be fully operational after the seismic event."
2. Component Importance Factor: As directed, 1.5 or 1.0.
3. Component Amplification Factor: 2.5.
4. Component Response Modification Factor: 6.0.

B. Service Conditions:

1. Switchgear shall be suitable for operation under service conditions specified as usual service conditions in IEEE C37.20.3, except for the following:

a. Unusual service condition as directed.

2.4 SWITCHGEAR ENCLOSURE

A. Indoor Enclosure: Steel.

B. Outdoor Enclosure: Weatherproof, galvanized steel, designed for installation outdoors. Aisleless, full-height doors, with provisions for padlocking, in front of basic weatherproof equipment. Integral structural-steel base frame with factory-applied asphaltic undercoating. The enclosure shall meet IEEE C37.20.3 Annex A, Category A enclosure requirements.

1. Each vertical section shall have the following features:

a. Structural design and anchorage adequate to resist loads imposed by 125-mph (200-km/h) wind.

b. Space heater operating at one-half or less of rated voltage, sized to prevent condensation, controlled by thermostats to maintain temperature of each section above expected dew point.
c. Louvers equipped with insect and rodent screens and filters and arranged to permit air circulation while excluding rodents and exterior dust.
d. Weatherproof ground-fault circuit interrupter duplex receptacle.
e. Power for heaters and receptacles shall be provided by control power transformer or as indicated.
f. Skid Mounted: Mount each shipping group on an integral base frame as a complete weatherproof unit.

C. Switchgear Enclosures Finish: Factory-applied finish in manufacturer's standard color, including under surfaces treated with corrosion-resistant undercoating.

D. Switchgear Enclosures Finish: Factory-applied finish in manufacturer's standard gray over a rust-inhibiting primer on treated metal surface.

2.5 FUSIBLE LOAD INTERRUPTER SWITCHGEAR

A. Construction:

1. Deadfront, metal-enclosed, fixed-mount, arc-resistant, fusible interrupter switchgear assembly of vertical sections.

a. Front and rear access switchgear.
b. Viewing window to show view of the position of the three poles of the interrupter.
c. Mechanical interlock preventing the door from opening when the switch is open and requiring the door to be closed before the switch can be closed.
d. Padlocking and tagging the switch in the opened or closed position.
e. Switch position indicator.
f. Front and rear vertical section covers shall have full-length hinges. The front cover shall be a flanged door with latching hardware. The rear cover may be bolted.

2. Bus: As directed, Tin-plated or Silver-plated copper.

a. Ground Bus: Sized to carry the rated short-time withstand current and connected to the metal enclosures of each vertical section.

3. Auxiliary Vertical Sections and Compartments:

a. Utility metering compartment that complies with utility company requirements.
b. Owner's Metering: Vertical section with a front hinged door for isolated access to meters and associated terminal and fuse blocks for maintenance, calibration or testing while the gear is energized.

B. Surge Arresters: Comply with IEEE C62.11, distribution class; metal-oxide-varistor type, connected in each phase of incoming circuit and ahead of disconnecting device.

C. Switches: Load interrupter type, with fuses. Omit fuses where specifically indicated.

1. Switch Operator: Manual.
2. Switch Operator: As directed, electrical, with an external power source or powered from a fused, control transformer integral to the switchgear.
3. Switch Construction:

    a. Grounded, metal shield to cover live components and terminals.
    b. Supported entirely by interior framework of structure, with copper switchblades and stored-energy operating mechanism.
    c. Phase barriers, full length of switchblades and fuses for each pole; readily removable and replaceable; designed to allow visual inspection of switch components when barrier is in place.

4. Fuses:

    a. Installed on a single mounting frame, de-energized when the switch is open.
    b. Current-Limiting Fuses: Full-range, fast-replaceable, current-limiting type that will operate without explosive noise or expulsion of gas, vapor, or foreign matter from tube.
    c. Expulsion Fuses: In disconnect-type mountings and renewable with replacement fuse units. Gases emitted on interruption are controlled and silenced by chambers designed for that purpose.
    d. Indicator integral with each fuse to show when it has blown.
    e. Spares: Include three fuses in use and three spare fuses in storage clips in each switch.

D. Accessory Set:

1. Tools and miscellaneous items required for interrupter switchgear test, inspection, maintenance, and operation.
2. Fuse-handling tool recommended by switchgear manufacturer.

E. Capacities and Characteristics:

1. Switchgear Assembly:

    a. Rated Maximum Voltage and BIL: As directed, 4.76 kV, 60 kV, 8.25 kV, 95 kV, 15 kV, 95 kV, 27 kV, 125 kV or 38 kV, 150 kV.
    b. Rated Continuous Current: As directed, 600 A or 1200 A.
    c. Rated Power-Frequency Withstand Voltage: As directed.
    d. Rated Momentary Withstand Current (600 A and 1200 A Continuous Current Ratings): 40 kA asym rmsfor 10 cycles.
    e. Rated Short-Time Withstand Current (600 A and 1200 A Continuous Current Ratings): 25 kA sym rms for 2 s.
    f. Rated Momentary Withstand Current (2000 A Continuous Current Rating): 61 kA asym rms for 10 cycles.
    g. Rated Short-Time Withstand Current (2000 A Continuous Current Rating): 38 kA sym rms for 2 s.

2. Non-Fused Load Interrupter Switch:

a. Rated Continuous Current and Load Switching Current: As directed, 600 A or 1200 A.
b. Rated Momentary Withstand Current: As directed, 40 kA asym rms or 64 kA asym rms for 10 cycles.
c. Rated Fault Close Withstand Current: As directed, kA asym.
d. Rated Short-Time Withstand Current: As directed, kA sym rms for 2 s.

3. Fused Switches with Current Limiting Fuses:

a. Fuse Type and Rated Continuous Current: As directed, Insert fuse type, Insert amperage.
b. Fuse Interrupting Rating: As directed, kA sym rms.
c. Fault Close Current Rating: As directed, kA asym.

2.6 POWER TRANSFER CONFIGURATIONS

A. Manual Transfer Selector:

1. Fusible-load, interrupter-switchgear assembly, with the incoming main consisting of a two-position, no-fuse, no-load break selector switch, mechanically interlocked with a fusible interrupter switch, connected to select one of two medium-voltage power sources.
2. Mechanical interlocks that prevent closing of the front door of the switch without the selector switch being closed in one of the two power sources.

B. Two-Switch Manual Transfer:

1. Fusible-load, interrupter-switchgear assembly, with a common load bus and two normally energized medium-voltage power sources, designated "normal" and "standby," connected to the load bus using fusible load interrupter switches.
2. Key interlock arranged so that only one incoming power switch can be closed at a time and the switch doors cannot be opened unless both switches are open.

2.7 INSTRUMENTS

A. Instrument Transformers: Comply with IEEE C57.13.

1. Potential Transformers: Secondary voltage rating of 120 V and NEMA C 12.11 accuracy class of 0.3 with burdens of W, X, and Y.
2. Current Transformers: Burden and accuracy class suitable for connected relays, meters, and instruments.

B. Multifunction Digital Meter and Monitor: Microprocessor-based unit suitable for three- or four-wire systems.

1. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.
2. Switch-selectable digital display with the following features:

a. Phase Currents, Each Phase: Plus or minus 1 percent.

b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
d. Three-Phase Real Power: Plus or minus 2 percent.
e. Three-Phase Reactive Power: Plus or minus 2 percent.
f. Power Factor: Plus or minus 2 percent.
g. Frequency: Plus or minus 0.5 percent.
h. Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
i. Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

3. Communications module suitable for remote monitoring of meter quantities and functions. Interface communication and metering requirements according to Section 260913 "Electrical Power Monitoring and Control."
4. Mounting: Display and control unit that is flush or semi-flush mounted in instrument compartment door.

C. Analog Instruments: Rectangular, 4-1/2 inches (115 mm) square, 1 percent accuracy, semi-flush mounting, with anti-parallax 250-degree scale and external zero adjustment.

1. Voltmeters: Cover an expanded scale range of normal voltage plus 10 percent.
2. Voltmeter Selector Switch: Rotary type with off position to provide readings of phase-to-phase and phase-to-neutral voltages.
3. Ammeters: Cover an expanded scale range of bus rating plus 10 percent.
4. Ammeter Selector Switch: Permits current reading in each phase and keeps current-transformer secondary circuits closed in off position.
5. Locate meter and selector switch on circuit-breaker compartment door for indicated feeder circuits only.
6. Watt-Hour Meters: Flush- or semi-flush-mounting type, 5 A, 120 V, three phase, three wire; with three elements, 15-minute indicating demand register, and provision for testing and adding pulse initiation.
7. Recording Demand Meter: Usable as totalizing relay or indicating and recording maximum demand meter with 15-minute interval.

a. Operation: Counts and records a succession of pulses entering two channels.
b. Housing: Drawout, back-connected case arranged for semi-flush mounting.

2.8 PROTECTIVE RELAYS

A. Multifunctional, solid-state microprocessor-based relay systems complying with IEEE C37.90.

B. Relay Mounting:

1. Each relay shall be mounted in a drawout case with a two-stage quick-release operation.
2. Removal of the relay from the case shall disconnect the trip circuits and short the current-transformer secondaries before the unit control power is disconnected.
3. When the relay is inserted into the case, control power connections shall be made before the trip circuits are activated.
4. Include a self-shorting contact on the case terminal block for alarm indication and tripping of circuit breaker upon removal of the relay from the case.

C. Equip each relay system with a communications module to transmit the following data according to Section 260913 "Electrical Power Monitoring and Control."

1. Relay's metered and target data, such as currents, set points, cause of trip, magnitude of trip current, and open-close trip status.
2. Ability to close and open the associated breaker with proper access code from remote location over the communication network when the relay is configured in remote open-close mode.

D. Overcurrent and Ground-Fault Protective Relays:

1. IEEE C37.2 Device Functions: 51/50 and 51/50N.
2. Field-Selectable Relay Settings: Required by the overcurrent protective device coordination study and arc-flash study.
3. Primary Current-Transformer Ratings: Programmable from 5 to 5000 A.
4. Phase and Ground Protection: Field-selectable curves from IEEE moderately inverse, very inverse, or extremely inverse.
5. Phase Instantaneous Overcurrent Trip Pickup Point: Field selectable as "none" or from 1.0 to 25 times current-transformer primary rating. Include discriminator circuit with "on" and "off" switch so that when phase instantaneous overcurrent has been programmed to "none," the discriminator circuit protects against currents exceeding 11 times current-transformer primary rating when the breaker is being closed and shall be deactivated after approximately eight cycles.
6. Contacts:

    a. Two Form-A contacts.
    b. Field selectable into contact pairs as follows and as required by the overcurrent protective device coordination study and arc-flash study:

        1) One contact assigned ANSI 51 phase and ANSI 51 ground, and the other contact assigned ANSI 50 phase and ANSI 50 ground.
        2) One contact assigned ANSI 51/50 phase, and the other contact assigned 51/50 ground.

7. Alphameric display to show the following parameters with metering accuracy not to exceed 2 percent of full scale:

    a. Individual phase currents.
    b. Ground current.
    c. Cause of trip.
    d. Magnitude and phase of current-causing trip.
    e. Phase or ground indication.
    f. Peak current demand for each phase and ground since last reset.
    g. Current-transformer primary rating.
    h. Programmed phase and ground set points.

8. Relay alarm and trip contacts shall not change state if power is lost or an undervoltage occurs. These contacts shall only cause a trip on detection of an overcurrent or fault condition based on programmed settings. Provide a "protection off" alarm, which shall be normally energized when the relay is powered and the self-diagnostics indicates the unit

is functional. On loss of power or relay failure, this alarm relay shall be de-energized, providing a fail-safe protection off alarm.

2.9 CONTROL POWER SUPPLY

A. Description: Control power transformer shall supply 120-V control circuits through secondary disconnect and overcurrent protective devices.

1. Dry-type transformer, in separate compartment, with primary and secondary fuses to provide current-limiting and overload protection.

B. Description: Uninterruptible ac power supply complying with requirements in Section 263353 "Static Uninterruptible Power Supply"

2.10 CONTROL POWER SUPPLY

A. Description: As directed, Dedicated 48 V dc or 120 V dc battery system.

B. System Requirements: Battery shall have number of cells and ampere-hour capacity based on an initial specific gravity of 1.210 at 25 deg C with electrolyte at normal level and minimum ambient temperature of 13 deg C. Cycle battery before shipment to guarantee rated capacity on installation. Arrange battery to operate ungrounded. Battery system capacity shall be as recommended by switchgear manufacturer to operate the circuit breakers for intended duty.

C. Battery:

1. As directed, Standard VRLA, Premium VRLA or Vented NiCd batteries, with system disconnect and overcurrent protective device.
2. Rack: Two-step rack with electrical connections between battery cells and between rows of cells; include two flexible connectors with bolted-type terminals for output leads. Rate battery rack, cell supports, and anchorage for seismic requirements.
3. Accessories:

    a. Thermometers with specific-gravity correction scales.
    b. Hydrometer syringes.
    c. Set of cell numerals.

4. Charger: Static-type silicon rectifier equipped with automatic regulation and provision for manual and automatic adjustment of charging rate. Unit shall automatically maintain output voltage within 0.5 percent from no load to rated charger output current, with ac input-voltage variation of plus or minus 10 percent and input-frequency variation of plus or minus 3 Hz.

    a. DC ammeter.
    b. DC Voltmeter: Maximum error of 5 percent at full-charge voltage, with toggle switch to select between battery and charger voltages.

c. Ground Indication: Two appropriately labeled lights to indicate circuit ground, connected in series between negative and positive terminals, with midpoint junction connected to ground by NO push-button contact.
d. Capacity: Sufficient to supply steady load, float-charge battery between 2.20 and 2.25 V per cell and equalizing charge at 2.33 V per cell.
e. Charging-Rate Switch: Manually operated switch to transfer to higher charging rate. Charger operation shall be automatic until manually reset.
f. AC Power Supply: 120 V, 60 Hz, subject to plus or minus 10 percent variation in voltage and plus or minus 3-Hz variation in frequency. Automatic charger operation shall resume after loss of ac power supply for any interval.
g. Charging Regulator: Protect charger from damage due to overload, including short circuit on output terminals. The device shall regulate charging current but shall not disconnect charger from either battery or ac supply.
h. Charger's Audible Noise: Less than 26 dB.

D. Battery Ground-Fault Detector: Initiates alarm when resistance to ground of positive or negative bus of battery is less than 5000 ohms.

E. Control Wiring: Factory installed, complete with bundling, lacing, and protection.

1. Conductors across Hinges and for Interconnections between Shipping Units: Flexible conductors for No. 8 AWG and smaller.
2. Conductors: Sized according to NFPA 70 for duty required.

2.11 WARNING LABELS AND SIGNS

A. Comply with requirements for labels and signs specified in Section 260553 "Identification for Electrical Systems."

1. Warning signs shall be baked enamel signs.
2. Equipment Identification Labels: As directed, Laminated acrylic or melamine label or Stenciled legend, minimum 4 inches (100 mm) high.

2.12 SOURCE QUALITY CONTROL

A. Perform production tests on each circuit breaker housing for this Project, complying with IEEE C37.20.3:

1. Perform mechanical operation tests to ensure proper functioning of shutters, operating mechanism, mechanical interlocks, and interchangeability of removable elements that are designed to be interchangeable.
2. Verify that control wiring is correct by verifying continuity. Perform electrical operation of relays and devices to ensure they function properly and in the intended sequence.
3. Perform the control wiring dielectric test at 1500 V for one minute.

B. Perform production tests, on each circuit breaker supplied for this Project, complying with IEEE C37.20.4.

1. Perform mechanical operation tests to ensure proper functioning of the switch.

2. Verify the contact gap. Perform terminal-to-terminal resistance test.
3. Verify that control wiring is correct by verifying continuity. Perform electrical operation of relays and devices to ensure they function properly and in the intended sequence.
4. Perform the control wiring dielectric test at 1500 V for one minute.

PART 3 - EXECUTION

3.1 SWITCHGEAR INSTALLATION

A. Upon delivery of switchgear and prior to unloading, inspect equipment for damage. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Equipment Mounting:

1. Install switchgear on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."
3. Comply with requirements for vibration isolation devices specified in Section 260529 "Hangers and Supports for Electrical Systems."

C. Switchgear shall be installed level and plumb. Switchgear shall tilt less than 1.5 degrees while energized.

D. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

E. Comply with NECA 1.

F. Comply with NECA 430.

3.2 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Grounding Connections at Interior Locations:

1. Install bare copper cable not smaller than No. 4/0 AWG for grounding to grounding electrodes.
2. Bond surge arrester and neutrals directly to the switchgear enclosure and then to the grounding electrode system with bare copper conductors.
3. Keep leads as short as practicable with no kinks or sharp bends.
4. Make joints in grounding conductors and loops by exothermic weld or compression connector.

C. Grounding Connections at Exterior Locations:

1. Install tinned bare copper cable not smaller than No. 4/0 AWG, for counterpoise buried not less than 30 inches (765 mm) below grade interconnecting the grounding electrodes.
2. Bond surge arrester and neutrals directly to the switchgear enclosure and then to the grounding electrode system with bare copper conductors, sized as shown.
3. Keep lead lengths as short as practicable with no kinks or sharp bends.
4. Fence and equipment connections shall not be smaller than No. 4 AWG.
5. Ground fence at each gate post and corner post and at intervals not exceeding 10 ft. (3050 mm).
6. Bond each gate section to the fence post using 1/8 by 1 inch (3 by 25 mm) tinned flexible braided copper strap and clamps.
7. Make joints in grounding conductors and loops by exothermic weld or compression connector.

D. Terminate all grounding and bonding conductors on a common equipment grounding terminal on the switchgear enclosure. Install supplemental terminal bars, lugs, and bonding jumpers as required to accommodate the number of conductors for termination.

E. Complete switchgear grounding and lightning arrester connections prior to making any other electrical connections.

F. Terminate medium-voltage cables according to Section 260513 "Medium-Voltage Cables."

3.3 SIGNS AND LABELS

A. Comply with the installation requirements for labels and signs specified in Section 260553 "Identification for Electrical Systems."

B. Install warning signs as required to comply with OSHA in 29 CFR 1910.269.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: As directed, Owner will engage or Engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

C. General Field Testing Requirements:

1. Comply with the provisions of NFPA 70B, "Testing and Test Methods."
2. After installing switchgear and after electrical circuitry has been energized, test for compliance with requirements.
3. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.

D. Medium-Voltage Switchgear Assembly Field Tests:

1. Visual and Mechanical Inspection:

a. Verify that fuse and circuit breaker sizes and types correspond to Drawings and coordination study, as well as to the circuit breaker's address in the control network.
b. Verify that current and voltage transformer ratios correspond to Drawings.
c. Inspect bolted electrical connections using calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
d. Confirm correct operation and sequencing of electrical and mechanical interlock systems.

    1) Attempt closure on locked-open devices. Attempt to open locked-closed devices.
    2) Make key exchange with devices operated in off-normal positions.

e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
f. Inspect insulators for evidence of physical damage or contaminated surfaces.
g. Verify correct barrier and shutter installation and operation.
h. Exercise active components.
i. Inspect mechanical indicating devices for correct operation.
j. Verify that filters are in place and vents are clear.
k. Perform visual and mechanical inspection of instrument transformers according to Article "Instrument Transformer Field Tests."
l. Inspect control power transformers.

    1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
    2) Verify that primary and secondary fuse or circuit breaker ratings match drawings.
    3) Verify correct functioning of drawout disconnecting and grounding contacts and interlocks.

2. Electrical Tests:

    a. Inspect bolted electrical connections using a low resistance ohmmeter to compare bolted resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
    b. Perform dc voltage insulation-resistance tests on each bus section, phase to phase and phase to ground, for one minute. If the temperature of the bus is other than plus or minus 20 deg C, adjust the resulting resistance as provided in NETA ATS, Table 100.11.

        1) Insulation-resistance values of bus insulation shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.1.

2) Do not proceed to the dielectric withstand voltage tests until insulation-resistance levels are raised above minimum values.

c. Perform a dielectric withstand voltage test on each bus section, each phase to ground with phases not under test grounded, according to manufacturer's published data. If manufacturer has no recommendation for this test, it shall be conducted according to NETA ATS, Table 100.2. Apply the test voltage for one minute.

1) If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.

d. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential shall be 500 volts dc for 300-volt rated cable and 1000 V dc for 600-V rated cable. Test duration shall be one minute. For units with solid-state components or control devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.

1) Minimum insulation-resistance values of control wiring shall not be less than two megohms.

e. Control Power Transformers:

1) Perform insulation-resistance tests. Perform measurements from winding to winding and each winding to ground. Insulation-resistance values of winding insulation shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.1.
2) Perform secondary wiring integrity test. Disconnect transformer at secondary terminals and connect secondary wiring to a rated secondary voltage source. Verify correct potential at all devices.
3) Verify correct secondary voltage by energizing the primary winding with system voltage. Measure secondary voltage with the secondary wiring disconnected.
4) Verify correct function of control transfer relays located in the switchgear with multiple control power sources.

f. Voltage Transformers:

1) Perform secondary wiring integrity test. Verify correct potential at all devices.
2) Verify secondary voltages by energizing the primary winding with system voltage.

g. Perform current-injection tests on the entire current circuit in each section of switchgear.

1) Perform current tests by secondary injection with magnitudes such that a minimum current of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.

2) Perform current tests by primary injection with magnitudes such that a minimum of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.

h. Perform system function tests according to "System Function Tests" Article.
i. Verify operation of space heaters.
j. Perform phasing checks on double-ended or dual-source switchgear to ensure correct bus phasing from each source.

E. Instrument Transformer Field Tests:

1. Visual and Mechanical Inspection:

a. Verify that equipment nameplate data complies with Contract Documents.
b. Inspect physical and mechanical condition.
c. Verify correct connection of transformers with system requirements.
d. Verify that adequate clearances exist between primary and secondary circuit wiring.
e. Verify the unit is clean.
f. Inspect bolted electrical connections using calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
g. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.
h. Verify that required grounding and shorting connections provide contact.
i. Verify correct operation of transformer withdrawal mechanism and grounding operation.
j. Verify correct primary and secondary fuse sizes for voltage transformers.
k. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

2. Electrical Tests of Current Transformers:

a. Inspect bolted electrical connections using a low resistance ohmmeter to compare bolted resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
b. Perform insulation-resistance test of each current transformer and its secondary wiring with respect to ground at 1000 V dc for one minute. For units with solid-state components that cannot tolerate the applied voltage, follow manufacturer's written recommendations. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.5.
c. Perform a polarity test of each current transformer according to IEEE C57.13.1. Polarity results shall agree with transformer markings.
d. Perform a ratio-verification test using the voltage or current method according to IEEE C57.13.1. Ratio errors shall be according to IEEE C57.13.

e. Perform an excitation test on transformers used for relaying applications according to IEEE C57.13.1. Excitation results shall match the curve supplied by the manufacturer or be according to IEEE C57.13.1.
f. Measure current circuit burdens at transformer terminals according to IEEE C57.13.1. Measured burdens shall be compared with and shall match instrument transformer ratings.
g. Perform insulation-resistance tests on the primary winding with the secondary grounded. Test voltages shall be according to Table 100.5.
h. Perform dielectric withstand tests on the primary winding with the secondary grounded. Test voltages shall be according to Table 100.9.
i. Perform power-factor or dissipation-factor tests according to test equipment manufacturer's published data.
j. Verify that current transformer secondary circuits are grounded and have only one grounding point according to IEEE C57.13.3. That grounding point should be located as specified by the engineer in the project drawings.

3. Electrical Tests of Voltage Transformers:

a. Inspect bolted electrical connections using a low resistance ohmmeter to compare bolted resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
b. Perform insulation-resistance tests winding-to-winding and each winding to ground. Test voltages shall be applied for one minute according to Table 100.5. For units with solid-state components that cannot tolerate the applied voltage, follow manufacturer's recommendations. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.5.
c. Perform a polarity test on each transformer to verify the polarity marks or H1- X1 relationship as applicable. Polarity results shall agree with transformer markings.
d. Perform a turns-ratio test on all tap positions. Ratio errors shall be according to IEEE C57.13.
e. Measure voltage circuit burdens at transformer terminals. Measured burdens shall be compared with and shall match instrument transformer ratings.
f. Perform a dielectric withstand test on the primary windings with the secondary windings connected to ground. The dielectric voltage shall be according to Table 100.9. The test voltage shall be applied for one minute. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the primary windings are considered to have passed the test.
g. Perform power-factor or dissipation-factor tests according to test equipment manufacturer's published data. Power-factor or dissipation-factor values shall be according to manufacturer's published data. In the absence of manufacturer's published data, use test equipment manufacturer's published data.
h. Verify that voltage transformer secondary circuits are grounded and have only one grounding point according to IEEE C57.13.3. Test results shall indicate that the circuits are grounded at only one point.

F. Ground Resistance Test:

1. Visual and Mechanical Inspection:

a. Verify ground system complies with the Contract Documents and NFPA 70 Article 250, "Grounding and Bonding."
b. Inspect physical and mechanical condition. Grounding system electrical and mechanical connections shall be free of corrosion.
c. Inspect bolted electrical connections using a calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
d. Inspect anchorage.

2. Electrical Tests:

a. Perform fall-of-potential or alternative test according to IEEE 81 on the main grounding electrode or system. The resistance between the main grounding electrode and ground shall be no more than 5 ohms or maximum ground resistance value specified in "Examination" Article as directed.
b. Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral, and derived neutral points. Investigate point-to-point resistance values that exceed 0.5 ohms. Compare equipment nameplate data with Contract Documents.
c. Inspect physical and mechanical condition.
d. Inspect bolted electrical connections for high resistance using a low-resistance ohmmeter to compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

G. Metering Devices Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect bolted electrical connections using calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.
c. Inspect cover gasket, cover glass, condition of spiral spring, disk clearance, contacts, and case shorting contacts, as applicable.
d. Verify the unit is clean.
e. Verify freedom of movement, end play, and alignment of rotating disk(s).

2. Electrical Tests:

a. Inspect bolted electrical connections using a low resistance ohmmeter to compare bolted resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
b. Verify accuracy of meters at all cardinal points. Meter accuracy shall be according to manufacturer's published data.

c. Calibrate meters according to manufacturer's published data. Calibration results shall be within manufacturer's published tolerances.
d. Verify all instrument multipliers. Instrument multipliers shall be according to system design specifications.
e. Verify that current transformer and voltage transformer secondary circuits are intact. Test results shall confirm the integrity of the secondary circuits of current and voltage transformers.

H. Medium-Voltage Surge Arrester Field Tests:

1. Visual and Mechanical Inspection:

a. Verify that equipment nameplate data complies with Contract Documents.
b. Inspect physical and mechanical condition.
c. Inspect anchorage, alignment, grounding, and clearances.
d. Verify the arresters are clean.
e. Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.
f. Verify that the stroke counter is correctly mounted and electrically connected if applicable. Record the stroke counter reading.

2. Electrical Test:

a. Perform an insulation-resistance test on each arrester, phase terminal to ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Replace units that fail to meet recommended minimum insulation resistance listed in the table.
b. Perform a watts-loss test. Evaluate watts-loss values by comparison with similar units and test equipment manufacturer's published data.
c. Test grounding connections. Resistance between the arrester ground terminal and the ground system shall be less than 0.5 ohm.

I. Microprocessor-Based Protective Relay Field Tests:

1. Visual and Mechanical Inspection:

a. Record model number, style number, serial number, firmware revision, software revision, and rated control voltage.
b. Verify operation of light-emitting diodes, display, and targets.
c. Record passwords for each access level.
d. Clean the front panel and remove foreign material from the case.
e. Check tightness of connections.
f. Verify that the frame is grounded according to manufacturer's instructions.
g. Set the relay according to results in Section 260573.16 "Coordination Studies" and in Section 260573.19 "Arc-Flash Hazard Analysis."
h. Download settings from the relay. Print a copy of the settings for the report and compare the settings to those specified in the coordination study.

2. Electrical Tests:

a. Perform insulation-resistance tests from each circuit to the grounded frame according to manufacturer's published data.
b. Apply voltage or current to analog inputs and verify correct registration of the relay meter functions.
c. Functional Operation: Check functional operation of each element used in the protection scheme as follows:

1) Timing Relay:

a) Determine time delay.
b) Verify operation of instantaneous contacts.

2) Volts/Hertz Relay:

a) Determine pickup frequency at rated voltage.
b) Determine pickup frequency at a second voltage level.
c) Determine time delay.

3) Sync Check Relay:

a) Determine closing zone at rated voltage.
b) Determine maximum voltage differential that permits closing at zero degrees.
c) Determine live line, live bus, dead line, and dead bus set points.
d) Determine time delay.
e) Verify dead bus/live line, dead line/live bus, and dead bus/dead line control functions.

4) Undervoltage Relay:

a) Determine dropout voltage.
b) Determine time delay.
c) Determine time delay at a second point on the timing curve for inverse time relays.

5) Directional Power Relay:

a) Determine minimum pickup at maximum torque angle.
b) Determine closing zone.
c) Determine maximum torque angle.
d) Determine time delay.
e) Verify time delay at a second point on the timing curve for inverse time relays.
f) Plot the operating characteristic.

6) Current Balance Relay:

a) Determine pickup of each unit.
b) Determine percent slope.
c) Determine time delay.

7) Negative Sequence Current Relay:

a) Determine negative sequence alarm level.
b) Determine negative sequence minimum trip level.
c) Determine maximum time delay.
d) Verify two points on the I-two-squared-t curve.

8) Phase Sequence or Phase Balance Voltage Relay:

a) Determine positive sequence voltage to close the NO contact.
b) Determine positive sequence voltage to open the NC contact (undervoltage trip).
c) Verify negative sequence trip.
d) Determine time delay to close the NO contact with sudden application of 120 percent of pickup.
e) Determine time delay to close the NC contact upon removal of voltage when previously set to rated system voltage.

9) Instantaneous Overcurrent Relay:

a) Determine pickup.
b) Determine dropout.
c) Determine time delay.

10) Time Overcurrent:

a) Determine minimum pickup.
b) Determine time delay at two points on the time current curve.

11) Ground Detector Relay:

a) Determine maximum impedance to ground causing relay pickup.

12) Directional Overcurrent Relay:

a) Determine directional unit minimum pickup at maximum torque angle.
b) Determine closing zone.
c) Determine maximum torque angle.
d) Plot operating characteristics.
e) Determine overcurrent unit pickup.
f) Determine overcurrent unit time delay at two points on the time current curve.

d. Control Verification:

1) Functional Tests:

a) Check operation of all active digital inputs.

b) Check output contacts or silicone-controlled rectifiers (SCRs), preferably by operating the controlled device, such as circuit breaker, auxiliary relay, or alarm.
c) Check internal logic functions used in protection scheme.
d) Upon completion of testing, reset min/max recorders, communications statistics, fault counters, sequence-of-events recorder, and event records.

2) In-Service Monitoring: After the equipment is initially energized, measure magnitude and phase angle of inputs and verify expected values.

J. Switchgear will be considered defective if it does not pass tests and inspections.

K. Remove and replace defective units and retest.

L. Prepare test and inspection reports. Record as-left set points of adjustable devices.

3.5 SYSTEM FUNCTION TESTS

A. System function tests shall prove the correct interaction of sensing, processing, and action devices. Perform system function tests after field quality control tests have been completed and all components have passed specified tests.

1. Develop test parameters and perform tests for the purpose of evaluating performance of integral components and their functioning as a complete unit within design requirements and manufacturer's published data.
2. Verify the correct operation of interlock safety devices for fail-safe functions in addition to design function.
3. Verify the correct operation of sensing devices, alarms, and indicating devices.

3.6 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain systems.

END OF SECTION 261323

SECTION 261326 - MEDIUM-VOLTAGE, METAL-CLAD SWITCHGEAR

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes indoor and outdoor metal-clad switchgear.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For each medium-voltage, metal-clad switchgear.

1. Include a tabulation of installed devices with features and ratings.
2. Include dimensioned plans and elevations, showing dimensions, shipping sections, and weights of each assembled section. Elevations shall show major components, features, and mimic bus diagram.
3. Include a plan view and cross section of equipment base showing clearances, manufacturer's recommended workspace, and locations of penetrations for grounding and conduits. Show location of anchor bolts and leveling channels.
4. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, and location and size of each field connection.
5. Locate accessory and spare equipment storage.
6. Include single-line diagram.
7. Include control power wiring diagrams.
8. Include batteries, battery rack, equipment base, and room layout.
9. Include copy of nameplate.
10. Test results of enclosure corrosion resistant finish.
11. Ratings the switchgear assembly:

    a. Voltage.
    b. Continuous current.
    c. Short-circuit current.
    d. Lightning impulse full-wave withstand voltage.

12. Utility company's metering provisions with indication of approval by utility company.
13. Design Calculations: Signed and sealed by a qualified professional engineer. Calculate requirements for selecting seismic restraints.
14. Relay settings.
15. Interface data with monitoring or control network.
16. Wiring Diagrams: For each switchgear assembly include the following:

    a. Power, signal, and control wiring.
    b. Three-line diagrams of current and future secondary circuits showing device terminal numbers and internal diagrams.
    c. Schematic control diagrams.

d. Diagrams showing connections of component devices and equipment.
e. Schematic diagrams showing connections to remote devices including connection details to the communications network.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:

1. Outdoor Installations:

a. Utilities site plan, drawn to scale, showing heavy equipment or truck access paths for maintenance and replacement.
b. Dimensioned concrete base, outline of the switchgear, conduit entries, and grounding equipment locations.

2. Indoor Installations:

a. Dimensioned concrete base, outline of the switchgear, conduit entries, and grounding equipment locations.
b. Support locations, type of support, and weight on each support. Locate structural supports for structure-supported raceways, cable trays, busways, overhead hoists and seismic anchors as directed.
c. Location of lighting fixtures, sprinkler piping and heads, ducts, and diffusers.

B. Qualification Data: For professional engineer and testing agency.

C. Seismic Qualification Data: Certificates, for switchgear and control power, accessories, and components, from manufacturer.

D. Product certificates.

E. Source quality-control reports.

F. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in "Field Quality Control" Article.

1.6 WARRANTY

A. Special Battery Warranties: Manufacturer and Installer agree to repair or replace the switchgear control system storage batteries that fail in materials or workmanship within specified warranty period.

1. Warranted Cycle Life for VRLA Batteries: Equal to or greater than that represented in manufacturer's published table, including figures corresponding to the following, based on annual average battery temperature of 77 deg F (25 deg C):

a. Cycle Life: 6 cycles.

1) Discharge Rate: 8 hours.
2) Discharge Duration: 8 hours.
3) Discharge End Voltage: 1.67 V.

b. Cycle Life: 20 cycles.

1) Discharge Rate: 30 minutes.
2) Discharge Duration: 30 minutes.
3) Discharge End Voltage: 1.67 V.

c. Cycle Life: 120 cycles.

1) Discharge Rate: 15 minutes.
2) Discharge Duration: 45 seconds.
3) Discharge End Voltage: 1.67 V.

2. Warranted Cycle Life for Premium VRLA Batteries: Equal to or greater than that represented in manufacturer's published table, including figures corresponding to the following, based on annual average battery temperature of 77 deg F (25 deg C):

a. Cycle Life: 40 cycles.

1) Discharge Rate: 8 hours.
2) Discharge Duration: 8 hours.
3) Discharge End Voltage: 1.67 V.

b. Cycle Life: 125 cycles.

1) Discharge Rate: 30 minutes.
2) Discharge Duration: 30 minutes.
3) Discharge End Voltage: 1.67 V.

c. Cycle Life: 750 cycles.

1) Discharge Rate: 15 minutes.
2) Discharge Duration: 1.5 minutes.
3) Discharge End Voltage: 1.67 V.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Manufactured Unit: Indoor and outdoor], metal-clad switchgear, designed for application in solidly grounded neutral, ungrounded or impedance-grounded system as directed.

B. Comply with IEEE C37.20.2.

C. The switchgear ratings shall comply with IEEE C37.04 and shall be the preferred ratings of IEEE C37.06.

D. Switchgear Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 MANUFACTURERS

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: The switchgear shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means the switchgear will remain in place without separation of any parts when subjected to the seismic forces specified and the switchgear will be fully operational after the seismic event."
2. Component Importance Factor: As directed 1.5 or 1.0.
3. Component Amplification Factor: 2.5.
4. Component Response Modification Factor: 6.0.

B. Service Conditions:

1. Switchgear shall be suitable for operation under service conditions specified as usual service conditions in IEEE C37.20.2, except for the following:

a. Unusual service condition as directed.

2.4 SWITCHGEAR ENCLOSURE

A. Indoor Enclosure: Steel.

B. Outdoor Enclosure: Weatherproof, galvanized steel, designed for installation outdoors. With full-height doors, with provisions for padlocking. With an integral structural-steel base frame with factory-applied asphaltic undercoating. The enclosure shall meet IEEE C37.20.2 Annex A, Category A enclosure requirements.

1. Each vertical section shall have the following features:

a. Structural design and anchorage adequate to resist loads imposed by 125-mph (200-km/h) wind.
b. Space heater operating at one-half or less of rated voltage, sized to prevent condensation, controlled by thermostats to maintain temperature of each section above expected dew point.
c. Louvers equipped with insect and rodent screens and filters and arranged to permit air circulation while excluding rodents and exterior dust.
d. Weatherproof ground-fault circuit interrupter duplex receptacles.
e. Power for heaters and receptacles shall be provided by control power transformer or as indicated.
f. Skid Mounted: Mount each shipping group on an integral base frame as a complete weatherproof unit.

C. Switchgear Enclosures Finish: Factory-applied finish in manufacturer's standard color, including under surfaces treated with corrosion-resistant undercoating.

D. Switchgear Enclosures Finish: Factory-applied finish in manufacturer's standard gray over a rust-inhibiting primer on treated metal surface.

2.5 SWITCHGEAR CONSTRUCTION

A. Deadfront, metal-clad, drawout, switchgear assembly of vertical sections, each with vacuum circuit breakers. Provide additional vertical sections to house accessories related to the switchgear functions.

1. Front and rear access switchgear.
2. Front and rear vertical section covers with full-length hinges. The front cover shall be a flanged door with latching hardware. The rear cover may be bolted.
3. Switchgear shall be arc resistant, complying with IEEE C37.20.7, Type 1A, Type 2A, Type 1C or Type 2C as directed.

B. Bus: As directed Tin-plated or Silver-plated copper.

1. Ground Bus: Sized to carry the rated short-time withstand current, extended full length of the switchgear assembly, and connected to the metal enclosures of each vertical section.

C. Circuit Breaker Compartments: Include a racking mechanism, circuit breaker operated automatic shutters covering the high-voltage bus connections, safety interlocks, and an electrical racking motor and accessories for remote racking of the circuit breaker.

D. Auxiliary Vertical Sections and Compartments:

1. Utility metering compartment that complies with utility company requirements.
2. Owner's Metering: A vertical section with a front hinged door for isolated access to meters and associated terminal and fuse blocks for maintenance, calibration, or testing while the gear is energized.

E. Circuit Breakers: Horizontally mounted, drawout, vacuum circuit breakers, operated by a motor-charged stored-energy mechanism, and having manual means of charging the mechanism.

1. Electrically Operated: As directed 120 V ac or 230 V ac close, ac capacitor trip. Powered from external power source or from a fused control transformer integral to the switchgear.
2. Electrically Operated: As directed 48, 120 or 240 V dc close and trip. Powered from an external power source.

F. Accessory Set: Tools and miscellaneous items required for interrupter switchgear test, inspection, maintenance, and operation.

1. One of each size handling device to remove the circuit breaker from metal-clad switchgear and to move the breaker about on the floor.
2. Test cabinet with accessories to connect to the secondary contacts on an electrically operated removable element, permitting operation and testing of the removable element when it is removed from the housing.

G. Capacities and Characteristics:

1. Comply with IEEE C37.06.
2. Switchgear Assembly:

a. Rated Maximum Design Voltage and BIL (Dielectric Test): 4.76 kV, 60 kV or 15 kV, 95 kV as directed.
b. Rated Continuous Current: As directed 1200 A or 2000 A.
c. Rated Short-Circuit Current and Short-Time Current: 40 kA rms.

3. Circuit Breakers:

a. Same capacities and characteristics as the switchgear assembly, and as follows:

1) Rated Continuous Current and Load Switching Current: As directed 1200 A or 2000 A.
2) Rated Closing and Latching Current: 104 kA, peak.
3) Rated Interrupting Time: 50 ms or 83 ms as directed.

2.6 SURGE ARRESTERS

A. Comply with IEEE C62.11, distribution class; metal-oxide-varistor type, connected in each phase of incoming circuit and ahead of disconnecting device.

2.7 INSTRUMENTS

A. Instrument Transformers: Comply with IEEE C57.13.

1. Potential Transformers: Secondary voltage rating of 120 V and NEMA C 12.11 accuracy class of 0.3 with burdens of W, X, and Y.
2. Current Transformers: Burden and accuracy class suitable for connected relays, meters, and instruments.

B. Metering: Install the following listed Owner's instruments, comply with requirements in Section 260913 "Electrical Power Monitoring and Control":

C. Multifunction Digital Meter and Monitor: Microprocessor-based unit suitable for three- or four-wire systems.

1. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.
2. Switch-selectable digital display with the following features:

    a. Phase Currents, Each Phase: Plus or minus 1 percent.
    b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
    c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
    d. Three-Phase Real Power: Plus or minus 2 percent.
    e. Three-Phase Reactive Power: Plus or minus 2 percent.
    f. Power Factor: Plus or minus 2 percent.
    g. Frequency: Plus or minus 0.5 percent.
    h. Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
    i. Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

3. Communications module suitable for remote monitoring of meter quantities and functions. Interface communication and metering requirements according to Section 260913 "Electrical Power Monitoring and Control."
4. Mounting: Display and control unit that is flush or semi-flush mounted in instrument compartment door.

D. Analog Instruments: Rectangular, 4-1/2 inches (115 mm) square, 1 percent accuracy, semi-flush mounting, with anti-parallax 250-degree scale and external zero adjustment.

1. Voltmeters: Cover an expanded scale range of normal voltage plus 10 percent.
2. Voltmeter Selector Switch: Rotary type with off position to provide readings of phase-to-phase and phase-to-neutral voltages.
3. Ammeters: Cover an expanded scale range of bus rating plus 10 percent.
4. Ammeter Selector Switch: Permits current reading in each phase and keeps current-transformer secondary circuits closed in off position.
5. Locate meter and selector switch on circuit-breaker compartment door for indicated feeder circuits only.
6. Watt-Hour Meters: Flush- or semi-flush-mounting type, 5 A, 120 V, three phase, three wire; with three elements, 15-minute indicating demand register, and provision for testing and adding pulse initiation.
7. Recording Demand Meter: Usable as totalizing relay or indicating and recording maximum demand meter with 15-minute interval.

    a. Operation: Counts and records a succession of pulses entering two channels.
    b. Housing: Drawout, back-connected case arranged for semi-flush mounting.

2.8 PROTECTIVE RELAYS

A. Multifunctional, solid-state microprocessor-based relay systems, complying with IEEE C37.90.

B. Relay Mounting:

1. Each relay shall be mounted in a drawout case with a two-stage quick-release operation.
2. Removal of the relay from the case shall disconnect the trip circuits and short the current-transformer secondaries before the unit control power is disconnected.
3. When the relay is inserted into the case, control power connections shall be made before the trip circuits are activated.
4. Include a self-shorting contact on the case terminal block for alarm indication and tripping of circuit breaker upon removal of the relay from the case.

C. Equip each relay system with a communications module to transmit the following data according to Section 260913 "Electrical Power Monitoring and Control."

1. Relay's metered and target data, such as currents, set points, cause of trip, magnitude of trip current, and open-close trip status.
2. Ability to close and open the associated breaker with proper access code from remote location over the communication network when the relay is configured in remote open-close mode.

D. Overcurrent and Ground-Fault Protective Relays:

1. IEEE C37.2 device functions 51/50 and 51/50N.
2. Field-Selectable Relay Settings: Required by the overcurrent protective device coordination study and arc-flash study.
3. Primary Current-Transformer Ratings: Programmable from 5 to 5000 A.
4. Phase and Ground Protection: Field-selectable curves from IEEE moderately inverse, very inverse, or extremely inverse.
5. Phase Instantaneous Overcurrent Trip Pickup Point: Field selectable as "none" or from 1.0 to 25 times current-transformer primary rating. Include discriminator circuit with "on" and "off" switch so that when phase instantaneous overcurrent has been programmed to "none," the discriminator circuit protects against currents exceeding 11 times current-transformer primary rating when the breaker is being closed and shall be deactivated after approximately eight cycles.
6. Contacts:

    a. Two Form-A contacts.
    b. Field selectable into contact pairs as follows and as required by the overcurrent protective device coordination study and arc-flash study:

        1) One contact assigned ANSI 51 phase and ANSI 51 ground, and the other contact assigned ANSI 50 phase and ANSI 50 ground.
        2) One contact assigned ANSI 51/50 phase, and the other contact assigned 51/50 ground.

7. Alphameric display to show the following parameters with metering accuracy not to exceed 2 percent of full scale:

    a. Individual phase currents.
    b. Ground current.
    c. Cause of trip.
    d. Magnitude and phase of current-causing trip.
    e. Phase or ground indication.

f. Peak current demand for each phase and ground since last reset.
g. Current-transformer primary rating.
h. Programmed phase and ground set points.

8. Relay alarm and trip contacts shall not change state if power is lost or an undervoltage occurs. These contacts shall only cause a trip on detection of an overcurrent or fault condition based on programmed settings. A "protection off" alarm shall be normally energized when the relay is powered and the self-diagnostics indicates the unit is functional. On loss of power or relay failure, this alarm relay shall be de-energized, providing a fail-safe protection off alarm.

2.9 CONTROL POWER SUPPLY

A. Description: Control power transformer shall supply 120 V ac control circuits through secondary disconnect and overcurrent protective devices.

1. Dry-type transformer, in separate compartment, with primary and secondary fuses to provide current-limiting and overload protection.

B. Description: Uninterruptible ac power supply complying with requirements of Section 263353 "Static Uninterruptible Power Supply."

2.10 CONTROL POWER SUPPLY

A. Dedicated As directed 48 V dc, 120 V dc or 240 V dc battery system.

B. System Requirements: Battery shall have number of cells and ampere-hour capacity based on an initial specific gravity of 1.210 at 25 deg C with electrolyte at normal level and minimum ambient temperature of 13 deg C. Cycle battery before shipment to guarantee rated capacity on installation. Arrange to operate ungrounded. Battery system capacity shall be as recommended by switchgear manufacturer to operate the circuit breakers for intended duty.

C. Battery:

1. As directed Standard VRLA or Premium VRLA batteries, with system disconnect and overcurrent protective device.
2. Rack: Two-step rack with electrical connections between battery cells and between rows of cells; include two flexible connectors with bolted-type terminals for output leads. Rate battery rack, cell supports, and anchorage for seismic requirements.
3. Accessories:

a. Set of cell numerals.
b. Monitoring system.

4. Charger: Static-type silicon rectifier equipped with automatic regulation and provision for manual and automatic adjustment of charging rate. Unit shall automatically maintain output voltage within 0.5 percent from no load to rated charger output current, with ac

input-voltage variation of plus or minus 10 percent and input-frequency variation of plus or minus 3 Hz.

a. DC ammeter.
b. DC Voltmeter: Maximum error of 5 percent at full-charge voltage, with toggle switch to select between battery and charger voltages.
c. Ground Indication: Two appropriately labeled lights to indicate circuit ground, connected in series between negative and positive terminals, with midpoint junction connected to ground by NO push-button contact.
d. Capacity: Sufficient to supply steady load, float-charge battery between 2.20 and 2.25 V per cell and equalizing charge at 2.33 V per cell.
e. Charging-Rate Switch: Manually operated switch to transfer to higher charging rate. Charger operation shall be automatic until manually reset.
f. AC Power Supply: 120 V, 60 Hz, subject to plus or minus 10 percent variation in voltage and plus or minus 3-Hz variation in frequency. Automatic charger operation shall resume after loss of ac power supply for any interval.
g. Charging Regulator: Protect charger from damage due to overload, including short circuit on output terminals. The device shall regulate charging current but shall not disconnect charger from either battery or ac supply.
h. Charger's Audible Noise: Less than 26 dB.

D. Battery Ground-Fault Detector: Initiates alarm when resistance to ground of positive or negative bus of battery is less than 5000 ohms.

E. Control Wiring: Factory installed, complete with bundling, lacing, and protection.

1. Conductors across Hinges and for Interconnections between Shipping Units: Flexible conductors for No. 8 AWG and smaller.
2. Conductors: Sized according to NFPA 70 for duty required.

2.11 WARNING LABELS AND SIGNS

A. Install appropriate precautionary labels to warn about potential hazards that are inherent to the equipment. Comply with requirements for labels and signs specified in Section 260553 "Identification for Electrical Systems."

1. Warning signs shall be baked enamel signs.
2. Equipment Identification Labels: Laminated acrylic or melamine plastic signs or Stenciled legend, minimum 4 inches (100 mm) high as directed.

2.12 SOURCE QUALITY CONTROL

A. Perform production tests on each circuit breaker housing for this Project, complying with IEEE C37.09.

1. Perform mechanical operation tests to ensure proper functioning of shutters, operating mechanism, mechanical interlocks, and interchangeability of removable elements that are designed to be interchangeable.
2. Conduct an alignment test with master circuit breaker to verify all interfaces.

3. Verify that control wiring is correct by verifying continuity. Perform electrical operation of relays and devices to ensure they function properly and in the intended sequence.
4. Perform the control wiring dielectric test at 1500 V for one minute.
5. Perform the dielectric test on primary and secondary circuits.

B. Perform production tests, on each circuit breaker supplied for this Project, complying with IEEE C37.09.

1. Perform mechanical operation tests to ensure proper functioning of the switch.
2. Conduct an alignment test with master cell to verify all interfaces and interchangeability.
3. Verify the contact gap. Perform terminal-to-terminal resistance test.
4. Verify that control wiring is correct by verifying continuity. Perform electrical operation of relays and devices to ensure they function properly and in the intended sequence. Operate the circuit breakers over the range of minimum to maximum of the control voltage.
5. Perform the control wiring dielectric test at 1500 V for one minute.
6. Set the contact gap.

PART 3 - EXECUTION

3.1 SWITCHGEAR INSTALLATION

A. Equipment Mounting:

1. Install switchgear on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."
3. Comply with requirements for vibration isolation devices specified in Section 260529 "Hangers and Supports for Electrical Systems."

B. Switchgear shall be installed level and plumb. Switchgear shall tilt less than 1.5 degrees while energized.

C. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

D. Comply with NECA 1.

E. Comply with NECA 430.

3.2 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Grounding Connections at Interior Locations:

1. Install bare copper cable not smaller than No. 4/0 AWG for grounding to grounding electrodes.
2. Bond surge arrester and neutrals directly to the switchgear enclosure and then to the grounding electrode system with bare copper conductors.
3. Keep leads as short as practicable with no kinks or sharp bends.
4. Make joints in grounding conductors and loops by exothermic weld or compression connector.

C. Grounding at Exterior Locations:

1. Install tinned bare copper cable not smaller than No. 4/0 AWG, for counterpoise buried not less than 30 inches (765 mm) below grade interconnecting the grounding electrodes.
2. Bond surge arrester and neutrals directly to the switchgear enclosure and then to the grounding electrode system with bare copper conductors, sized as shown.
3. Keep lead lengths as short as practicable with no kinks or sharp bends.
4. Fence and equipment connections shall not be smaller than No. 4 AWG.
5. Ground fence at each gate post and corner post and at intervals not exceeding 10 ft. (3050 mm).
6. Bond each gate section to the fence post using 1/8 by 1 inch (3 by 25 mm) tinned flexible braided copper strap and clamps.
7. Make joints in grounding conductors and loops by exothermic weld or compression connector.

D. Terminate grounding and bonding conductors on a common equipment grounding terminal on the switchgear enclosure. Install supplemental terminal bars, lugs, and bonding jumpers as required to accommodate the number of conductors for termination.

E. Complete switchgear grounding and lightning arrester connections prior to making any other electrical connections.

F. Terminate medium-voltage cables according to Section 260513 "Medium-Voltage Cables."

3.3 SIGNS AND LABELS

A. Comply with the installation requirements for labels and signs specified in Section 260553 "Identification for Electrical Systems."

B. Install warning signs as required to comply with OSHA 29 CFR 1910.269.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. General Field Testing Requirements:

1. Comply with the provisions of NFPA 70B, "Testing and Test Methods."
2. After installing switchgear and after electrical circuitry has been energized, test for compliance with requirements.

3. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.

C. Medium-Voltage Switchgear Assembly Field Tests:

1. Visual and Mechanical Inspection:

a. Verify that fuse and circuit breaker sizes and types correspond to Drawings and coordination study, as well as to the circuit breaker's address in the control network.
b. Verify that current and voltage transformer ratios correspond to Drawings.
c. Inspect bolted electrical connections using calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
d. Confirm correct operation and sequencing of electrical and mechanical interlock systems.

1) Attempt closure on locked-open devices. Attempt to open locked-closed devices.
2) Make key exchange with devices operated in off-normal positions.

e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
f. Inspect insulators for evidence of physical damage or contaminated surfaces.
g. Verify correct barrier and shutter installation and operation.
h. Exercise active components.
i. Inspect mechanical indicating devices for correct operation.
j. Verify that filters are in place and vents are clear.
k. Perform visual and mechanical inspection of instrument transformers according to according to Article "Instrument Transformer Field Tests."
l. Inspect control power transformers.

1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
2) Verify that primary and secondary fuse or circuit breaker ratings match drawings.
3) Verify correct functioning of drawout disconnecting and grounding contacts and interlocks.

2. Electrical Tests:

a. Inspect bolted electrical connections using a low resistance ohmmeter to compare bolted resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
b. Perform dc voltage insulation-resistance tests on each bus section, phase to phase and phase to ground, for one minute. If the temperature of the bus is other than

plus or minus 20 deg. C, adjust the resulting resistance as provided in NETA ATS, Table 100.11.

1) Insulation-resistance values of bus insulation shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.1.
2) Do not proceed to the dielectric withstand voltage tests until insulation-resistance levels are raised above minimum values.

c. Perform a dielectric withstand voltage test on each bus section, each phase to ground with phases not under test grounded, according to manufacturer's published data. If manufacturer has no recommendation for this test, it shall be conducted according to NETA ATS, Table 100.2. Apply the test voltage for one minute.

1) If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.

d. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential shall be 500 V dc for 300-volt rated cable and 1000 V dc for 600-V rated cable. Test duration shall be one minute. For units with solid-state components or control devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.

1) Minimum insulation-resistance values of control wiring shall not be less than two megohms.

e. Control Power Transformers:

1) Perform insulation-resistance tests. Perform measurements from winding to winding and each winding to ground. Insulation-resistance values of winding insulation shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.1.
2) Perform secondary wiring integrity test. Disconnect transformer at secondary terminals and connect secondary wiring to a rated secondary voltage source. Verify correct potential at all devices.
3) Verify correct secondary voltage by energizing the primary winding with system voltage. Measure secondary voltage with the secondary wiring disconnected.
4) Verify correct function of control transfer relays located in the switchgear with multiple control power sources.

f. Voltage Transformers:

1) Perform secondary wiring integrity test. Verify correct potential at all devices.

2) Verify secondary voltages by energizing the primary winding with system voltage.

g. Perform current-injection tests on the entire current circuit in each section of switchgear.

1) Perform current tests by secondary injection with magnitudes such that a minimum current of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.
2) Perform current tests by primary injection with magnitudes such that a minimum of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.

h. Perform system function tests according to according to "System Function Tests" Article.
i. Verify operation of space heaters.
j. Perform phasing checks on double-ended or dual-source switchgear to ensure correct bus phasing from each source.

D. Medium-Voltage Vacuum Circuit Breaker Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, grounding, and required clearances.
c. Verify that maintenance devices such as special tools and gages specified by the manufacturer are available for servicing and operating the breaker.
d. Verify the unit is clean.
e. Perform mechanical operation tests on operating mechanism according to manufacturer's published data.
f. Measure critical distances on operating mechanism as recommended by the manufacturer. Critical distances of the operating mechanism shall be according to manufacturer's published data.
g. Verify cell fit and element alignment.
h. Verify racking mechanism operation.
i. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
j. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
k. Perform time-travel analysis. Travel and velocity values shall be according to manufacturer's published data.
l. Record as-found and as-left operation counter reading. Operation counter shall advance one digit per close-open cycle.

2. Electrical Tests:

a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to ground with switch closed, and across each open pole. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Insulation-resistance values shall be according to manufacturer's published data. In the absence of

manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than this table or manufacturer's recommendations. Dielectric-withstand-voltage tests shall not proceed until insulation-resistance levels are raised above minimum values.

b. Perform a contact/pole-resistance test. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value. Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in the manufacturer's published data. If manufacturer's published data is not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.

c. Perform minimum pickup voltage tests on trip and close coils according to manufacturer's published data. Minimum pickup voltage of the trip and close coils shall comply with manufacturer's published data. In the absence of the manufacturer's published data, comply with NETA ATS, Table 100.20.

d. Verify correct operation of any auxiliary features, such as electrical close and trip operation, trip-free operation, and anti-pump function. Auxiliary features shall operate according to manufacturer's published data.

e. Trip circuit breaker by operation of each protective device. Reset trip logs and indicators.

f. Perform power-factor or dissipation-factor tests on each pole with the breaker open and each phase with the breaker closed. Power-factor or dissipation-factor values shall comply with manufacturer's published data.

g. Perform vacuum bottle integrity (dielectric-withstand-voltage) test across each vacuum bottle, with the contacts in the "open" position according to manufacturer's published data. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the vacuum bottle integrity test, the test specimen is considered to have passed the test.

h. Perform a dielectric-withstand-voltage test according to manufacturer's published data. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric-withstand-voltage test, the test specimen is considered to have passed the test.

i. Verify operation of heaters.

E. Instrument Transformer Field Tests:

1. Visual and Mechanical Inspection:

a. Verify that equipment nameplate data complies with Contract Documents.

b. Inspect physical and mechanical condition.

c. Verify correct connection of transformers with system requirements.

d. Verify that adequate clearances exist between primary and secondary circuit wiring.

e. Verify the unit is clean.

f. Inspect bolted electrical connections using calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.

g. Verify that all required grounding and shorting connections provide contact.

h. Verify that all required grounding and shorting connections provide contact.

i. Verify correct operation of transformer withdrawal mechanism and grounding operation.
j. Verify correct primary and secondary fuse sizes for voltage transformers.
k. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

2. Electrical Tests of Current Transformers:

a. Inspect bolted electrical connections using a low resistance ohmmeter to compare bolted resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
b. Perform insulation-resistance test of each current transformer and its secondary wiring with respect to ground at 1000 V dc for one minute. For units with solid-state components that cannot tolerate the applied voltage, follow manufacturer's recommendations. Investigate and correct values of insulation resistance less than manufacturer's written recommendations or NETA ATS, Table 100.5.
c. Perform a polarity test of each current transformer according to according to IEEE C57.13.1. Polarity results shall agree with transformer markings.
d. Perform a ratio-verification test using the voltage or current method according to according to IEEE C57.13.1. Ratio errors shall be according to according to IEEE C57.13.
e. Perform an excitation test on transformers used for relaying applications according to according to IEEE C57.13.1. Excitation results shall match the curve supplied by the manufacturer or be according to according to IEEE C57.13.1.
f. Measure current circuit burdens at transformer terminals according to according to ANSI/IEEE C57.13.1. Measured burdens shall be compared with and shall match instrument transformer ratings.
g. Perform insulation-resistance tests on the primary winding with the secondary grounded. Test voltages shall be according to according to Table 100.5.
h. Perform dielectric withstand tests on the primary winding with the secondary grounded. Test voltages shall be according to according to Table 100.9.
i. Perform power-factor or dissipation-factor tests according to test equipment manufacturer's published data.
j. Verify that current transformer secondary circuits are grounded and have only one grounding point according to IEEE C57.13.3. That grounding point should be located as specified by the engineer in the project drawings.

3. Electrical Tests of Voltage Transformers.

a. Inspect bolted electrical connections using a low resistance ohmmeter to compare bolted resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
b. Perform insulation-resistance tests winding-to-winding and each winding to ground. Test voltages shall be applied for one minute according to Table 100.5. For units with solid-state components that cannot tolerate the applied voltage, follow manufacturer's recommendations. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.5.

c. Perform a polarity test on each transformer to verify the polarity marks or H1- X1 relationship as applicable. Polarity results shall agree with transformer markings.
d. Perform a turns-ratio test on all tap positions. Ratio errors shall be according to IEEE C57.13.
e. Measure voltage circuit burdens at transformer terminals. Measured burdens shall be compared with and shall match instrument transformer ratings.
f. Perform a dielectric withstand test on the primary windings with the secondary windings connected to ground. The dielectric voltage shall be according to Table 100.9. The test voltage shall be applied for one minute. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the primary windings are considered to have passed the test.
g. Perform power-factor or dissipation-factor tests according to test equipment manufacturer's published data. Power-factor or dissipation-factor values shall be according to manufacturer's published data. In the absence of manufacturer's published data, use test equipment manufacturer's published data.
h. Verify that voltage transformer secondary circuits are grounded and have only one grounding point according to IEEE C57.13.3. Test results shall indicate that the circuits are grounded at only one point.

F. Ground Resistance Test

1. Visual and Mechanical Inspection:

a. Verify ground system complies with Contract Documents and NFPA 70 Article 250, "Grounding and Bonding."
b. Inspect physical and mechanical condition. Grounding system electrical and mechanical connections shall be free of corrosion.
c. Inspect bolted electrical connections using calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.
d. Inspect anchorage.

2. Electrical Tests.

a. Perform fall-of-potential or alternative test according to IEEE 81 on the main grounding electrode or system. The resistance between the main grounding electrode and ground shall be no more than 5 ohms or maximum resistance value specified in "Examination" Article as directed.
b. Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral, and derived neutral points. Investigate point-to-point resistance values that exceed 0.5 ohm. Compare equipment nameplate data with Contract Documents.
c. Inspect physical and mechanical condition.
d. Inspect bolted electrical connections for high resistance using a low-resistance ohmmeter to compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

G. Metering Devices Field Tests

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect bolted electrical connections using calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.
c. Inspect cover gasket, cover glass, condition of spiral spring, disk clearance, contacts, and case shorting contacts, as applicable.
d. Verify the unit is clean.
e. Verify freedom of movement, end play, and alignment of rotating disk(s).

2. Electrical Tests:

a. Inspect bolted electrical connections using a low resistance ohmmeter to compare bolted resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
b. Verify accuracy of meters at all cardinal points. Meter accuracy shall be according to manufacturer's published data.
c. Calibrate meters according to manufacturer's published data. Calibration results shall be within manufacturer's published tolerances.
d. Verify all instrument multipliers. Instrument multipliers shall be according to system design specifications.
e. Verify that current transformer and voltage transformer secondary circuits are intact. Test results shall confirm the integrity of the secondary circuits of current and voltage transformers.

H. Medium-Voltage Surge Arrester Field Tests:

1. Visual and Mechanical Inspection:

a. Verify that equipment nameplate data complies with Contract Documents.
b. Inspect physical and mechanical condition.
c. Inspect anchorage, alignment, grounding, and clearances.
d. Verify the arresters are clean.
e. Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.
f. Verify that the stroke counter is correctly mounted and electrically connected if applicable. Record the stroke counter reading.

2. Electrical Test:

a. Perform an insulation-resistance test on each arrester, phase terminal-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Replace units that fail to meet recommended minimum insulation resistance listed in the table.

b. Perform a watts-loss test. Evaluate watts-loss values by comparison with similar units and test equipment manufacturer's published data.
c. Test grounding connections. Resistance between the arrester ground terminal and the ground system shall be less than 0.5 ohm.

I. Microprocessor-Based Protective Relay Field Tests:

1. Visual and Mechanical Inspection:

a. Record model number, style number, serial number, firmware revision, software revision, and rated control voltage.
b. Verify operation of light-emitting diodes, display, and targets.
c. Record passwords for each access level.
d. Clean the front panel and remove foreign material from the case.
e. Check tightness of connections.
f. Verify that the frame is grounded according to manufacturer's instructions.
g. Set the relay according to results in Section 260573.16 "Coordination Studies" and in Section 260573.19 "Arc-Flash Hazard Analysis."
h. Download settings from the relay. Print a copy of the settings for the report and compare the settings to those specified in the coordination study.

2. Electrical Tests:

a. Perform insulation-resistance tests from each circuit to the grounded frame according to manufacturer's published data.
b. Apply voltage or current to analog inputs, and verify correct registration of the relay meter functions.
c. Functional Operation: Check functional operation of each element used in the protection scheme as follows:

1) Timing Relay:

a) Determine time delay.
b) Verify operation of instantaneous contacts.

2) Volts/Hertz Relay:

a) Determine pickup frequency at rated voltage.
b) Determine pickup frequency at a second voltage level.
c) Determine time delay.

3) Sync Check Relay:

a) Determine closing zone at rated voltage.
b) Determine maximum voltage differential that permits closing at zero degrees.
c) Determine live line, live bus, dead line, and dead bus set points.
d) Determine time delay.
e) Verify dead bus/live line, dead line/live bus, and dead bus/dead line control functions.

4) Undervoltage Relay:

   a) Determine dropout voltage.
   b) Determine time delay.
   c) Determine time delay at a second point on the timing curve for inverse time relays.

5) Directional Power Relay:

   a) Determine minimum pickup at maximum torque angle.
   b) Determine closing zone.
   c) Determine maximum torque angle.
   d) Determine time delay.
   e) Verify time delay at a second point on the timing curve for inverse time relays.
   f) Plot the operating characteristic.

6) Current Balance Relay:

   a) Determine pickup of each unit.
   b) Determine percent slope.
   c) Determine time delay.

7) Negative Sequence Current Relay:

   a) Determine negative sequence alarm level.
   b) Determine negative sequence minimum trip level.
   c) Determine maximum time delay.
   d) Verify two points on the I-two-squared-t curve.

8) Phase Sequence or Phase Balance Voltage Relay:

   a) Determine positive sequence voltage to close the NO contact.
   b) Determine positive sequence voltage to open the NC contact (undervoltage trip).
   c) Verify negative sequence trip.
   d) Determine time delay to close the NO contact with sudden application of 120 percent of pickup.
   e) Determine time delay to close the NC contact upon removal of voltage when previously set to rated system voltage.

9) Instantaneous Overcurrent Relay:

   a) Determine pickup.
   b) Determine dropout.
   c) Determine time delay.

10) Time Overcurrent:

   a) Determine minimum pickup.
   b) Determine time delay at two points on the time current curve.

11) Ground Detector Relay:

a) Determine maximum impedance to ground causing relay pickup.

12) Directional Overcurrent Relay:

a) Determine directional unit minimum pickup at maximum torque angle.
b) Determine closing zone.
c) Determine maximum torque angle.
d) Plot operating characteristics.
e) Determine overcurrent unit pickup.
f) Determine overcurrent unit time delay at two points on the time current curve.

d. Control Verification:

1) Functional Tests:

a) Check operation of all active digital inputs.
b) Check output contacts or silicone-controlled rectifiers (SCRs), preferably by operating the controlled device, such as circuit breaker, auxiliary relay, or alarm.
c) Check internal logic functions used in protection scheme.
d) Upon completion of testing, reset min/max recorders, communications statistics, fault counters, sequence-of-events recorder, and event records.

2) In-Service Monitoring: After the equipment is initially energized, measure magnitude and phase angle of inputs and verify expected values.

J. DC System VRLA Batteries Field Test:

1. Visual and Mechanical Inspection:

a. Verify that batteries are adequately located.
b. Verify that battery area ventilation system is operable.
c. Verify existence of suitable eyewash equipment.
d. Verify equipment nameplate data complies with Contract Documents.
e. Inspect physical and mechanical condition.
f. Verify adequacy of battery support racks, mounting, anchorage, alignment, grounding, and clearances.
g. Verify the units are clean.
h. Inspect spill containment installation.
i. Verify application of an oxide inhibitor on battery terminal connections.

2. Electrical Tests:

a. Measure charger float and equalizing voltage levels. Adjust to battery manufacturer's recommended levels.

b. Verify charger functions and that alarms comply with system manufacturer's recommendations.
c. Measure negative post temperature. Negative post temperature shall comply with manufacturer's published data or IEEE 1188.
d. Measure charger float and equalizing voltage levels. Charger float and equalizing voltage levels shall be according to the battery manufacturer's published data.
e. Measure each monoblock/cell voltage and total battery voltage with charger energized and in float mode of operation. Monoblock/cell voltages shall be according to manufacturer's published data.
f. Measure intercell connection resistances.
g. Perform internal ohmic measurement tests. Cell internal ohmic values (resistance, impedance, or conductance) shall not vary by more than 25 percent between identical cells that are in a fully charged state. Monoblock/cell internal ohmic values (resistance, impedance, or conductance) shall not vary by more than 25 percent between identical monoblocks/cells in a fully charged state.
h. Perform a load test according to manufacturer's published data or IEEE 1188. Replace units that fail to pass the test.
i. Measure the battery system voltage from positive to ground and negative to ground. Voltage measured from positive to ground shall be equal in magnitude to the voltage measured from negative to ground.

K. DC System Vented NiCd Batteries Field Test:

1. Visual and Mechanical Inspection:

a. Verify that batteries are adequately located.
b. Verify that battery area ventilation system is operable.
c. Verify existence of suitable eyewash equipment.
d. Verify equipment nameplate data complies with Contract Documents.
e. Inspect physical and mechanical condition.
f. Verify adequacy of battery support racks, mounting, anchorage, alignment, grounding, and clearances.
g. Verify electrolyte level. Measure pilot-cell electrolyte temperature and correct as recommended by manufacturer's maintenance procedures to bring the temperature and electrolyte level to within normal limits.
h. Verify the units are clean.
i. Inspect spill containment installation.
j. Verify application of an oxide inhibitor on battery terminal connections.

2. Electrical Tests:

a. Measure charger float and equalizing voltage levels. Adjust to battery manufacturer's recommended levels.
b. Verify charger functions and that alarms comply with system manufacturer's recommendations.
c. Measure each cell voltage and total battery voltage with charger energized and in float mode of operation. Cell voltages shall be within 0.05 volt of each other or according to manufacturer's published data.
d. Measure intercell connection resistances.

e. Perform internal ohmic measurement tests. Cell internal ohmic values (resistance, impedance, or conductance) shall not vary by more than 25 percent between identical cells that are in a fully charged state.
f. Perform a load test according to manufacturer's published data or IEEE 1106. Replace units that fail to pass the test.
g. Measure the battery system voltage from positive to ground and negative to ground. Voltage measured from positive-to-ground shall be equal in magnitude to the voltage measured from negative to ground.

L. Switchgear will be considered defective if it does not pass tests and inspections.

M. Remove and replace defective units and retest.

N. Prepare test and inspection reports. Record as-left set points of adjustable devices.

3.5 SYSTEM FUNCTION TESTS

A. System function tests shall prove the correct interaction of sensing, processing, and action devices. Perform system function tests after field quality control tests have been completed and all components have passed specified tests.

1. Develop test parameters and perform tests for the purpose of evaluating performance of integral components and their functioning as a complete unit within design requirements and manufacturer's published data.
2. Verify the correct operation of interlock safety devices for fail-safe functions in addition to design function.
3. Verify the correct operation of sensing devices, alarms, and indicating devices.

3.6 DEMONSTRATION

A. As Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain systems.

END OF SECTION 261326

SECTION 261329 - MEDIUM-VOLTAGE, PAD-MOUNTED SWITCHGEAR

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes dead-front, remotely controlled insulated vacuum load and fault interrupting switchgear.

1.2 DEFINITIONS

A. BIL: Basic Impulse Insulation Level.

B. Bushing: An insulating structure including a central conductor, or providing a central passage for a conductor, with provision for mounting on a barrier, conducting or otherwise, for insulating the conductor from the barrier and conducting current from one side of the barrier to the other.

C. Bushing Elbow: An insulated device used to connect insulated conductors to separable insulated connectors on dead-front, pad-mounted switchgear and to provide a fully insulated connection. Also called an "elbow connector."

D. Bushing Insert: That component of a separable insulated connector that is inserted into a bushing well to complete a dead-front, load break or non-load break, separable insulated connector (bushing).

E. Bushing Well: A component of a separable insulated connector, either permanently welded or clamped to an enclosure wall or barrier, having a cavity that receives a replaceable component (bushing insert) to complete the separable insulated connector (bushing).

F. Fault Interrupter: A self-controlled mechanical switching device capable of making, carrying, and automatically interrupting an alternating current. It includes an assembly of control elements to detect overcurrents and control the fault interrupter. A fault interrupter always consists of a switching device, a control unit, and sensors for current and/or voltage sensing.

G. Hotstick: An insulated stick, usually made of fiberglass, that is used to work energized overhead conductors and operate electrical equipment that is overhead, underground, and compartmentalized.

H. NETA ATS: InterNational Electrical Testing Association, Acceptance Testing Specification.

I. SCADA: Supervisory control and data acquisition.

J. Way: A three-phase or single-phase circuit connection to the bus that may contain combinations of switches and protective devices or may be a solid bus.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For pad-mounted switchgear.

1. Include a tabulation of installed devices with features and ratings.
2. Include dimensioned plans and elevations, showing dimensions, shipping sections, and weights of each assembled section. Elevations shall show major components and features, and they will mimic bus diagram.
3. Include a plan view and cross section of equipment base, showing clearances, manufacturer's recommended workspace, and locations of penetrations for grounding and conduits. Show location of anchor bolts and leveling channels.
4. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, and location and size of each field connection.
5. Design Calculations: Signed and sealed by a qualified professional engineer. Calculate requirements for selecting seismic restraints.
6. Wiring Diagrams: For each switchgear assembly, include the following:

    a. Power, signal, and control wiring.
    b. Schematic diagrams showing connections to remote devices including SCADA remote terminal unit.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Utilities site plan, drawn to scale, showing heavy equipment or truck access paths for maintenance and replacement.

B. Seismic Qualification Data: Certificates, for pad-mounted switchgear, from manufacturer.

C. Product Certificates: For pad-mounted switchgear.

D. Source quality-control reports.

E. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 SYSTEM DESCRIPTION

A. Manufactured Unit: Pad-mounted switchgear, designed for application in solidly grounded neutral, ungrounded or impedance-grounded underground distribution systems.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with IEEE C2.

D. Comply with IEEE C37.74

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: The switchgear shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the switchgear will remain in place without separation of any parts when subjected to the seismic forces specified and the switchgear will be fully operational after the seismic event."
2. Component Importance Factor: As directed, 1.5 or 1.0.
3. Component Amplification Factor: 2.5.
4. Component Response Modification Factor: 6.0.

B. Service Conditions:

1. Switchgear shall be suitable for operation under service conditions specified as usual service conditions in IEEE C37.20.3, except for the following: As directed.

2.4 RATINGS

A. Switchgear is applied to a nominal 4.16, 13.2, 13.8, 23, 24.94 or 34.5 kV (L-L) medium-voltage electrical power system as directed. Minimum ratings of the switchgear shall be as follows:

1. Rated Maximum Voltage and Rated BIL: As directed, 15.5 kV and 95 kV BIL, 27 kV and 125 kV BIL or 38 kV and 150 kV BIL.
2. Continuous and Load Interrupting Current: 600 A.
3. Short-Time and Short-Circuit Interrupting Current: As directed, 12.5 kA rms Sym, 16 kA rms Sym, 20 kA rms Sym or 25 kA rms Sym.

2.5 SWITCHGEAR ENCLOSURE

A. Weatherproof enclosure with an integral skid mounting frame, designed for mounting on a concrete pad, suitable to allow skidding or rolling of the switchgear in any direction, and with provision for anchoring the frame to the pad.

B. Enclosure Integrity: Comply with IEEE C57.12.28 for compartmentalized enclosures that contain energized electrical equipment in excess of 600 V that may be exposed to the public.

1. Each vertical section shall have the following features:

a. Structural design and anchorage adequate to resist loads imposed by 125-mph (200-km/h) wind.
b. Space heater operating at one-half or less of rated voltage, sized to prevent condensation, controlled by thermostats to maintain temperature of each section above expected dew point.
c. Louvers equipped with insect and rodent screens and filters, and arranged to permit air circulation while excluding rodents and exterior dust.
d. Weatherproof ground-fault circuit interrupter duplex receptacles.
e. Power for heaters and receptacles shall be provided by control power transformer or as indicated.
f. Skid Mounted: Mount each shipping group on an integral base frame as a complete weatherproof unit.

C. Corrosion Protection: Enclosure coating system shall be factory applied, meeting the requirements of IEEE C57.12.28 or IEEE C57.12.29 as directed, in manufacturer's standard color green.

D. Corrosion Protection: Fabricate the support frame, enclosure base, and the enclosure from stainless steel, ASTM A167, Type 304 or 304L. Enclosure coating system shall be factory applied, meeting the requirements of IEEE C57.12.28 or IEEE C57.12.29 as directed, standard color green.

2.6 SWITCHGEAR CONSTRUCTION

A. Dead-front, front and rear access switchgear.

B. Each disconnect switch in switched ways shall be in a sealed, dielectric filled stainless-steel tank, factory-filled with SF6 gas, mineral oil or less-flammable, high-firepoint fluid as directed.

1. SF6 Gas: Comply with ASTM D2472. Provide enclosure with pressure gauge and self-sealing fill valve.
2. Mineral Oil: Comply with ASTM D3487, Type II, and tested for compliance with ASTM D117. Provide enclosure with level gauge to monitor the dielectric level; automatic pressure relief valve; and fill, drain, and sampling valves.

C. Construct switchgear assembly with switched ways that have front-accessible terminations for cables entering from below and with manual operating provisions with a lineman's hotstick.

D. Trapped Key Interlocks: Kirk key interlock system using a dowel pin design having no openings. Brass housing and 316 stainless-steel key and lock bolts.

E. Viewing Windows: For each switch, located adjacent to manual operating devices, and positioned to show switch contact position.

F. Grounding: Provision to make grounding cable and wire connections at each way.

2.7 SWITCHED WAYS

A. Source Switch Ways: Non-fused, hotstick operated, ganged vacuum load interrupter switches, in series with a visible-break disconnect switch.

1. Rated Continuous Current and Load Switching Current: 600 A.
2. Vacuum Load Interrupter:

    a. With 24 V dc motor operators to open or close the load interrupter.
    b. Trip-free switch mechanism. Closing the switch shall be independent of the speed of the operating handle.

3. Visible-Break Disconnect Switch: As directed, three positions, with open, closed, and ground positions or Two positions, with open and closed positions. The switch shall be mechanically interlocked so that the vacuum interrupter opens and closes first.

    a. Switch position indicator, clearly labeled.
    b. Padlocking and tagging provisions.

B. Fault Interrupting Switched Ways: Non-fused, hotstick-operated, ganged vacuum fault interrupter switches, in series with a visible-break disconnect. With internally mounted current transformers and electronic overcurrent sensing for single-phase or three-phase ganged tripping of the interrupter. Comply with IEEE C37.60.

1. Rated Continuous Current and Load Switching Current: 600 A.
2. Vacuum Fault Interrupter:

    a. Operated by a motor-charged stored energy mechanism, with provision to manually charge the mechanism. Charging motors shall operate at 24 V ac.
    b. Auxiliary Switches: Provide two auxiliary switches, each with field-selectable NC or NO switch position, for connection of remote indication of the position of the switched way. The switches shall be rated at 15 A, 120 V ac, and 1 A, 120 V dc.
    c. Trip-free switch mechanism when manually operated. Closing the switch shall be independent of the speed of the operating handle.
    d. Single operating handle and a clearly labeled switch position indicator; open, closed, tripped.
    e. Operations Counters: Mechanical type, linked to the operating handle of each switched way.
    f. Padlocking and tagging provisions.

3. Visible-Break Disconnect Switch: As directed, three positions, with open, closed, and ground positions or Two positions, with open and closed positions. The switch shall be

mechanically interlocked so that the switch cannot be operated unless the vacuum fault interrupter is open.

a. Switch position indicator, clearly labeled.
b. Padlocking and tagging provisions.

C. Controls:

1. Motor Actuators: "Open," "close," and "stop" push buttons.
2. Switch Status LEDs: "Open" and "closed" lights. Show status of disconnect switch using its auxiliary contact.
3. Motor Actuator Process LEDs: "Opening" and "closing" lights indicating that the selected motor is operating the switch.
4. Power Switch: "On" and "off" toggle switch and circuit protector, to disconnect the dc supply to its motor and provide overload and short-circuit protection.
5. 120 V ac LED to display battery system power level.
6. Battery voltage meter to show battery condition.
7. Local and Remote Selector: In the "local" position remote operation of the switches is disabled and is possible only under the control of switchgear-mounted push buttons.

D. Overcurrent and Control Relays: Field-adjustable microprocessor electronic relays in each phase at indicated locations. Provide for current adjustment from 0 to 600 A.

1. Device Functions: 51/50, 51N/50N, or 51G/50G according to IEEE C37.2.

a. Device Functions: As directed.

2.8 POWER SUPPLY

A. The power supply for instrumentation, communications, and switch operations shall be for connection to two 120 V ac power sources, controlled by an automatic transfer switch to connect to the alternate supply when the primary supply has failed.

B. The power supply for instrumentation, communications, and switch operations shall be from a potential transformer installed as part of the switchgear.

C. Dedicated As directed, 48 V dc, 120 V dc or 240 V dc battery system.
1. System Requirements: Battery shall have number of cells and ampere-hour capacity based on an initial specific gravity of 1.210 at 25 deg C with electrolyte at normal level and minimum ambient temperature of 13 deg C. Cycle battery before shipment to guarantee rated capacity on installation. Arrange to operate ungrounded. Battery system capacity shall be as recommended by switchgear manufacturer to operate the circuit breakers for intended duty.
2. Battery:

a. As directed, Standard VRLA or Premium VRLA batteries, with system disconnect and overcurrent protective device.
b. Rack: Two-step rack with electrical connections between battery cells and between rows of cells; include two flexible connectors with bolted-type terminals for output leads. Rate battery rack, cell supports, and anchorage for seismic requirements.

c. Accessories:

1) Set of cell numerals.
2) Monitoring system.

d. Charger: Static-type silicon rectifier equipped with automatic regulation and provision for manual and automatic adjustment of charging rate. Unit shall automatically maintain output voltage within 0.5 percent from no load to rated charger output current, with ac input-voltage variation of plus or minus 10 percent and input-frequency variation of plus or minus 3 Hz.

1) DC ammeter.
2) DC Voltmeter: Maximum error of 5 percent at full-charge voltage, with toggle switch to select between battery and charger voltages.
3) Ground Indication: Two appropriately labeled lights to indicate circuit ground, connected in series between negative and positive terminals, with midpoint junction connected to ground by NO push-button contact.
4) Capacity: Sufficient to supply steady load, float-charge battery between 2.20 and 2.25 V per cell and equalizing charge at 2.33 V per cell.
5) Charging-Rate Switch: Manually operated switch to transfer to higher charging rate. Charger operation shall be automatic until manually reset.
6) AC Power Supply: 120 V, 60 Hz, subject to plus or minus 10 percent variation in voltage and plus or minus 3-Hz variation in frequency. Automatic charger operation shall resume after loss of ac power supply for any interval.
7) Charging Regulator: Protect charger from damage due to overload, including short circuit on output terminals. The device shall regulate charging current but shall not disconnect charger from either battery or ac supply.
8) Charger's Audible Noise: Less than 26 dB.

3. Battery Ground-Fault Detector: Initiates alarm when resistance to ground of positive or negative bus of battery is less than 5000 ohms.
4. Control Wiring: Factory installed, complete with bundling, lacing, and protection.

a. Conductors across Hinges and for Interconnections between Shipping Units: Flexible conductors for No. 8 AWG and smaller.
b. Conductors: Sized according to NFPA 70 for duty required.

5. An automatic transfer switch to connect the alternate power supply when the primary power supply has failed.

2.9 CONTROL NETWORK

A. Compliance with ASHRAE 135: Controllers shall support serial MS/TP and Ethernet IP communications and shall be able to communicate directly via RS-485 serial networks and Ethernet 10Base-T networks as a native device.

B. Support DNP3 protocol remote control commands received from the SCADA master stations that control switch operations. Comply with the requirements of IEEE 1815.

2.10 BUSHINGS

A. Separable insulated connectors shall be used to connect primary cable. Comply with requirements in Section 260513 "Medium-Voltage Cables."

1. Bushings: One-piece, 600 A, BIL ratings the same as the connectors. Comply with IEEE 386.
2. Supply a standoff bracket or parking stand for each bushing, mounted horizontally adjacent to each bushing.

2.11 SURGE ARRESTERS

A. Distribution class; metal-oxide-varistor type, fully shielded, separable elbow type, suitable for plugging into the inserts. Comply with IEEE C62.11 and IEEE 386.

1. Nominal System Line-to-Line Voltage: As directed.
2. Maximum Continuous Operating Voltage: As directed.
3. Duty-Cycle Voltage: As directed.

2.12 WARNING LABELS AND SIGNS

A. Comply with requirements in Section 260553 "Identification for Electrical Systems" for labels and signs.

1. High-Voltage Warning Label: Self-adhesive warning labels on the outside of the high-voltage compartment door(s). Legend shall be "DANGER HIGH VOLTAGE" printed in two lines of minimum 2-inch (50 mm) high letters. The word "DANGER" shall be in white letters on a red background and the words "HIGH VOLTAGE" shall be in black letters on a white background.
2. Arc-Flash Warning Label: Self-adhesive labels on the outside of the high-voltage compartment door(s), warning of potential electrical arc-flash hazards and appropriate personal protective equipment required.

2.13 SOURCE QUALITY CONTROL

A. Factory Tests: Comply with requirements in IEEE C37.60 and IEEE C37.74 for testing procedures.

1. Circuit Resistance Test: Verify that switchgear contacts have been properly aligned and current transfer points have been properly assembled.
2. Power-frequency dry withstand voltage test.
3. Dielectric withstand test; one-minute dry power-frequency.
4. Calibrate overcurrent devices for conformance to published time-current characteristic curves.
5. Sealed Tank Leak Test:

    a. Comply with IEC 62271-1 for test procedure for switchgear using SF6.
    b. The test procedure for vacuum switchgear shall be as follows:

1) Each vacuum tube shall be identified by its serial number. Its vacuum pressure level shall be tested by the manufacturer of the vacuum interrupter. Document the test results.
2) After assembly of the switchgear way, test the vacuum pressure level of the vacuum tubes by the routine dielectric test across the open contacts. The test voltage shall be stated by the manufacturer. The dielectric test shall be carried out after the mechanical routine test.

6. Operating tests shall verify the following:

a. Switch position indicators and contacts are in the correct position for both the open and closed positions.
b. Insulating medium quantity indicator (if provided) is functioning properly.
c. Circuit configuration is shown correctly.
d. Mechanical interlocks are in place and operative.
e. Position and polarity of current transformers meets requirements.
f. Control, secondary wiring, and accessory devices are connected correctly.
g. Devices and relays actually operate as intended. Circuits for which operation is not feasible shall be checked for continuity.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Upon delivery of switchgear and prior to unloading, inspect equipment for damage.

B. Handle switchgear, according to manufacturer's recommendations; avoid damage to the enclosure, termination compartments, base, frame, and internal components. Do not subject switchgear to impact, jolting, jarring, or rough handling.

C. Switchgear may be stored outdoors. If possible, store switchgear at final installation locations on concrete pads. If dry concrete surfaces are not available, use pallets of adequate strength to protect switchgear from direct contact with the ground. Ensure switchgear is level.

3.2 SWITCHGEAR INSTALLATION

A. Comply with NECA 1.

B. Equipment Mounting:

1. Install switchgear on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."

C. Install level and plumb, tilting less than 1.5 degrees when energized.

D. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

E. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and IEEE C2.

3.3 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Terminate medium-voltage cables in incoming section of switchgear according to Section 260513 "Medium-Voltage Cables."

3.4 SIGNS AND LABELS

A. Comply with the installation requirements for labels and signs specified in Section 260553 "Identification for Electrical Systems."

B. Install warning signs as required to comply with OSHA 29 CFR 1910.269.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: As directed, Owner will engage or Engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for each of the following NETA categories:

    a. Switchgear.
    b. Circuit breakers.
    c. Protective relays.
    d. Instrument transformers.
    e. Metering and instrumentation.
    f. Ground-fault systems.
    g. Battery systems.
    h. Surge arresters.
    i. Capacitors.

C. Switchgear will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.6 SYSTEM FUNCTION TESTS

A. System function tests shall prove the correct interaction of sensing, processing, and action devices. Perform system function tests after "Field Quality Control" tests have been completed and all components have passed specified tests.

1. Develop test parameters and perform tests for evaluating performance of integral components and their functioning as a complete unit within design requirements and manufacturer's published data.
2. Verify the correct operation of interlock safety devices for fail-safe functions in addition to design function.
3. Verify the correct operation of sensing devices, alarms, and indicating devices.

3.7 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain systems.

END OF SECTION 261329

SECTION 262213 - LOW-VOLTAGE DISTRIBUTION TRANSFORMERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes distribution, dry-type transformers with a nominal primary and secondary rating of 600 V and less, with capacities up to 1500 kVA.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
3. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for transformers, accessories, and components, from manufacturer.

B. Source quality-control reports.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Transformers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the transformer will remain in place without separation of any parts when subjected to the seismic forces specified and the transformer will be fully operational after the seismic event."

2.3 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Comply with NFPA 70.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

C. Transformers Rated 15 kVA and Larger:

1. Comply with 10 CFR 431 (DOE 2016) efficiency levels.
2. Marked as compliant with DOE 2016 efficiency levels by an NRTL.

D. Encapsulation: Transformers smaller than 30 kVA shall have core and coils completely resin encapsulated.

E. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.

F. Coils: Continuous windings without splices except for taps.

1. Coil Material: Aluminum or Copper.
2. Internal Coil Connections: Brazed or pressure type.
3. Terminal Connections: As directed, Welded or Bolted.

G. Shipping Restraints: Paint or otherwise color-code bolts, wedges, blocks, and other restraints that are to be removed after installation and before energizing. Use fluorescent colors that are easily identifiable inside the transformer enclosure.

2.4 DISTRIBUTION TRANSFORMERS

A. Comply with NFPA 70, and list and label as complying with UL 1561.

B. Provide transformers that are constructed to withstand seismic forces specified in Section 260548.16 "Seismic Controls for Electrical Systems."

C. Cores: One leg per phase.

D. Enclosure: As directed, Ventilated or Totally enclosed, nonventilated.

1. As directed, NEMA 250, Type 2, Type 3R or Type 4X, Stainless Steel: Core and coil shall be encapsulated within resin compound using a vacuum-pressure impregnation process to seal out moisture and air.
2. KVA Ratings: Based on convection cooling only and not relying on auxiliary fans.
3. Wiring Compartment: Sized for conduit entry and wiring installation.

E. Enclosure: As directed, Ventilated or Totally enclosed, nonventilated.

1. As directed, NEMA 250, Type 3R or Type 4X, Stainless Steel: Core and coil shall be encapsulated within resin compound, sealing out moisture and air.
2. Wiring Compartment: Sized for conduit entry and wiring installation.

F. Taps for Transformers 3 kVA and Smaller: As directed, None or One 5 percent tap above normal full capacity.

G. Taps for Transformers 7.5 to 24 kVA: As directed, one 5 percent tap above and one 5 percent tap below normal full capacity or Two 5 percent taps below rated voltage.

H. Taps for Transformers 25 kVA and Larger: As directed, Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity or Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity.

I. Insulation Class, Smaller Than 30 kVA: 180 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.

J. Insulation Class, 30 kVA and Larger: As directed, 220 deg C, UL-component-recognized insulation system with a maximum of 150, 115 or 80 deg C rise above 40 deg C ambient temperature.

K. Grounding: Provide ground-bar kit or a ground bar installed on the inside of the transformer enclosure.

L. Wall Brackets: Manufacturer's standard brackets or Wall brackets fabricated from design drawings signed and sealed by a licensed structural engineer.

2.5 IDENTIFICATION

A. Nameplates: Engraved, laminated-acrylic or melamine plastic signs for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 260553 "Identification for Electrical Systems."

B. Nameplates: Self-adhesive label for each distribution transformer. Self-adhesive labels are specified in Section 260553 "Identification for Electrical Systems."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

E. Environment: Enclosures shall be rated for the environment in which they are located. Covers for NEMA 250, Type 4X enclosures shall not cause accessibility problems.

3.2 INSTALLATION

A. Install wall-mounted transformers level and plumb with wall brackets fabricated by transformer manufacturer or from design drawings signed and sealed by a licensed structural engineer as directed.

1. Coordinate installation of wall-mounted and structure-hanging supports with actual transformer provided.

B. Install transformers level and plumb on a concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.

C. Construct concrete bases according to Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" and anchor floor-mounted transformers according to manufacturer's written instructions, seismic codes applicable to Project, and requirements in Section 260529 "Hangers and Supports for Electrical Systems."

1. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

D. Secure transformer to concrete base according to manufacturer's written instructions.

E. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.

F. Remove shipping bolts, blocking, and wedges.

3.3 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

D. Provide flexible connections at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Small (Up to 167-kVA Single-Phase or 500-kVA Three-Phase) Dry-Type Transformer Field Tests:

1. Visual and Mechanical Inspection.

    a. Inspect physical and mechanical condition.
    b. Inspect anchorage, alignment, and grounding.
    c. Verify that resilient mounts are free and that any shipping brackets have been removed.
    d. Verify the unit is clean.
    e. Perform specific inspections and mechanical tests recommended by manufacturer.
    f. Verify that as-left tap connections are as specified.
    g. Verify the presence of surge arresters and that their ratings are as specified.

2. Electrical Tests:

    a. Measure resistance at each winding, tap, and bolted connection.
    b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: the value of the index shall not be less than 1.0.
    c. Perform turns-ratio tests at all tap positions. Test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If test fails, replace the transformer.
    d. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

E. Remove and replace units that do not pass tests or inspections and retest as specified above.

F. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.5 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 262213

SECTION 262216 - LOW-VOLTAGE BUCK-BOOST TRANSFORMERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes buck-boost, dry-type transformers with primaries and secondaries rated 600 V and less.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
3. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for transformers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Certification: Indicate that equipment meets Project or equipment seismic requirements.

B. Source quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Transformers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the transformer will remain in place without separation of any parts when subjected to the seismic forces specified and the transformer will be fully operational after the seismic event."

2.3 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Comply with NFPA 70.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

C. Energy Efficiency:

1. Comply with 10 CFR 431 (DOE 2016) efficiency levels.
2. Marked as compliant with DOE 2016 efficiency levels by an NRTL.

2.4 BUCK-BOOST TRANSFORMERS

A. Description: Self-cooled, two-winding dry type, rated for continuous duty and with wiring terminals suitable for connection as autotransformer.

1. Transformers shall be listed and labeled as complying with UL 1561.

B. Standard Impedance at 60 Hz: 2 to 5 percent (up to 10 kVA), 4 to 6.5 percent (above 10 kVA).

C. Nameplate Rating: Linear load, 60 Hz.

D. Insulation Class: 220 deg C or 200 deg C system.

E. Temperature Rise: As directed, 150 deg C, 130 deg C, 115 deg C or 80 deg C.

F. Core Construction: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.

1. Grounded to enclosure.

G. Coil Conductors: As directed, Continuous aluminum or copper windings, with terminations brazed, welded, or bolted.

H. Encapsulation: Transformers shall have core and coils completely resin encapsulated.

I. Terminations: Transformer coils shall terminate in mounting pads. Mounting lugs shall be provided on all units up to and including 270-A ratings.

J. Antivibration pads or isolators shall be used between the transformer core and coil and the enclosure.

K. Ground core and coil assembly to enclosure with a flexible copper grounding strap or equivalent.

L. Mounting:

1. Ventilated Units up to 750 lb (340 kg): Suitable for wall, floor, or ceiling mounting (drip plate required).
2. Ventilated Units over 750 lb (340 kg): Suitable for floor mounting only.
3. Encapsulated Units up to 285 lb (130 kg): Suitable for wall or floor mounting.
4. Encapsulated Units over 285 lb (130 kg): Suitable for floor mounting only.

M. Seismic: Floor-mounted units comply with "Earthquake Loads" Section of the International Building Code with site-specific parameters of Occupancy Category III and Site Profile Type SD with seismic forces defined as Spectral Acceleration for Short Periods equal to 1.0 g.

N. Enclosure:

1. As directed, Ventilated or Totally enclosed, non-ventilated.
2. As directed, NEMA 250, Type 2, NEMA 250, Type 3R, NEMA 250, Type 4, NEMA 250, Type 4X or NEMA 250, Type 12.

2.5 IDENTIFICATION

A. Nameplates: Engraved, laminated-acrylic or melamine plastic signs for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 260553 "Identification for Electrical Systems."

B. Nameplates: Self-adhesive label for each distribution transformer. Self-adhesive labels are specified in Section 260553 "Identification for Electrical Systems."

2.6 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.01 and IEEE C57.12.91.

1. Resistance measurements of all windings at rated voltage connections and at all tap connections.
2. Ratio tests at rated voltage connections and at all tap connections.
3. Phase relation and polarity tests at rated voltage connections.
4. No load losses, and excitation current and rated voltage at rated voltage connections.

5. Impedance and load losses at rated current and rated frequency at rated voltage connections.
6. Applied and induced tensile tests.
7. Regulation and efficiency at rated load and voltage.
8. Insulation-Resistance Tests:

    a. High-voltage to ground.
    b. Low-voltage to ground.
    c. High-voltage to low-voltage.

9. Temperature tests.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

E. Environment: Enclosures shall be rated for the environment in which they are located. Covers for NEMA 250, Type 4X enclosures shall not cause accessibility problems.

F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install wall-mounted transformers level and plumb with wall brackets fabricated by transformer manufacturer or from design drawings signed and sealed by a licensed structural engineer.

B. Install transformers level and plumb on a concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.

C. Construct concrete bases according to Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" and anchor floor-mounted transformers according to manufacturer's written instructions, seismic codes applicable to Project, and requirements in Section 260529 "Hangers and Supports for Electrical Systems."

D. Secure transformer to concrete base according to manufacturer's written instructions.

E. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.

3.3 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

D. Provide flexible connections at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.

3.4 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 262216

SECTION 262300 - LOW-VOLTAGE SWITCHGEAR

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes metal-enclosed, low-voltage switchgear, with drawout power circuit breakers and metering and control accessories.

1. Switchgear structure.
2. Requirements for indoor switchgear.
3. Circuit breakers.
4. Surge suppression.
5. Control power supply, 120-V ac.
6. Control power supply, 24-V dc.
7. Instrumentation and control.
8. Identification.
9. Source quality control.

B. Related Requirements:

1. Section 230923.13 "Energy Meters" for electricity meters for HVAC equipment.
2. Section 262713 "Electricity Metering" for equipment to meter electricity consumption and demand for submetering.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

C. Shop Drawings: For low-voltage switchgear.

1. System Power One-Line Diagrams: Depict power sources, feeders, distribution components, and major loads. Include as-built data for low-voltage power switchgear and connections.
2. Include plans, elevations, sections, shipping splits, and mounting details.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices used. Describe characteristics of network and other data communication lines.
5. Indicate short-time and short-circuit current rating of switchgear assembly.

6. Include features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
7. Include mimic-bus diagram.

D. Delegated-Design Submittal: For low-voltage switchgear.

1. Comply with Section 260572 "Overcurrent Protective Device Short-Circuit Study" and Section 260573.16 "Coordination Studies."
2. For the differential ground-fault protection scheme, include wiring diagram of the differential system along with test procedure recommended by UL 1558, using high-current injection equipment.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans showing dimensioned layout, required working clearances, and required area above and around the low-voltage switchgear where pipe and ducts are prohibited.

B. Seismic Qualification Data: Certificates, for switchgear, accessories, and components, from manufacturer.

C. Product test reports.

D. Source quality-control reports.

E. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

B. Software and firmware operational documentation.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 SYSTEM DESCRIPTION

A. Description: Metal-enclosed, low-voltage switchgear with drawout fused or fused, where indicated, power circuit breakers, with accessories and metering components.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with IEEE C37.20.1.

D. Listed and labeled as complying with UL 1558.

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Switchgear shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the assembly will remain in place without separation of any parts when subjected to the seismic forces specified and the assembly will be fully operational after the seismic event."
2. Component Importance Factor: As directed, 1.5 or 1.0.

B. Capacities and Characteristics:

1. Nominal System Voltage: As directed, 480 V, three, 480/277 V, four, 240 V, three or 208/120 V, four wire, 60 Hz.
2. Rated Insulation Level: Power frequency withstand shall be not less than 2.2-kV rms.
3. Rated Main-Bus Continuous Current: As directed, 1600, 2000, 3000, 3200, 4000 or 5000 A.
4. Rated Short-Circuit Withstand Current: As directed, 42,000, 65,000, 85,000, 100,000 or 200,000 A symmetrical.
5. Short-Time and Short-Circuit Current: Match rating of integrated short-circuit current rating.

2.4 SWITCHGEAR STRUCTURE

A. Allow circuit-breaker functions to be performed when the compartment door is closed.

B. Install instrument compartments when additional space is required for metering and instrumentation. Allow for routing of instrumentation, control and communications wires, and cables.

C. Switchgear Bus:

1. Use bus bars to connect compartments and vertical sections. Cable connections are not permitted.
2. Main Phase Bus: Uniform capacity the entire length of assembly.
3. Neutral Bus: As directed, 50 or 100 percent of phase-bus ampacity unless otherwise indicated. Equip bus with pressure-connector terminations for outgoing circuit neutral conductors.
4. Ground Bus: Uniform capacity the entire length of assembly, with pressure connector terminations for feeder and branch-circuit ground conductors, minimum size 1/4 by 2 inches (6 by 50 mm).
5. Bus Material and Connections:

    a. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent minimum conductivity, with copper feeder circuit-breaker line connections.
    b. Use copper for connecting circuit-breaker line to copper bus.
    c. Contact Surfaces of Buses: Silver plated.
    d. Feeder Circuit-Breaker Load Terminals: Silver-plated copper bus extensions equipped with pressure connectors for outgoing circuit conductors.

6. Neutral Disconnect Link: Bolted, uninsulated, bus, arranged to connect neutral bus to ground bus.

D. Circuit-Breaker Compartment:

1. Drawout Features: Circuit-breaker mounting assembly equipped with a racking mechanism to position circuit breaker and hold it rigidly in connected, test, disconnected, and withdrawn positions. Include the following features:

    a. Provide circuit-breaker racking system with positive stops at connected, test, disconnected, and withdrawn positions.
    b. Circuit-Breaker Positioning: Permit the racking of an open circuit breaker to or from connected, test, and disconnected positions only when the compartment door is closed unless live parts are covered by a full dead-front shield. Permit manual withdrawal of an open circuit breaker to a position for removal from the structure.
    c. Primary Disconnect: Mount on the stationary part of the compartment. Disconnect shall consist of a set of contacts extending to the rear through an insulating support barrier, and of corresponding moving finger contacts on the power circuit-breaker studs, which engage in only the connected position. Assembly shall provide multiple silver-to-silver full floating, spring-loaded, high-pressure-point contacts with uniform pressure on each finger. Load studs shall connect to bus extensions that terminate in solderless terminals in the rear cable compartment.
    d. Secondary Disconnect: Floating terminals mounted on the stationary part of the compartment that engage mating contacts at the front of breaker.
    e. Provide a verification of positive ground contact between the circuit breaker and its compartment when the accessory cover is removed while the circuit breaker is in connected, test, disconnected, and withdrawn positions.

E. Enclosure Rating: Indoor.

F. Enclosure Material: Steel.

G. Enclosure Finish: IEEE C37.20.1, manufacturer's standard gray finish over a rust-inhibiting primer on phosphatizing-treated metal surfaces.

H. Enclosure Rear Panels: Removable and hinged, to allow access to rear interior of switchgear.

2.5 CIRCUIT BREAKERS

A. Drawout type, unfused, power operated, with electromechanical or electronic trip devices. Comply with IEEE C37.13, IEEE C37.13a, and UL 1066.

B. Ratings: For continuous, interrupting, and short-time current ratings for each circuit breaker; voltage and frequency ratings same as switchgear. Comply with IEEE C37.16.

C. Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with the following features:

1. Normal Closing Speed: Independent of both control and operator.
2. Slow Closing Speed: Optional with operator for inspection and adjustment.
3. Stored-Energy Mechanism: Manually charged, Electrically charged or Electrically charged, and the operator's choice of manual charging as directed.
4. Operation counter.

D. Operator Display: Located on the face of the circuit breaker.

1. Electrical operation buttons to open and close the circuit breaker. Provide a clear lockable cover over the buttons.
2. Indicating Lights: To indicate circuit breaker is open or closed. An energized or hot condition shall be indicated by a red light. The de-energized, open, and safe condition shall be indicated by a green light.
3. Provide a "charged-not OK to close" indicator when closing springs are charged but circuit breaker is not ready to close.

E. Overcurrent Protective Tripping: Microprocessor-based, programmable, time-current shaping adjustments; complete with current transformers and sensors and the following features:

1. Programmable functions independent of each other in both action and adjustment.

    a. Long-time setting.
    b. Long-time-delay with selectable I2T or I4T curve shaping.
    c. Short-time setting.
    d. Short-time-delay with flat or selectable I2T curve shaping.
    e. Instantaneous trip.

2. Field-adjustable, time-current characteristics.
3. Current Adjustability: Dial settings and rating plugs on trip units, or sensors on circuit breakers, or a combination of these methods.
4. Three bands, minimum, for long-time- and short-time-delay functions; marked "minimum," "intermediate," and "maximum."
5. Pickup Points:

a. Five minimum, for long-time- and short-time-trip functions. Equip short-time-trip function for switchable I-squared-T operation.
b. Five minimum, for instantaneous-trip functions.

F. Ground-Fault Protection:

1. Ground-fault protection with at least three short-time-delay settings and three trip-time-delay bands; adjustable current pickup.
2. Trip Indication: Labeled, battery-powered lights or mechanical targets on trip device to indicate type of fault.
3. Test Form: Provide each ground-fault relay with information sheets describing system-testing instructions, and with a test form; comply with UL 1558.

G. Undervoltage Trip Devices: Instantaneous, with adjustable pickup voltage.

H. Undervoltage Trip Devices: Adjustable time-delay and pickup voltage.

I. Shunt-Trip Devices.

J. Metering:

1. Accuracy: As directed, 0.5 or 1.0 percent of reading, complying with ANSI C12.20.
2. Values shall be rms average over a period of one second.

K. Auxiliary Contacts:

1. Contacts and switches required for normal circuit-breaker operation, sufficient for interlocking and remote indication of circuit-breaker position.
2. Spare auxiliary switches, at least two, unless otherwise indicated. Each switch shall consist of two Type A and two Type B contacts wired through secondary disconnect devices to a terminal block in stationary circuit-breaker compartment.

L. Arc Chutes: Readily removable from associated circuit breaker when it is in disconnected position and arranged to permit inspection of contacts without removing circuit breaker from switchgear.

M. Padlocking Provisions: For installing at least three padlocks on each circuit breaker to secure its enclosure and prevent movement of drawout mechanism.

2.6 SURGE SUPPRESSION

A. Surge Suppression: Factory installed as an integral part of low-voltage switchgear, complying with UL 1449 SPD, Type 1, with the following features and accessories:

1. Integral disconnect switch.
2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
3. Indicator light display for protection status.
4. Form-C contacts rated at 5-A 250-V ac, one NO and one NC, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on

opening of any current-limiting device. Coordinate with building power monitoring and control system.

5. Surge counter.

2.7 CONTROL POWER SUPPLY, 120-V AC

A. Control Power Transformer: Supply 120-V control circuits through dry-type control power transformers, include secondary disconnect devices.

1. Place transformers larger than 3 kVA in separate compartments at the bottom of the vertical section, including the related primary and secondary fuses.
2. Two control power transformers in separate compartments with necessary interlocking relays; each transformer connected to line side of associated main circuit breaker.

    a. Secondary windings connected through relay(s) to control bus to affect an automatic transfer scheme.
    b. Secondary windings connected through an internal automatic transfer switch to switchgear control power bus.

3. Control Power Fuses: Primary and secondary fuses provide current-limiting and overload protection.

2.8 CONTROL POWER SUPPLY, 24-V DC

A. System Requirements: Battery shall have number of cells and ampere-hour capacity based on an initial specific gravity of 1.210 at 25 deg C with electrolyte at normal level and minimum ambient temperature of 13 deg C. Cycle battery before shipment to guarantee rated capacity on installation. Arrange battery to operate ungrounded. Battery system capacity shall be as recommended by switchgear manufacturer to operate the circuit breakers for intended duty.

B. Battery: As directed, Standard VRLA, Premium VRLA or Vented NiCd, batteries, with battery disconnect and overcurrent protective device.

C. Rack: Two-step rack with electrical connections between battery cells and between rows of cells; include two flexible connectors with bolted-type terminals for output leads. Rate battery rack, cell supports, and anchorage for seismic requirements.

D. Accessories:

1. Thermometers with specific-gravity correction scales.
2. Hydrometer syringes.
3. Set of cell numerals.

E. Charger: Static-type silicon rectifier equipped with automatic regulation and provision for manual and automatic adjustment of charging rate. Unit shall automatically maintain output voltage within 0.5 percent from no load to rated charger output current, with ac input-voltage variation of plus or minus 10 percent and input-frequency variation of plus or minus 3 Hz.

1. DC ammeter.

2. DC Voltmeter: Maximum error of 5 percent at full-charge voltage, with toggle switch to select between battery and charger voltages.
3. Ground Indication: Two appropriately labeled lights to indicate circuit ground, connected in series between negative and positive terminals, with midpoint junction connected to ground by NO push-button contact.
4. Capacity: Sufficient to supply steady load, float-charge battery between 2.20 and 2.25 V per cell, and equalizing charge at 2.33 V per cell.
5. Charging-Rate Switch: Manually operated switch to transfer to higher charging rate. Charger operation shall be automatic until manually reset.
6. AC Power Supply: 120 V, 60 Hz, subject to plus or minus 10 percent variation in voltage and plus or minus 3-Hz variation in frequency. Automatic charger operation shall resume after loss of ac power supply for any interval.
7. Charging Regulator: Protect charger from damage due to overload, including short circuit on output terminals. Device shall regulate charging current but shall not disconnect charger from either battery or ac supply.
8. Charger's Audible Noise: Less than 26 dB.

2.9 INSTRUMENTATION AND CONTROL

A. Power Distribution Equipment shall be web enabled, direct connected to the Local Area Network (LAN) or Intranet.

B. Ethernet Connectivity:

1. Install a multipoint, RS-485 Modbus serial communications network within the switchgear to interconnect all breaker trip units, protective relays, drives, and metering devices equipped with communications.
2. Serial communications network shall be wired to an Ethernet gateway in the switchgear. Gateway shall be web enabled, with integral network port and embedded web server with factory-configured firmware and HTML-formatted web pages for viewing of power monitoring and equipment status information from switchgear devices equipped with digital communication ports.
3. LAN shall consist of a multipoint, RS-485 Modbus serial communication network to interconnect all breaker trip units, protective relays, drives, and metering devices equipped with communications. Serial communication network shall be connected to Ethernet server that functions as a gateway and server, providing data access via 10 Base-T, 100 Base-T, 100 Base-TX or 100 Base FX LAN as directed.
4. Server Configuration:

    a. Initial network parameters set using a standard web browser. Connect via a local operator interface, or an RJ-45 port accessible from front of equipment.
    b. Network server shall be factory programmed with embedded HTML-formatted web pages that are user configurable and that provide detailed communication diagnostic information for serial and Ethernet ports as status of RS-485 network; with internal memory management information pages for viewing using a standard web browser.
    c. Password-protected login, with password administration accessible from the LAN using a standard web browser.
    d. Operating Software: Suitable for local access; firewall protected.

5. All serial communications devices within the equipment shall be addressed at the factory and tested.

C. Instrument Transformers: Comply with IEEE C57.13. Instrument transformers may not be used to power space conditioning equipment associated with outdoor switchgear, of for power to convenience receptacles and lighting.

1. Potential Transformers: Secondary voltage rating of 120 V and NEMA C12.11 Accuracy class of 0.3 with burdens of W, X, and Y.
2. Current Transformers: Burden and Accuracy class suitable for connected relays, meters, and instruments.

D. Power Monitoring: Separately mounted, modular, permanently installed, solid-state, digital I/O multifunction metering instrument for power and energy metering and monitoring, complying with UL 61010-1.

1. Capable of metering four-wire Y, three-wire Y, three-wire delta, and single-phase power systems.
2. Equipped with security lock to protect revenue-related metering from unauthorized and accidental changes.
3. Comply with IEC 60529 degree of protection code of IP65 for the front of meter, and code of IP30 for the body.
4. Overvoltage: Comply with UL 61010-1 overvoltage withstand rating for CAT III.
5. Accuracy: Comply with ANSI C12.20, Class 0.5.
6. Data Link: Ethernet connectivity specified in this article.
7. Meter Physical Characteristics:

    a. Display: Backlit LCD with antiglare and scratch-resistant lens.
    b. Display of Metered Values: One screen to show at least three user-selected values displayed at the same time.

8. Sampling Rate: Continuously sample and record voltage and current at a rate not less than 64 samples per cycle, simultaneously on all voltage and current channels of the meter.
9. Meters:

    a. Instantaneous, rms:

        1) Current: Each phase, neutral and three-phase average.
        2) Voltage: L-L for each phase, L-L three-phase average, L-N each phase, and L-N three-phase average.
        3) Active Power (kW): Each phase and three-phase total.
        4) Reactive Power (kVAr): Each phase and three-phase total.
        5) Apparent Power (kVA): Each phase and three-phase total.
        6) Power Factor: Each phase and three-phase total.

    b. Energy:

        1) Active Energy (kWh): Three-phase total.

    c. Demand, Derived from Instantaneous rms Meters:

1) Current: Present and maximum.
2) Active: Present and maximum.
3) Reactive: Present and maximum.
4) Apparent: Present and maximum.

d. Power Quality Measurements:

1) THD: Current and voltage from measurements simultaneously from the same cycle, as can be calculated from the specified sampling rate.

10. I/O: Two optically isolated digital outputs for KYZ pulsing or control. Output signal characteristics shall be 150 mA at 200 V.

a. KYZ Pulse: Generate standard KYZ pulses for a user-defined increment of metered active energy as follows:

1) User-defined pulse output, associated with kWh.
2) User-defined pulse output, associated with kVArh.

11. Capacities and Characteristics:

a. Circuit Connections:

1) Voltage: Measurement autoranging, 60- to 400-V ac L-N. Connect directly to low-voltage (600 V and less) without using voltage transformers. Connect to instrument-grade potential transformers secondary at 120 V. Meter impedance shall be 2 Mohms L-L or greater.
2) Overload Tolerance: 1500-V ac, rms, continuously.
3) Current: Connect to instrument-grade current transformer with a metering range of 5 mA to 6 A. Overcurrent tolerance of the instrument shall be 10 A continuous, 50 A for 10 seconds once per hour, and 120 A for one second per hour.
4) Frequency: 45 to 65 Hz.
5) Time: Input from a GPS receiver to synchronize the internal clock of the instrument and to time-synchronize this instrument with the network to a deviation of not greater than 1 ms.

2.10 POWER TRANSFER CONFIGURATIONS

A. Factory-installed and -tested controls of circuit breakers to accomplish automatic transfer controls for switchgear having two power sources.

B. Relays: Comply with IEEE C37.90, types and settings as indicated; with test blocks and plugs.

C. Control Wiring:

1. Factory installed, complete with bundling, lacing, and protection.
2. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges and for conductors for interconnections between shipping units.
3. Install plugs in control wiring at shipping splits.

D. Two-Breaker Transfer Control:

1. Two-breaker transfer control shall provide for a switchgear assembly with a common load bus and two normally energized medium-voltage power sources, designated "normal" and "standby," connected to the load bus. Circuit breakers connecting the two power sources to the load bus shall be controlled by a microprocessor-based automatic transfer control. Power for the transfer control shall be from the voltage sensing transformers.
2. In automatic mode, the load bus is connected to the normal power source. When the normal source fails, the control shall automatically open the normal power source and close the standby source circuit breaker.
3. Sequence of Operation:

    a. Default operation shall be with the normal source main breaker closed and the standby main breaker open. On detection of an undervoltage to the line side of the normal main breaker and after a field-adjustable time delay, that main breaker shall open and after an additional field-adjustable time delay, the standby breaker shall close restoring power to the facility.
    b. On restoration of voltage to the line side of the normal main breaker and after a field-adjustable time delay, the standby main breaker shall open and after a field-adjustable time delay, the normal main breaker shall close.

4. Field-Adjustable Transfer Parameters:

    a. Delay the transfer from the normal power source to the standby power source and from the standby power source to the normal source. The time delay is to allow the load voltage to decay before reconnecting to another power source. Delay range: zero seconds to 30 minutes.
    b. Delay the initiation of the transfer sequence. The time delay is recommended to override a momentary power outage or voltage fluctuation. Delay range: zero seconds to 120 seconds.
    c. Delay the transfer from the standby power source to the normal power source. Delay range: zero seconds to 30 minutes.
    d. A relay with contact that changes state when the power is available on the normal source and a relay with contact that changes state when the power is available on the standby source.

5. Controls and Indicators: Besides the delay setting controls, provide the following:

    a. Interlocks or relay control to prevent transfer when either of the two controlled circuit breakers are tripped due to overcurrent or ground fault.
    b. Three-position selector switch to select the normal source: Source 1, Source 2, or none.
    c. Transfer-control automatic and manual selector.

        1) Interlock shall prevent paralleling of the two power sources in manual mode.

    d. Open-close control switch for manual electrical operation of each controlled circuit breaker.
    e. Selector to place control into programming mode.

f. Circuit-breaker control switch for each of the normal and standby source breakers, providing open and close operation.
g. Push button to initiate manual retransfer to the normal source when the transfer controller is in automatic mode.
h. Meters and display to show the following:

1) Voltage and frequency of both sources.
2) A multiline display showing the following:

a) Set points of timers, and voltage pickup and dropout set points.
b) Date, time, and reason for at least the last 10 transfers. Display may show the information for one transfer at a time using a scrolling control, with the others held in memory.
c) When the control system is in the transferring process, display shall show delay countdown in seconds.

i. LED indicator lights to show the following:

1) Normal source available.
2) Standby source available.
3) Normal source connected.
4) Standby source connected.
5) Load bus energized.

6. Voltage Transformers: Primary and secondary protection and disconnecting means for sensing functions and control power.
7. Voltage Sensing Relays: Microprocessor-based ANSI No. 27/47 voltage detection relays for three-phase undervoltage protection and negative sequence voltage protection.

E. Three-Breaker Transfer Control:

1. Switchgear assembly, with two normally energized, medium-voltage power sources designated "Main 1" and "Main 2," each connected to its load bus. An NO bus tie circuit breaker can tie the two load buses. Three circuit breakers shall be controlled by a microprocessor-based automatic-transfer control. Power for the transfer control shall be from the voltage sensing transformers.
2. In automatic mode, on loss of voltage to the line side of a source, that main breaker shall open and then the bus tie shall close. On restoration of power to the previously failed main breaker, the bus tie shall open and the open main shall close.
3. Sequence of Operation:

a. Default operation shall be with the main breakers closed and the bus tie breaker open. On detection of an undervoltage to the line side of a main breaker and after a field-adjustable time delay, that main breaker shall open and after an additional field-adjustable time delay, the bus tie breaker shall close, restoring power to the failed bus.
b. On restoration of voltage to the line side of the previously failed main breaker and after a field-adjustable time delay, the tie breaker shall open and after a field-adjustable time delay, the previously failed main breaker shall close.

4. Field-Adjustable Transfer Parameters:

a. Delay the opening of the failed main and closing of the bus tie. The time delay is to allow the load voltage to decay before reconnecting to another power source. Delay range: zero seconds to 30 minutes.
b. Delay the initiation of the transfer sequence. The time delay is recommended to override a momentary power outage or voltage fluctuation. Delay range: zero to 120 seconds.
c. Delay the opening of the bus tie and closing of the previously failed main. The time delay is to allow the bus voltage to decay before reconnecting to another power source. Delay range: zero seconds to 30 minutes.

5. Controls and indicators shall include the following in addition to the delay setting controls:

a. Interlocks or relay control to prevent transfer when any of the three controlled circuit breakers trip due to overcurrent or ground fault.
b. Transfer control automatic and manual selector.

1) Interlock that prevents paralleling of the two mains in manual or automatic mode.

c. Open-close control switch for manual electrical operation of each controlled circuit breaker.
d. Selector shall place control into programming mode.
e. A relay with contact that changes state when the power is available on both mains and a relay with contact that changes state to indicate the open main and when the bus tie is closed.
f. Push button to initiate manual retransfer to the previously failed source when the transfer controller is in automatic mode.
g. Meters and display shall show the following:

1) Voltage and frequency at the line side of both mains.
2) A multiline display shall show the following:

a) Set points of timers, and voltage pickup and dropout set points.
b) Date, time, and reason for at least the last 10 transfers. Display may show the information for one transfer at a time using a scrolling control, with the others held in memory.
c) When the control system is in the transferring process, display shall show delay countdown in seconds.

h. LED indicator lights shall show the following:

1) Each main source available.
2) Each main source unavailable.
3) Each main closed.
4) Each main open.
5) Bus tie open or closed.

6. Voltage transformers shall have primary and secondary protection and disconnecting means for sensing functions and control power.

7. Voltage Sensing Relays: Microprocessor-based ANSI No. 27/47 voltage detection relays for three-phase undervoltage protection and negative-sequence voltage protection.

2.11 DIFFERENTIAL GROUND-FAULT PROTECTION

A. Description: Ground-fault protection system for three-phase, four-wire switchgear having multiple sources shall be devised by manufacturer to insure that the proper main or tie breaker(s) operate properly in normal and emergency conditions. Switchgear shall include additional current transformers, ground-fault relays, interlocks, wiring, and accessories to avoid nuisance tripping of circuit breakers connected to the main bus of the switchgear. Ensure that the following occurs on the main bus:

1. A ground fault at any location in the switchgear shall trip the system.
2. Combination of normal current flow and ground-fault current flow shall trip the system.
3. Circulating currents through the neutral due to multiple grounds and sources external to the immediate low-voltage power sources shall not trip the system.
4. System shall not trip if there is no ground fault, during normal current flow.
5. System shall not trip due to large single-phase currents.

B. Relays: Comply with IEEE C37.90, with test blocks and plugs.

C. Control Wiring:

1. Factory installed, complete with bundling, lacing, and protection.
2. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges and for conductors for interconnections between shipping units.
3. Install plugs in control wiring at shipping splits.

2.12 IDENTIFICATION

A. Compartment Nameplates: As directed, Engraved, laminated-acrylic, Engraved, melamine plastic or Preprinted aluminum signs, as described in Section 260553 "Identification for Electrical Systems," for each compartment, mounted with corrosion-resistant screws.

B. Arc-Flash Warning Labels:

1. Comply with requirements in Section 260573.19 "Arc-Flash Hazard Analysis." Produce a 3.5-by-5-inch (76-by-127-mm) self-adhesive equipment label for each work location included in the analysis.
2. Comply with requirements in Section 260553 "Identification for Electrical Systems." Produce a 3.5-by-5-inch (76-by-127-mm) self-adhesive equipment label for each work location included in the analysis.

2.13 SOURCE QUALITY CONTROL

A. Testing: Test and inspect low-voltage switchgear according to IEEE C37.20.1. Drawout circuit breakers need not be tested in the assembly if they are tested separately.

1. Dielectric Tests: Perform power-frequency withstand tests to demonstrate the ability of the insulation system to withstand the voltages listed in IEEE C37.20.1. The voltage is to be increased gradually from zero to the required test value within 5 to 10 seconds and shall be held at that value for one minute.
2. Perform mechanical operation tests to ensure proper functioning of operating mechanism, mechanical interlocks, and interchangeability of removable elements that are designed to be interchangeable.
3. Test the effectiveness of grounding of each metal-case instrument transformer frame or case.
4. Verify that control wiring is correct by verifying continuity. Perform electrical operation of component devices to ensure that they function properly and in the intended sequence.
5. Perform the control wiring insulation tests.
6. Verify correct polarity of the connections between instrument transformers and meters and relays.

B. All serial communications devices within the equipment shall be addressed at the factory and tested to verify reliable communications to the equipment's Ethernet gateway.

C. Low-voltage switchgear assembly will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install switchgear on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.

B. Comply with requirements for vibration isolation and seismic-control devices specified in Section 260529 "Hangers and Supports for Electrical Systems" and Section 260548.16 "Seismic Controls for Electrical Systems."

C. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

D. Electrical Identification: Comply with requirements in Section 260553 "Identification for Electrical Systems." Produce a 3.5-by-5-inch (76-by-127-mm) self-adhesive equipment label for each work location included in the analysis. Labels shall be machine printed, with no field-applied markings.

3.2 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Terminate all grounding and bonding conductors on a common equipment grounding terminal on the switchgear enclosure. Install supplemental terminal bars, lugs, and bonding jumpers as required to accommodate the number of conductors for termination.

C. Complete switchgear grounding and surge-protector connections prior to making any other electrical connections.

3.3 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Tests and Inspections:

1. Comply with provisions of NFPA 70B, "Testing and Test Methods" Chapter and of NETA ATS.
2. After installing switchgear and after electrical circuitry has been energized, test for compliance with requirements.
3. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
4. Visual and Mechanical Inspection:

    a. Verify that fuse and circuit-breaker sizes and types correspond to Drawings and coordination study, as well as to the circuit breaker's address in the control network.
    b. Verify that current and voltage transformer ratios correspond to Drawings.
    c. Inspect bolted electrical connections for high resistance using one of the following two methods:

        1) Use a low-resistance ohmmeter to compare bolted-connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
        2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.

    d. Confirm correct operation and sequencing of electrical interlock systems.

        1) Attempt closure on locked-open devices. Attempt to open locked-closed devices.
        2) Make key exchange with devices operated in off-normal positions.

e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
f. Inspect insulators for evidence of physical damage or contaminated surfaces.
g. Verify correct barrier and shutter installation and operation.
h. Exercise active components.
i. Inspect mechanical indicating devices for correct operation.
j. Verify that filters are in place and that vents are clear.
k. Perform visual and mechanical inspection of instrument transformers according to "Instrument Transformer Field Tests" Paragraph.
l. Inspect control power transformers.

1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
2) Verify that primary and secondary fuse or circuit-breaker ratings match Drawings.
3) Verify correct functioning of drawout disconnecting and grounding contacts and interlocks.

5. Electrical Tests:

a. Perform dc voltage insulation-resistance tests on each bus section, phase-to-phase and phase-to-ground, for one minute. If the bus temperature is other than plus or minus 20 deg C, adjust the resulting resistance as provided in NETA ATS, Table 100.11.

1) Insulation-resistance values of bus insulation shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's written instructions or NETA ATS, Table 100.1.
2) Do not proceed to the dielectric withstand voltage tests until insulation-resistance levels are raised above minimum values.

b. Perform a dielectric withstand voltage test on each bus section, phase-to-ground with phases not under test grounded, according to manufacturer's published data. If manufacturer has no recommendation for this test, it shall be conducted according to NETA ATS, Table 100.2. Apply the test voltage for one minute.

1) If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.

c. Perform insulation-resistance tests on control wiring for ground. Applied potential shall be 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable. Test duration shall be one minute. For units with solid-state components or control devices that cannot tolerate the applied voltage, follow the manufacturer's written instruction.

1) Minimum insulation-resistance values of control wiring shall not be less than 2 megohms.

d. Control Power Transformers:

1) Perform insulation-resistance tests. Perform measurements from winding-to-winding and each winding-to-ground. Insulation-resistance values of winding insulation shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's written instructions or NETA ATS, Table 100.1.
2) Perform secondary wiring integrity test. Disconnect transformer at secondary terminals and connect secondary wiring to a rated secondary voltage source. Verify correct potential at all devices.
3) Verify correct secondary voltage by energizing the primary winding with system voltage. Measure secondary voltage with the secondary wiring disconnected.
4) Verify correct function of control transfer relays located in the switchgear with multiple control power sources.

e. Voltage Transformers:

1) Perform secondary wiring integrity test. Verify correct potential at all devices.
2) Verify secondary voltages by energizing the primary winding with system voltage.

f. Perform current-injection tests on the entire current circuit in each section of switchgear.

1) Perform current tests by secondary injection with magnitudes such that a minimum 1.0-A current flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.
2) Perform current tests by primary injection with magnitudes such that a minimum 1.0-A current flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.

g. Perform system function tests according to "System Function Tests" Article.
h. Verify operation of space heaters.
i. Perform phasing checks on double-ended or dual-source switchgear to ensure correct bus phasing from each source.

E. Circuit-Breaker Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, and grounding.
c. Verify that all maintenance devices are available for servicing and operating the breaker.
d. Verify the unit is clean.
e. Verify that the arc chutes are intact.
f. Inspect moving and stationary contacts for condition and alignment.

g. Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of the breaker are correct.
h. Perform mechanical operator and contact alignment tests on both the breaker and its operating mechanism according to manufacturer's published data.
i. Verify cell fit and element alignment.
j. Verify racking mechanism operation.
k. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
l. Perform adjustments for final protective-device settings according to coordination study provided by Owner.
m. Record as-found and as-left operation counter readings.

2. Electrical Tests:

a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to ground with switch closed, and across each open pole. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.1. Insulation-resistance values shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Values of insulation resistance less than Table 100.1 or manufacturer's written instructions shall be investigated.
b. Measure contact resistance across each power contact of the circuit breaker. Microhm or dc millivolt drop values shall not exceed the high levels of the normal range as indicated in manufacturer's published data. In the absence of manufacturer's published data, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
c. Determine long-time pickup and delay by primary current injection. Long-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors. If manufacturer's curves are unavailable, trip times shall not exceed the value shown in NETA ATS, Table 100.7.
d. Determine short-time pickup and delay by primary current injection. Short-time pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
e. Determine ground-fault pickup and delay by primary current injection. Ground-fault pickup values shall be as specified, and the trip characteristic shall not exceed manufacturer's published time-current tolerance band.
f. Determine instantaneous pickup value by primary current injection. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.8.
g. Test functions of the trip unit by means of secondary injection. Pickup values and trip characteristic shall be as specified and within manufacturer's published tolerances.
h. Perform minimum pickup voltage tests on shunt trip and close coils according to manufacturer's published data. Minimum pickup voltage of the shunt trip and close coils shall comply with manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.20.
i. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.

j. Verify correct operation of any auxiliary features, such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free operation, antipump function, and trip-unit battery condition. Reset trip logs and indicators. Auxiliary features shall operate according to manufacturer's published data.
k. Verify operation of charging mechanism. Charging mechanism shall operate according to manufacturer's published data.

F. Instrument Transformer Field Tests:

1. Visual and Mechanical Inspection:

a. Verify that equipment nameplate data complies with the Contract Documents.
b. Inspect physical and mechanical condition.
c. Verify correct connection of transformers with system requirements.
d. Verify that adequate clearances exist between primary and secondary circuit wiring.
e. Verify that the unit is clean.
f. Inspect bolted electrical connections for high resistance using one of the following two methods:

1) Use a low-resistance ohmmeter to compare bolted-connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.

g. Verify that required grounding and shorting connections provide contact.
h. Verify correct operation of transformer withdrawal mechanism and grounding operation.
i. Verify correct primary and secondary fuse sizes for voltage transformers.
j. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

2. Electrical Tests of Current Transformers:

a. Perform insulation-resistance test of each current transformer and its secondary wiring for ground at 1000-V dc for one minute. For units with solid-state components that cannot tolerate the applied voltage, follow manufacturer's written instructions. Investigate and correct values of insulation resistance less than manufacturer's written instructions or NETA ATS, Table 100.5.
b. Perform a polarity test of each current transformer according to IEEE C57.13.1. Polarity results shall agree with transformer markings.
c. Perform a ratio-verification test using the voltage or current method according to IEEE C57.13.1. Ratio errors shall be according to IEEE C57.13.

d. Perform an excitation test on transformers used for relaying applications according to IEEE C57.13.1. Excitation results shall match the curve supplied by manufacturer or be according to IEEE C57.13.1.
e. Measure current circuit burdens at transformer terminals according to IEEE C57.13.1. Measured burdens shall be compared to, and shall match, instrument transformer ratings.
f. Perform insulation-resistance tests on the primary winding with the secondary grounded. Test voltages shall be according to NETA ATS, Table 100.5.
g. Perform dielectric withstand tests on the primary winding with the secondary grounded. Test voltages shall be according to NETA ATS, Table 100.9.
h. Perform power-factor or dissipation-factor tests according to test equipment manufacturer's published data.
i. Verify that current transformer secondary circuits are grounded and have only one grounding point according to IEEE C57.13.3. That grounding point should be located as specified by Engineer in Project Drawings.

3. Electrical Tests of Voltage Transformers:

a. Perform insulation-resistance tests, winding-to-winding and winding-to-ground. Test voltages shall be applied for one minute according to NETA ATS Table 100.5. For units with solid-state components that cannot tolerate the applied voltage, follow manufacturer's written instructions. Investigate and correct values of insulation resistance less than manufacturer's written instructions or NETA ATS, Table 100.5.
b. Perform a polarity test on each transformer to verify the polarity marks or H1-X1 relationship as applicable. Polarity results shall agree with transformer markings.
c. Perform a turns-ratio test on all tap positions. Ratio errors shall be according to IEEE C57.13.
d. Measure voltage circuit burdens at transformer terminals. Measured burdens shall be compared to, and shall match, instrument transformer ratings.
e. Perform a dielectric withstand test on the primary windings with the secondary windings connected to ground. Dielectric voltage shall be according to NETA ATS, Table 100.9. Test voltage shall be applied for one minute. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the primary windings are considered to have passed the test.
f. Perform power-factor or dissipation-factor tests according to test equipment manufacturer's published data. Power-factor or dissipation-factor values shall be according to manufacturer's published data. In the absence of manufacturer's published data, use test equipment manufacturer's published data.
g. Verify that voltage transformer secondary circuits are grounded and have only one grounding point according to IEEE C57.13.3. Test results shall indicate that the circuits are grounded at only one point.

G. Ground-Resistance Test:

1. Visual and Mechanical Inspection:

a. Verify that ground system complies with the Contract Documents and with NFPA 70, Article 250, "Grounding and Bonding."

b. Inspect physical and mechanical condition. Grounding system electrical and mechanical connections shall be free of corrosion.
c. Inspect bolted electrical connections for high resistance using one of the following two methods:

1) Use a low-resistance ohmmeter to compare bolted-connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.

d. Inspect anchorage.

2. Electrical Tests:

a. Perform fall-of-potential or alternative test according to IEEE 81 on the main grounding electrode or system. Resistance between the main grounding electrode and ground shall be no more than 5 ohms or maximum ground-resistance value specified in "Examination" Article as directed.
b. Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral, and derived neutral points. Investigate point-to-point resistance values that exceed 0.5 ohms. Compare equipment nameplate data with the Contract Documents.
c. Inspect physical and mechanical condition.
d. Inspect bolted electrical connections for high resistance using one of the following two methods:

1) Use a low-resistance ohmmeter to compare bolted-connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.

H. Metering Devices Field Tests:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect bolted electrical connections for high resistance using one of the following two methods:

1) Use a low-resistance ohmmeter to compare bolted-connection resistance values to values of similar connections. Investigate values that deviate from

those of similar bolted connections by more than 50 percent of the lowest value.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.

c. Inspect cover gasket, cover glass, condition of spiral spring, disk clearance, contacts, and case shorting contacts, as applicable.
d. Verify that the unit is clean.
e. Verify freedom of movement, end play, and alignment of rotating disk(s).

2. Electrical Tests:

a. Verify accuracy of meters at all cardinal points. Meter accuracy shall be according to manufacturer's published data.
b. Calibrate meters according to manufacturer's published data. Calibration results shall be within manufacturer's published tolerances.
c. Verify all instrument multipliers. Instrument multipliers shall be according to system design specifications.
d. Verify that current transformer and voltage transformer secondary circuits are intact. Test results shall confirm the integrity of the secondary circuits of current and voltage transformers.

I. Microprocessor-Based Protective Relay Field Tests:

1. Visual and Mechanical Inspection:

a. Record model number, style number, serial number, firmware revision, software revision, and rated control voltage.
b. Verify operation of LEDs, display, and targets.
c. Record passwords for each access level.
d. Clean the front panel and remove foreign material from the case.
e. Check tightness of connections.
f. Verify that the frame is grounded according to manufacturer's written instructions.
g. Set the relay according to results in Section 260573.16 "Coordination Studies" and in Section 260573.19 "Arc-Flash Hazard Analysis."
h. Download settings from the relay. Print a copy of the settings for the report and compare the settings to those specified in the coordination study.

2. Electrical Tests:

a. Perform insulation-resistance tests from each circuit to the grounded frame according to manufacturer's published data.
b. Apply voltage or current to analog inputs and verify correct registration of the relay meter functions.
c. Check functional operation of each element used in the protection scheme as follows:

1) ANSI No. 2/62, Timing Relay:

a) Determine time delay.
b) Verify operation of instantaneous contacts.

2) ANSI No. 24, Volts/Hertz Relay:

a) Determine pickup frequency at rated voltage.
b) Determine pickup frequency at a second voltage level.
c) Determine time delay.

3) ANSI No. 25, Sync Check Relay:

a) Determine closing zone at rated voltage.
b) Determine maximum voltage differential that permits closing at zero degrees.
c) Determine set points of live line, live bus, dead line, and dead bus.
d) Determine time delay.
e) Verify control functions of dead bus/live line, dead line/live bus, and dead bus/dead line.

4) ANSI No. 27, Undervoltage Relay:

a) Determine dropout voltage.
b) Determine time delay.
c) Determine time delay at a second point on the timing curve for inverse time relays.

5) ANSI No. 32, Directional Power Relay:

a) Determine minimum pickup at maximum torque angle.
b) Determine closing zone.
c) Determine maximum torque angle.
d) Determine time delay.
e) Verify time delay at a second point on the timing curve for inverse time relays.
f) Plot the operating characteristic.

6) ANSI No. 46, Current Balance Relay:

a) Determine pickup of each unit.
b) Determine percent slope.
c) Determine time delay.

7) ANSI No. 46N, Negative Sequence Current Relay:

a) Determine negative sequence alarm level.
b) Determine negative sequence minimum trip level.
c) Determine maximum time delay.
d) Verify two points on the I-two-squared-T curve.

8) ANSI No. 47, Phase Sequence or Phase Balance Voltage Relay:

a) Determine positive sequence voltage to close the NO contact.
b) Determine positive sequence voltage to open the NC contact (undervoltage trip).
c) Verify negative sequence trip.
d) Determine time delay to close the NO contact with sudden application of 120 percent of pickup.
e) Determine time delay to close the NC contact on removal of voltage when previously set to rated system voltage.

9) ANSI No. 50, Instantaneous Overcurrent Relay:

a) Determine pickup.
b) Determine dropout.
c) Determine time delay.

10) ANSI No. 51, Time Overcurrent:

a) Determine minimum pickup.
b) Determine time delay at two points on the time current curve.

11) ANSI No. 64, Ground Detector Relay:

a) Determine maximum impedance to ground causing relay pickup.

12) ANSI No. 67, Directional Overcurrent Relay:

a) Determine directional unit minimum pickup at maximum torque angle.
b) Determine closing zone.
c) Determine maximum torque angle.
d) Plot operating characteristics.
e) Determine overcurrent unit pickup.
f) Determine overcurrent unit time delay at two points on the time current curve.

13) ANSI No. 87, Differential Relay:

a) Determine operating unit pickup.
b) Determine the operation of each restraint unit.
c) Determine slope.
d) Determine harmonic restraint.
e) Determine instantaneous pickup.
f) Plot operating characteristics for each restraint.

d. Control Verification:

1) Functional Tests:

a) Check operation of all active digital inputs.

b) Check output contacts or SCRs, preferably by operating the controlled device, such as circuit breaker, auxiliary relay, or alarm.
c) Check internal logic functions used in protection scheme.
d) On completion of testing, reset minimum/maximum recorders, communications statistics, fault counters, sequence-of-events recorder, and event records.

2) In-Service Monitoring: After the equipment is initially energized, measure magnitude and phase angle of inputs and verify expected values.

J. Ground-Fault Protection Field Tests: Evaluate the interconnected system according to switchgear manufacturer's written instructions.

1. Determine the proper location of the sensors around the bus of the circuit to be protected. This determination may be done visually, with knowledge of which bus is involved.
2. Verify the grounding points of the system to determine that ground paths do not exist that would bypass the sensors. Use high-voltage testers and resistance bridges.
3. Test the installed system for correct response by application of full-scale current into the equipment to duplicate a ground-fault condition, or by equivalent means such as by simulated fault current generated by the following:

a. A coil around the sensors.
b. A separate test winding in the sensors.

4. Record the test results on the test form provided with the instructions provided by manufacturer.

K. DC System VRLA Batteries Field Test:

1. Visual and Mechanical Inspection:

a. Verify that batteries are adequately located.
b. Verify that battery area ventilation system is operable.
c. Verify existence of suitable eyewash equipment.
d. Verify that equipment nameplate data complies with the Contract Documents.
e. Inspect physical and mechanical condition.
f. Verify adequacy of battery support racks, mounting, anchorage, alignment, grounding, and clearances.
g. Verify that the units are clean.
h. Inspect spill containment installation.
i. Verify application of an oxide inhibitor on battery terminal connections.

2. Electrical Tests:

a. Measure charger float and equalizing voltage levels. Adjust to battery manufacturer's recommended levels.
b. Verify charger functions and verify that alarms comply with system manufacturer's written instructions.
c. Measure negative post temperature. This temperature shall comply with manufacturer's published data or IEEE 1188.

d. Measure charger float and equalizing voltage levels. These levels shall be according to battery manufacturer's published data.
e. Measure each monoblock/cell voltage and total battery voltage with charger energized and in float mode of operation. Monoblock/cell voltages shall be according to manufacturer's published data.
f. Measure intercell connection resistances.
g. Perform internal ohmic measurement tests. Cell internal ohmic values (resistance, impedance, or conductance) shall not vary by more than 25 percent between identical cells that are in a fully charged state. Monoblock/cell internal ohmic values (resistance, impedance, or conductance) shall not vary by more than 25 percent between identical monoblocks/cells in a fully charged state.
h. Perform a load test according to manufacturer's published data or IEEE 1188. Replace units that fail to pass the test.
i. Measure the battery system voltage from positive-to-ground and negative-to-ground. Voltage measured from positive-to-ground shall be equal in magnitude to the voltage measured from negative-to-ground.

L. DC System Vented NiCd Batteries Field Test:

1. Visual and Mechanical Inspection:

a. Verify that batteries are adequately located.
b. Verify that battery area ventilation system is operable.
c. Verify existence of suitable eyewash equipment.
d. Verify that equipment nameplate data complies with the Contract Documents.
e. Inspect physical and mechanical condition.
f. Verify adequacy of battery support racks, mounting, anchorage, alignment, grounding, and clearances.
g. Verify electrolyte level. Measure pilot-cell electrolyte temperature and correct as recommended by manufacturer's maintenance procedures to bring the temperature and electrolyte level to within normal limits.
h. Verify that the units are clean.
i. Inspect spill containment installation.
j. Verify application of an oxide inhibitor on battery terminal connections.

2. Electrical Tests:

a. Measure charger float and equalizing voltage levels. Adjust to battery manufacturer's recommended levels.
b. Verify charger functions and verify that alarms comply with system manufacturer's written instructions.
c. Measure each cell voltage and total battery voltage with charger energized and in float mode of operation. Cell voltages shall be within 0.05 V of each other or according to manufacturer's published data.
d. Measure intercell connection resistances.
e. Perform internal ohmic measurement tests. Cell internal ohmic values (resistance, impedance, or conductance) shall not vary by more than 25 percent between identical cells that are in a fully charged state.
f. Perform a load test according to manufacturer's published data or IEEE 1106. Replace units that fail to pass the test.

g. Measure the battery system voltage from positive-to-ground and negative-to-ground. Voltage measured from positive-to-ground shall be equal in magnitude to the voltage measured from negative-to-ground.

M. Switchgear components will be considered defective if they do not pass tests and inspections.

N. Remove and replace defective units and retest.

O. Prepare test and inspection reports. Record as-left set points of adjustable devices.

3.4 SYSTEM FUNCTION TESTS

A. System function tests shall prove the correct interaction of sensing, processing, and action devices. Perform system function tests after field quality-control tests have been completed and all components have passed specified tests.

1. Develop test parameters and perform tests for the purpose of evaluating performance of integral components and their functioning as a complete unit within design requirements and manufacturer's published data.
2. Verify the correct operation of interlock safety devices for fail-safe functions in addition to design function.
3. Verify the correct operation of sensing devices, alarms, and indicating devices.

B. Switchgear will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 FOLLOW-UP SERVICE

A. Voltage Monitoring and Adjusting: After Substantial Completion, but not more than six months after Final Acceptance, and if requested by Owner, perform the following voltage monitoring:

1. During a period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at the outgoing section of each piece of switchgear. Use voltmeters with calibration traceable to NIST standards and with a chart speed of not less than 1 inch (25 mm) per hour. Voltage unbalance greater than 1 percent between phases, or deviation of phase voltage from the nominal value by more than plus or minus 5 percent during the test period, is unacceptable.
2. Corrective Action: If test results are unacceptable, perform corrective action.
3. Retests: Repeat monitoring, after corrective action has been performed, until specified results are obtained.
4. Report: Prepare a written report covering monitoring performed and corrective action taken.

B. Infrared Inspection: Perform the survey during periods of maximum possible loading. Remove covers prior to inspection.

1. After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of the electrical power connections of switchgear.

2. Instrument: Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1 deg C at 30 deg C.
3. Record of Infrared Inspection: Prepare a certified report that identifies the testing technician and equipment used and that lists the results.
4. Act on inspection results according to recommendations in NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Owner's operations permit. Retest until deficiencies are corrected.
5. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.

3.6 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.7 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain switchgear.

END OF SECTION 262300

SECTION 262313 - PARALLELING LOW-VOLTAGE SWITCHGEAR

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Metal-enclosed, low-voltage, circuit-breaker switchgear rated 600 V and less, and associated monitoring and control systems for paralleling standby generators on an isolated bus and for distributing electrical power.

B. Related Requirements:

1. Section 260913 "Electrical Power Monitoring and Control" for interfacing communication and metering requirements.

1.2 DEFINITIONS

A. ATS: Acceptance Testing Specification.

B. DDC: Direct digital control.

C. Legally Required: As used in this Section, it shall have the same meaning as used in NFPA 70.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of paralleling low-voltage switchgear.

1. Include technical data on features, performance, electrical characteristics, ratings, and finishes for programmable logic controllers, instrumentation, control devices, monitoring devices, SCADA interface devices, Ethernet interface, and display components.
2. Include rated capacities, operating characteristics, furnished specialties, factory settings, and accessories for individual circuit breakers.
3. Include time-current characteristic curves for overcurrent protective devices.

B. Shop Drawings: For each type of paralleling low-voltage switchgear.

1. Include tabulation of installed devices with features and ratings.
2. Include enclosure types and details.
3. Detail locations for anchor bolts and leveling channels.
4. Show bus configuration with current rating, size, and number of conductors in each bus run, including phase, neutral, and ground conductors of main and branch buses.
5. Indicate short-time and short-circuit current rating of switchgear assembly.
6. Include features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
7. Detail nameplate legends.
8. Include mimic-bus diagram.

9. Include three-line power wiring diagrams for paralleling low-voltage switchgear, generators, and related equipment showing device terminal numbers.
10. Include point-to-point schematic control, monitoring, and alarm wiring diagrams showing internal component terminal numbers.
11. Include point-to point schematic control, monitoring, and alarm wiring diagrams for external components indicating terminal numbers for the following:

    a. Engine generators.
    b. Transfer switches.
    c. Other load-control devices.
    d. Elevator controller in each elevator bank.
    e. DDC system for HVAC controller.
    f. SCADA remote terminal unit.

C. Sequence of Operation: Description of sequence of operation for paralleling controls in automatic and manual modes.

1.4 INFORMATIONAL SUBMITTALS

A. Source quality-control reports.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Updated mimic bus diagram reflecting field changes after final switchgear load connections have been made, for record.

B. Operation and maintenance data.

1.6 FIELD CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation at indicated ampere ratings for the following conditions:

1. Ambient temperature not exceeding 104 deg F (40 deg C), 122 deg F (50 deg C) or 140 deg F (60 deg C) as directed.
2. Altitude above sea level as directed.

1.7 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace paralleling equipment that fails in materials or workmanship within specified warranty period.

1. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for paralleling low-voltage switchgear, including clearances between paralleling switchgear and adjacent surfaces and other items. Comply with indicated maximum dimensions.

C. The generator paralleling monitoring and control panel in the paralleling low-voltage switchgear shall monitor and control the following standby power system components:

1. Paralleling low-voltage switchgear.
2. Generator monitoring and control system.
3. Generator paralleling monitoring and control systems that are part of the paralleling low-voltage switchgear or located at engine generator as directed.
4. Engine generators.
5. Transfer switches.
6. Circuit breakers downstream of transfer switches.
7. Other load-control devices.
8. Distribution circuit breakers in paralleling low-voltage switchgear.

D. Redundant Standby Power System:

1. Generator with associated generator paralleling monitoring and control system.
2. Black-start controller with no single point of failure.

E. Sequence of Operation for Normal Conditions:

1. Paralleling low-voltage switchgear, including controlled generators, controlled circuit breakers other controlled devices, and transfer switches, shall be in the automatic position and ready to operate on loss of power or other designated initiation conditions.
2. Generator monitoring and control system has not received a "start" signal from the following:

    a. Transfer switch.

F. Sequence of Operation for Loss of Normal Power Conditions:

1. Generator monitoring and control system shall receive a start signal from a redundant system. Start signal may come from a transfer switch or other device directly wired to start engine generator.
2. On receiving a start signal, generator monitoring and control system shall start engine generators and achieve rated voltage and frequency.
3. If engine generator fails to start, after expiration of overcrank time delay, engine generator shuts down and alarm is initiated.

4. Black-Start Control: Prevent out-of-phase paralleling. Inhibit the connection of generator-controlled circuit breakers to the isolated paralleling bus, then close the circuit breaker connecting the first generator to the isolated paralleling bus.

    a. Comply with requirements in applicable engine generator Section for selection of the first engine generator to connect to the isolated paralleling bus.

5. Generator paralleling monitoring and control system synchronizes its associated engine generator and allows closure of generator paralleling low-voltage circuit breakers to the isolated paralleling bus. On closure to isolated paralleling bus, each engine generator assumes its proportional share of total load.
6. Failure of an Engine Generator to Synchronize: If engine generator fails to synchronize, sound an alarm after a preset time delay, but continue to attempt to synchronize the engine generator until signaled to stop by manual operation.

G. Overload Sequence of Operation:

1. Signal to shed loads from generator source may be accomplished by one of the following:

    a. Signaling load-shed relay in a transfer switch associated with the priority load.
    b. Disabling another device.

2. Overload sequence of operation sends signal to shed lowest connected load priority when isolated paralleling bus frequency does not return to normal frequency within its adjustable time period.
3. If isolated paralleling bus does not return to normal frequency after shedding lowest connected priority load within adjustable time period, additional load continues to be shed by signaling to load shed in reverse priority until isolated paralleling bus returns to normal frequency.
4. Loads shed can be reconnected to isolated paralleling bus only by manual reset at human-machine interface.

H. Transfer Switch Return to Normal Condition Sequence of Operation: Enable transfer switch to return to normal power when normal power is available at the transfer switch.

I. Feeder Circuit Breakers in Paralleling Low-Voltage Switchgear Return to Normal Condition Sequence of Operation: When normal power is available at transfer switch served by feeder circuit breaker, open circuit breaker.

J. Circuit Breaker or Other Load Device for Loads Controlled Downstream from Transfer Switch Sequence of Operation: Return circuit breaker or other load device to closed position when transfer switch serving circuit breaker has returned to normal power.

K. Return to Normal Condition Sequence of Operation:

1. Process starts on removal of start signals from system.
2. When no load remains on isolated paralleling bus, all generator breakers open, go through cool-down period, and shut down.
3. If start signal is received during cool-down period, engine generator is reconnected to isolated paralleling bus, and system operation follows that of "loss of normal power."

L. Comply with NFPA 110 for the following:

1. Emergency: EPSS Level 1, Type 10.
2. Legally Required Standby: EPSS Level 1, Type 60.
3. Optional Standby: EPSS Level 1, Level 2, Type 10, Type 60, Type 120 or Manual as directed.

M. Comply with NFPA 99 for healthcare applications.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Paralleling low-voltage switchgear shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

B. Source Limitations: Obtain paralleling low-voltage switchgear from same manufacturer as required for engine generator or transfer switches, transfer switches and engine generator as directed.

C. Components and Devices: Factory mount in each single-generator section of the metal-enclosed, paralleling low-voltage switchgear.

1. Paralleling low-voltage switchgear door-mounted control devices shall be industrial oil-type devices. Indicator lamps shall be high-intensity digital display.

D. Control Power: Supply control power from the 24-V dc starting batteries from the controlled generator. Include separate control power battery system rated 24-V dc for any equipment unable to accept the voltage drop that occurs during engine cranking.

E. Programmable Logic Controller: Factory-mounted controller, separate from the multiple-generator paralleling monitoring and control system in each single-generator paralleling monitoring and control module of the metal-enclosed, paralleling low-voltage switchgear.

F. Single-Generator Paralleling Low-Voltage Switchgear Circuit Breaker:

1. Factory mount the circuit-breaker control switch.
2. Paralleling Circuit-Breaker Monitor and Control:

a. Monitors circuit-breaker auxiliary contacts.
b. Initiates fault signal if circuit breaker fails to close within adjustable time-delay period (0.5 to 15 seconds).
c. Trips open and locks out paralleling circuit breaker on paralleling circuit breaker failure to close, until manually reset.

G. Generator Mode Selector Switch: Factory mounted in the single-generator paralleling monitoring and control system module of the metal-enclosed, paralleling low-voltage switchgear.

1. "Lockout/Reset" mode prevents generator from starting or immediately shuts down generator if running.
2. "Off/Cool-Down" mode stops engine after a cool-down period.
3. "Auto" mode allows generator to start on receipt of remote start signal. If the generator is already running and there is not a start signal, then "Auto" mode allows engine to run for predetermined cool-down period before stopping.
4. "Test Off-Line" allows engine to start and run as if a start signal were received, except it does not allow generator to connect to the isolated paralleling bus unless a start signal is received.
5. "Test Online" allows the engine to start, run, and connect to the isolated paralleling bus as if a start signal were received.

H. Engine Generator Controller: Woodward compatible.

1. Factory mount governor (speed control and load sharing) supplied in applicable engine generator Section in single-generator monitoring and control module.
2. Loading control interface to the governor system.
3. Automatic synchronizer.

I. Automatic Synchronizer:

1. Include sync mode selector switch with RUN-OFF-CHECK-PERMISSIVE positions. In RUN mode, enable active synchronization and sync-check function. In CHECK mode, perform the sync-check function. In PERMISSIVE mode, annunciate when generator and bus are synchronized, but do not allow breaker closure.

    a. Include discrete inputs in synchronizer to switch to each mode.

2. Bias the generator speed and voltage to match the paralleling isolated bus.
3. If the automatic synchronizer receives a permissive signal to allow closure to the paralleling isolated bus and the generator is within synchronizing limits, send a close signal to the single-generator paralleling circuit breaker.

J. Sync-switch, removable, keyed T-handle.

K. "Engine Generator Synchronized" Indication: Indicator lamp or digital-display indication of synchronization.

L. Voltage and Frequency Raise and Lower Switches: Allow plus or minus 5 percent adjustment when engine generator is operating but is not connected to the isolated paralleling bus.

M. Control and Reset Push Button: Have flashing lamp to indicate generator is locked out due to fault condition.

N. Lamp Test Push Button: Simultaneously tests all lamps on panel.

O. Control Panel Illumination: DC lamps illuminate panel when lighting from surrounding environment is unavailable.

P. Emergency Stop Push Button: Red mushroom-head switch maintains its position until manually reset.

Q. Alarm and Status Indicating Display:

1. Status and Alarm Indications:

a. Status, Light Only (Nonlatching):

1) Generator mode selector switch not in auto (red).
2) Generator mode selector switch in auto (green).
3) Start signal received (green).
4) Emergency stop activated (red).
5) Demand mode standby (green).
6) Timing for start (green).
7) Timing for shutdown (green).
8) Generator circuit breaker closed (red).
9) Generator circuit breaker open (green).

a) Generator circuit breaker locked out (white).
b) Generator circuit breaker racked out (white).

10) Remote generator breaker is open (red).
11) Engine stopped (green).
12) Time-delay start (green).
13) Engine running (red).
14) Engine cool-down (green).

b. Pre-Alarm, Light and Horn (Non-latching):

1) Pre-high coolant temperature (amber).
2) Pre-low oil pressure (amber).
3) Low coolant temperature (amber).
4) Engine low battery (amber).
5) Battery charger failure (amber).
6) Auxiliary power failure (amber).
7) Low fuel-day tank (amber).
8) Paralleling low-voltage switchgear generator breaker failed to close (amber).
9) Paralleling low-voltage switchgear generator breaker failed to open (amber).
10) Overcurrent alarm (amber).
11) Day tank low-fuel alarm (amber).
12) Ground-fault alarm (amber).

c. Shutdown Alarm, Light and Horn (Latching):

1) Engine overcrank (red).
2) Engine overspeed (red).
3) Engine low oil pressure (red).
4) Engine high coolant temperature (red).
5) Engine low coolant level (red).
6) Engine remote emergency shutdown (red).
7) Generator failed to synchronize shutdown (red).
8) Generator circuit breaker tripped (red).
9) Generator circuit breaker failure (red).

10) Generator not in auto (red).
11) Generator loss of field (red).
12) Generator reverse power (red).
13) Generator undervoltage (red).
14) Generator overvoltage (red).
15) Generator underfrequency (red).
16) Generator over frequency (red).
17) Phase rotation (red).
18) Generator short circuit (red)
19) Day tank low-fuel shutdown (red).
20) Air damper activated, shutdown (red).

R. Paralleling Controls and Protection:

1. Engine Generator Governor (Speed Control and Load Sharing): Comply with requirements in applicable engine generator Section. Components shall be Woodward compatible.
2. Kilowatt Load Sharing Control and Interface:

   a. Operates engine generator governors during synchronizing and provides isochronous load sharing when paralleled.
   b. Allows engine generator to ramp up to kilowatt load level signaled by multiple-generator monitoring and control controller.

3. Load-Demand Governing Control:

   a. Causes engine generator to ramp down at an operator-adjustable rate to zero load when signaled to shut down in load-demand mode.
   b. Causes engine generator to ramp up at an operator-adjustable rate to a proportional share of total isolated paralleling bus load when signaled to restart.

4. Kilovolt-Ampere-Reactive Load Sharing Control:

   a. Operates alternator excitation system while engine generator is paralleled.
   b. Causes sharing of reactive load among engine generators to within 1 percent of equal levels without voltage drop.

5. Paralleling Monitor and Control:

   a. Monitors and verifies that engine generator has reached 90 percent of nominal voltage and frequency before closing to the isolated paralleling bus.
   b. Prevents accidental closure of the breaker with the engine generator out of phase with the bus.
   c. Prevents out-of-phase closure to the isolated paralleling bus due to errant manual or automatic operation of synchronizer.
   d. System of diagnostic digital displays to assist in analyzing synchronization.

6. Synchronizer Control:

   a. Adjusts engine governor to match voltage, frequency, and phase angle of the isolated paralleling bus.

b. Maintains engine generator voltage within 1 percent of the isolated paralleling bus voltage, and phase angle within 20 electrical degrees of the isolated paralleling bus for 0.5 seconds before circuit-breaker closing.
c. Provides "fail-to-synchronize time delay" adjustable from 10 to 120 seconds; with field selectivity to either initiate alarm or shut down engine generator on failure condition.

7. Reverse Power Monitor and Control:

a. Prevents sustained reverse power flow in engine generator.
b. Trips generator paralleling circuit breaker and initiates engine generator shutdown when reverse power condition exceeds 10 percent of engine generator kilowatt for three seconds.
c. Trips generator paralleling circuit breaker and initiates engine generator shutdown when reverse kilovolt-ampere conditions exceeds 20 percent of generator kilovolt-ampere rating.

8. Phase Rotation Monitor and Control: Verifies engine generator and isolated paralleling bus phase rotation match prior to closing paralleling circuit breaker.
9. Electronic Alternator Overcurrent Alarm and Shutdown Control:

a. Monitors current flow at engine generator output terminals.
b. Initiates alarm when load current on engine generator is more than 110 percent of rated current for more than 60 seconds.
c. Overcurrent shutdown function matched to thermal damage curve of alternator.

10. Electronic Alternator Short-Circuit Protection: Shuts down generator, without instantaneous-trip function, when load current is more than 175 percent of rated current and combined time/current approaches thermal damage curve of alternator.
11. Loss of Excitation Monitor: Displays alarm on single-generator paralleling monitoring and control panel when generator controls sense loss of excitation to alternator while paralleled to the isolated paralleling bus.
12. Cool-Down, Time-Delay Control: Adjustable, zero to 600 seconds.
13. Start Time-Delay Control: Adjustable, zero to 300 seconds.
14. Frequency Control: Initiate an alarm condition when engine generator is below 90 percent of rated frequency for more than 20 seconds or is over the frequency.
15. Under- and Overvoltage Control: Initiate an alarm condition when the engine generator is at 90 percent voltage for more than 20 seconds or is over the voltage.

2.3 METAL-ENCLOSED, CIRCUIT-BREAKER SWITCHGEAR (600 V AND LESS)

A. Source Limitations: Obtain paralleling low-voltage switchgear from same manufacturer as required for engine generator, transfer switches or transfer switches and engine generators as directed.

B. Description: Factory assembled and tested and complying with IEEE C37.20.1 and UL 1558.

C. Ratings: Suitable for application in three-phase, 60-Hz, solidly grounded neutral system.

D. Nominal System Voltage: As directed, 480 V, three, 480/277 V, four, 240 V, three or 208/120 V, four wire, 60 Hz.

E. Isolated Paralleling Bus: As directed, 5000, 4000, 3200, 2000 or 1600 A.

1. Phase-, Neutral-, and Ground-Bus Materials:

a. Phase and Neutral Bus: Copper, silver plated at connection points, Copper, tin plated or Aluminum, tin plated as directed.
b. Ground Bus: Copper, silver, tin plated as directed; minimum size 1/4 by 2 inches (6 by 50 mm).

2. Bus bars connect between vertical sections and between compartments. Cable connections are not permitted.

a. Uniform capacity for horizontal and vertical bus.
b. Neutral Bus: As directed, 50 or 100 percent of phase-bus ampacity, except as indicated. As directed, equip bus with pressure-connector terminations for outgoing neutral conductors or Include braces for neutral-bus extensions for busway feeders.
c. Supports and Bracing for Buses: Adequate strength for indicated short-circuit currents.

F. Short-Circuit Current: Match rating of highest-rated circuit breaker in switchgear assembly.

G. Switchgear Fabrication:

1. Bus isolation barriers shall be arranged to isolate line bus from load bus at each main and tie circuit breaker.
2. Circuit-breaker compartments shall be equipped to house drawout-type circuit breakers and shall be fitted with hinged outer doors.
3. Auxiliary Compartments: Match and align with basic switchgear assembly.

a. Bus transition sections.
b. Pull sections.
c. Hinged front panels for access to accessory and blank compartments.
d. Pull box on top of switchgear for extra room for pulling cable, with removable top, front, and side covers; and ventilation provisions adequate to maintain air temperature in pull box within same limits as switchgear.

1) Set pull box back from front to clear circuit-breaker lifting mechanism.
2) Bottom: Insulating, fire-resistive material with separate holes for cable drops into switchgear.
3) Cable Supports: Arranged to ease cabling and adequate to support cables indicated, including those for future installation.

e. Neutral Disconnect Link: Bolted, uninsulated, 1/4-by-2-inch (6-by-50-mm) copper bus, arranged to connect neutral bus to ground bus.
f. Provide for future extensions from either end of main phase, neutral, and ground bus by means of predrilled bolt-holes and connecting links.

g. Bus-Bar Insulation: Individual bus bars wrapped with factory-applied, flame-retardant tape or spray-applied, flame-retardant insulation.

1) Sprayed Insulation Thickness: 3 mils (0.08 mm), minimum.
2) Bolted Bus Joints: Insulate with secure joint covers that can easily be removed and reinstalled.

4. Circuit-Breaker Terminals for Cable Connections: Silver-plated copper bus extensions equipped with pressure connectors for conductors.

H. Circuit Breakers: Comply with IEEE C37.13, IEEE C37.16, and IEEE C37.17.

1. Ratings: As indicated for continuous, interrupting, and short-time current ratings for each circuit breaker; voltage and frequency ratings same as switchgear.
2. Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with the following features:

a. Normal Closing Speed: Independent of both control and operator.
b. Slow Closing Speed: Optional with operator for inspection and adjustment.

3. Stored-Energy Mechanism: Electrically charged, with optional manual charging and operation counter.
4. Trip Devices:

a. Solid-state, overcurrent trip-device system consisting of one or two current transformers or sensors per phase, and a release mechanism.
b. Functions: Long-time-delay, short-time-delay, and instantaneous-trip functions, independent of each other in both action and adjustment.
c. Temperature Compensation: Ensures accuracy and calibration stability from minus 5 to plus 40 deg C.
d. Time-Current Characteristics: Field adjustable.
e. Current Adjustability: Dial settings and rating plugs on trip units or sensors on circuit breakers, or a combination of these methods.
f. Long-Time- and Short-Time-Delay Functions: Three bands, minimum; marked "minimum," "intermediate," and "maximum."
g. Pickup Points: Five minimum, for long-time- and short-time-trip functions. Equip short-time-trip function for switchable I-squared-t operation.
h. Pickup Points: Five minimum, for instantaneous-trip functions.
i. Ground-fault protection alarm with at least three short-time-delay settings and three trip-time-delay bands; adjustable current pickup. Arrange to provide protection for the following:

1) Three-wire circuit or system.
2) Four-wire circuit or system.
3) Four-wire, double-ended substation.

j. Trip Indication: Labeled, battery-powered lights or mechanical targets on trip device to indicate type of fault.

5. Auxiliary Contacts: For interlocking or remote indication of circuit-breaker position, with spare auxiliary switches and other auxiliary switches required for normal circuit-breaker

operation, quantity as indicated. Each consists of two Type "a" and two Type "b" stages (contacts) wired through secondary disconnect devices to a terminal block in stationary housing.

6. Drawout Features: Circuit-breaker mounting assembly equipped with a racking mechanism to position circuit breaker and hold it rigidly in connected, test, and disconnected positions.

    a. Interlocks: Prevent movement of circuit breaker to or from connected position when it is closed.
    b. Circuit-Breaker Positioning:

        1) An open circuit breaker may be racked to or from connected, test, and disconnected positions only with the associated compartment door closed, unless live parts are covered by a full dead-front shield.
        2) An open circuit breaker may be manually withdrawn to a position for removal from the structure with the door open.
        3) Status for connection devices for different positions includes the following:

            a) Test Position: Primary disconnect devices disengaged, and secondary disconnect devices and ground contact engaged.
            b) Disconnected Position: Primary and secondary devices and ground contact disengaged.

7. Arc Chutes: Readily removable from associated circuit breaker when it is in disconnected position; arranged to permit inspection of contacts without removing circuit breaker from switchgear.
8. Padlocking Provisions: For installing at least three padlocks on each circuit breaker to secure its enclosure and prevent movement of drawout mechanism.
9. Operating Handle: One for each circuit breaker capable of manual operation.

    a. Generator Paralleling Circuit Breakers: Interlocked with system control so that circuit breaker does not close unless mode selector switch is in "Auto" position and engine generator is synchronized with the isolated paralleling bus.

10. Electric Close Button: One for each electrically operated circuit breaker.

    a. Generator Paralleling Circuit Breakers: Interlocked with system control so that circuit breaker does not close unless mode selector switch is in "Auto" position and engine generator is synchronized with the isolated paralleling bus.

11. Key Interlocks: Arranged so keys are attached at devices indicated. Mountings and hardware are included where future installation of key-interlock devices is indicated.
12. Undervoltage Trip Devices: Instantaneous, with adjustable pickup voltage.
13. Shunt-Trip Devices:

    a. 24-V dc for generator paralleling circuit breakers and for distribution paralleling switchgear circuit breakers.
    b. Where indicated.

14. Indicating Lights: To indicate circuit breaker is open or closed, for main and bus tie circuit breakers interlocked either with each other or with external devices.

I. Metering:

1. Type and Locations:

a. Isolated Paralleling Bus: Multifunction digital-metering monitor; on door of separate metering compartment.
b. Generator Circuit Breakers: Multifunction digital-metering monitor; on circuit-breaker door.
c. Distribution Circuit Breakers: Multifunction digital-metering monitor; on circuit-breaker door.

2. Instrument Transformers:

a. Comply with IEEE C57.13.
b. Potential Transformers: Secondary-voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.
c. Current Transformers:

1) Burden and accuracy class suitable for connected relays, meters, and instruments.
2) Size for the maximum momentary current amperage based on calculation or the momentary rating of the circuit breaker protecting the conductor.
3) Include shorting-type terminal blocks.

3. Multifunction Digital-Metering Monitor:

a. Microprocessor-based unit suitable for three- or four-wire systems.
b. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.
c. Switch-selectable digital display with the following features:

1) Phase Currents, Each Phase: Plus or minus 1 percent.
2) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
3) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
4) Three-Phase Real Power: Plus or minus 2 percent.
5) Three-Phase Reactive Power: Plus or minus 2 percent.
6) Power Factor: Plus or minus 2 percent.
7) Frequency: Plus or minus 0.5 percent.
8) Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
9) Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

d. Communications module suitable for remote monitoring of meter quantities and functions. Interface communication and metering requirements according to Section 260913 "Electrical Power Monitoring and Control."
e. Mounting: Display and control unit that is flush or semirecessed mounted in instrument compartment door.

J. Relays: Comply with IEEE C37.90, integrated digital type; with test blocks and plugs.

1. Functions: As directed.
2. Characteristics: As directed.

K. Door-Mounted Control Components: Industrial-type oiltight devices and digital-display indicator lamps.

L. Control Power Supply:

1. Control power transformer shall supply 120-V ac control circuits from the generator source through secondary disconnect devices.
2. Include a control power transformer for each generator paralleling switchgear circuit breaker connected to the generator side of the circuit breaker.
3. Include a control power transformer for each distribution paralleling switchgear circuit breaker.
4. Dry-type transformers shall be in separate compartments for units larger than 3 kVA, including primary and secondary fuses.
5. Two control power transformers in separate compartments with necessary interlocking relays; each transformer shall be connected to line side of associated main circuit breaker.

    a. Secondary windings shall be connected through relay(s) to control bus to effect an automatic transfer scheme.
    b. Secondary windings shall be connected through an internal automatic transfer switch to paralleling switchgear control power bus.

6. Control Power Fuses: Primary and secondary fuses shall provide current-limiting and overload protection.

M. Control Wiring:

1. Factory installed, complete with bundling, lacing, and protection.
2. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges and for conductors for interconnections between shipping units.
3. Conductors shall be sized according to NFPA 70 for duty required.

N. Provision for Future Devices: Equip compartments with rails, mounting brackets, supports, necessary appurtenances, and bus connections.

O. Identification: Comply with requirements in Section 260553 "Identification for Electrical Systems" for electrical identification devices and installation.

1. Identify units, devices, controls, and wiring.
2. Mimic Bus: Continuous mimic bus, applied to front of paralleling low-voltage switchgear, arranged in one-line diagram format, using symbols and lettered designations consistent with approved mimic-bus diagram.

    a. Mimic-bus segments coordinated with devices in paralleling low-voltage switchgear sections to which applied, to produce a concise visual presentation of principal paralleling switchgear components and connections.
    b. Medium: Painted graphics, as selected by Architect.
    c. Color: Contrasting with factory-finish background; as selected by Architect from manufacturer's full range.

P. Enclosure Material: Steel.

Q. Access: Fabricate enclosure with hinged, rear cover panels to allow access to rear interior of paralleling low-voltage switchgear.

R. Finish: Manufacturer's standard gray finish over a rust-inhibiting primer on phosphatizing-treated metal surfaces.

S. Accessories:

1. Tools for circuit-breaker and switchgear tests, inspections, maintenance, and operation.
2. Racking handle to manually move circuit breaker between connected and disconnected positions.
3. Portable test set for testing all functions of circuit-breaker, solid-state trip devices without removal from switchgear.
4. Relay and meter test plugs suitable for testing switchgear meters and switchgear class relays.

T. Circuit-Breaker Removal Apparatus: Portable, floor-supported, roller-base, elevating carriage arranged for moving circuit breakers in and out of compartments.

U. Circuit-Breaker Removal Apparatus: Overhead-circuit-breaker lifting device, track mounted at top front of switchgear and complete with hoist and lifting yokes matching each size of draw-out circuit breaker installed.

V. Spare-Fuse Cabinet: Identified and compartmented steel box or cabinet with lockable door.

W. Storage for Manual: Rack or holder, near the operating instructions, for a copy of maintenance manual.

2.4 SOURCE QUALITY CONTROL

A. Testing: Test and inspect paralleling low-voltage switchgear, with generators or generators and transfer switches as directed, at paralleling low-voltage switchgear manufacturer's factory.

1. Paralleling Low-Voltage Switchgear:

a. NETA ATS, 7.6.1.2, "Circuit Breaker, Air, Low-Voltage Power Switchgear."
b. Factory test with simulated inputs. Test control and relay functions for proper operation.

2. Engine Generator:

a. NETA ATS, 7.22.1, "Emergency Systems, Engine Generator."
b. NETA ATS, 7.15.1, "Rotating Machinery, AC Motors & Generator."

3. Automatic Transfer Switches:

a. NETA ATS, 7.22.3, "Emergency System, Automatic Transfer Switches."

B. Verification of Performance: Rate paralleling low-voltage switchgear, with generators or generators and transfer switches as directed, according to operation of functions and features specified.

C. Paralleling low-voltage switchgear, with generators or generators and transfer switches as directed, will be considered defective if it does not pass tests and inspections.

D. Coordinate scheduling of the factory witness test with Architect and Owner. Perform successfully tests prior to witness test.

E. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment Mounting:

1. Install paralleling low-voltage switchgear on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed
2. Comply with requirements for seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."

B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, brackets, and temporary blocking of moving parts from paralleling low-voltage switchgear units and components.

C. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Section 260553 "Identification for Electrical Systems."

D. Diagrams and Instructions:

1. Frame and mount under clear acrylic plastic on front of paralleling low-voltage switchgear.

    a. Operating Instructions: Printed basic instructions for paralleling low-voltage switchgear, including control and key-interlock sequences and emergency procedures.
    b. System Power Riser Diagrams: Depict power sources, feeders, distribution components, and major loads.

2. Storage for Maintenance: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.

E. Comply with grounding and bonding requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

F. Comply with wire and cable requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.2 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each switchgear bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.
3. Inspect paralleling switchgear installation, including wiring, components, connections, and equipment. Test and adjust components and equipment.
4. Complete installation and startup checks according to manufacturer's written instructions.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for each of the following NETA categories:

    a. AC generators and emergency systems.
    b. Switchgear.
    c. Circuit breakers.
    d. Instrument transformers.
    e. Metering and instrumentation.
    f. Ground-fault systems.
    g. Battery systems.
    h. Surge arresters.
    i. Capacitors.

2. Perform NFPA 100 tests for Type 1 essential power systems.

D. Paralleling low-voltage switchgear will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

F. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchgear. Remove front and rear panels so joints and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchgear 11 months after date of Substantial Completion.
2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

3. Record of Infrared Scanning: Prepare a certified report that identifies switchgear checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

G. Test sequence of operation step by step for each mode.

3.3 ADJUSTING

A. Set field-adjustable, electronic circuit-breaker trip characteristics according to results specified in Section 260573.16 "Coordination Studies."

B. Set field-adjustable, electronic circuit-breaker trip characteristics.

3.4 PROTECTION

A. Temporary Heating: Apply temporary heat to paralleling low-voltage switchgear, according to manufacturer's written instructions, throughout periods when paralleling switchgear environment is not controlled for temperature and humidity within manufacturer's stipulated service conditions.

3.5 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain paralleling low-voltage switchgear.

END OF SECTION 262313

SECTION 262413 - SWITCHBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Service and distribution switchboards rated 600 V and less.
2. Surge protection devices.
3. Disconnecting and overcurrent protective devices.
4. Instrumentation.
5. Control power.
6. Accessory components and features.
7. Identification.

1.2 ACTION SUBMITTALS

A. Product Data: For each switchboard, overcurrent protective device, surge protection device, ground-fault protector, accessory, and component.

B. Shop Drawings: For each switchboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Detail short-circuit current rating of switchboards and overcurrent protective devices.
5. Detail utility company's metering provisions with indication of approval by utility company.
6. Include evidence of NRTL listing for series rating of installed devices.
7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
8. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.
9. Include schematic and wiring diagrams for power, signal, and control wiring.

C. Delegated Design Submittal:

1. For arc-flash hazard analysis.
2. For arc-flash labels.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For As directed, Installer or testing agency.

B. Seismic Qualification Data: Certificates, for switchboards, overcurrent protective devices, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.4 Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.

B. Testing Agency Qualifications: Member company of NETA or an NRTL.

1.7 FIELD CONDITIONS

A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.

B. Environmental Limitations:

1. Do not deliver or install switchboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above switchboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

a. Ambient Temperature: Not exceeding 104 deg F (40 deg C).
b. Altitude: Not exceeding 6600 feet (2000 m).

1.8 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace switchboard enclosures, buswork, overcurrent protective devices, accessories, and factory installed interconnection wiring that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Three years from date of Substantial Completion.

B. Manufacturer's Warranty: Manufacturer's agrees to repair or replace surge protection devices that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Switchboards shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation. Shake-table testing shall comply with ICC-ES AC156.
2. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.2 SWITCHBOARDS

A. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

C. Comply with NEMA PB 2.

D. Comply with NFPA 70.

E. Comply with UL 891.

F. Front-Connected, Front-Accessible Switchboards:

1. Main Devices: As directed, Panel or Fixed, individually mounted.
2. Branch Devices: Panel mounted.
3. Sections front and rear aligned.

G. Nominal System Voltage: As directed, 480Y/277 V or 208Y/120 V.

H. Main-Bus Continuous: As directed, 5000, 4000, 3000, 2500, 2000, 1600 or 1200 A.

I. Seismic Requirements: Fabricate and test switchboards according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation. Shake-table testing shall comply with ICC-ES AC156.

    a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
    b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

J. Indoor Enclosures: Steel, NEMA 250, Type 1 or Type 2 as directed.

K. Outdoor Enclosures: As directed, Type 3R or Type 3R, with interior-lighted walk-in aisle.

1. Finish: Factory-applied finish in manufacturer's standard or custom color; undersurfaces treated with corrosion-resistant undercoating.
2. Enclosure: As directed, Flat or Downward, rearward sloping roof; bolt-on rear covers or rear hinged doors for each section, with provisions for padlocking.
3. Doors: Personnel door at each end of aisle, minimum width of 30 inches (762 mm); opening outwards; with panic hardware and provisions for padlocking or cylinder lock as directed. At least one door shall be sized to permit the largest single switchboard section to pass through without disassembling doors, hinges, or switchboard section.
4. Accessories: LED luminaires, ceiling mounted; wired to a three-way light switch at each end of aisle; ground-fault circuit interrupter (GFCI) duplex receptacle; emergency battery pack luminaire installed on wall of aisle midway between personnel doors.
5. Walk-in Aisle Heating and Ventilating:

    a. Factory-installed electric unit heater(s), wall or ceiling mounted, with integral thermostat and disconnect and with capacities to maintain switchboard interior temperature of 40 deg F (5 deg C) with outside design temperature of 0 deg F (minus 18 deg C).
    b. Factory-installed exhaust fan with capacities to maintain switchboard interior temperature of 100 deg F (38 deg C) with outside design temperature of 90 deg F (32 deg C).
    c. Ventilating openings complete with replaceable fiberglass air filters.
    d. Thermostat: Single stage; wired to control heat and exhaust fan.

L. Space Heaters: Factory-installed electric space heaters of sufficient wattage in each vertical section to maintain enclosure temperature above expected dew point.

1. Space-Heater Control: Thermostats to maintain temperature of each section above expected dew point or Manual switching of branch-circuit protective device.
2. Space-Heater Power Source: Transformer, factory installed in switchboard or 120-V external branch circuit as directed.

M. Service Entrance Rating: Switchboards intended for use as service entrance equipment shall contain from one to six service disconnecting means with overcurrent protection, a neutral bus with disconnecting link, a grounding electrode conductor terminal, and a main bonding jumper.

N. Utility Metering Compartment: Barrier compartment and section complying with utility company's requirements; hinged sealable door; buses provisioned for mounting utility

company's current transformers and potential transformers or potential taps as required by utility company. If separate vertical section is required for utility metering, match and align with basic switchboard. Provide service entrance label and necessary applicable service entrance features.

O. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

P. Removable, Hinged Rear Doors and Compartment Covers: Secured by captive thumb screws or standard bolts as directed, for access to rear interior of switchboard.

Q. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

R. Pull Box on Top of Switchboard:

1. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.
2. Set back from front to clear circuit-breaker removal mechanism.
3. Removable covers shall form top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.
4. Bottom shall be insulating, fire-resistive material with separate holes for cable drops into switchboard.
5. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.

S. Buses and Connections: Three phase, four wire unless otherwise indicated.

1. Provide phase bus arrangement A, B, C from front to back, top to bottom, and left to right when viewed from the front of the switchboard.
2. Phase- and Neutral-Bus Material: Tin-plated, high-strength, electrical-grade aluminum alloy with tin-plated aluminum circuit-breaker line connections.
3. Tin-plated aluminum feeder circuit-breaker line connections.
4. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with mechanical or compression connectors for outgoing circuit conductors as directed. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.
5. Ground Bus: As directed, 1/4-by-2-inch- (6-by-50-mm-), 1/4-by-1-inch- (6-by-25-mm-) or Minimum-size required by UL 891, hard-drawn copper of 98 percent conductivity, equipped with mechanical or compression connectors for feeder and branch-circuit ground conductors.
6. Main-Phase Buses and Equipment-Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
7. Disconnect Links:

    a. Isolate neutral bus from incoming neutral conductors.
    b. Bond neutral bus to equipment-ground bus for switchboards utilized as service equipment or separately derived systems.

8. Neutral Buses: As directed, 50 or 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical or compression connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.

T. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

2.3 SURGE PROTECTION DEVICES

A. SPDs: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1449, Type 1 or Type 2 as directed.

B. Features and Accessories:

1. Integral disconnect switch.
2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
3. Indicator light display for protection status.
4. Form-C contacts rated at 5 A and 250-V ac or 2 A and 24-V ac as directed, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
5. Surge counter.

C. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 200 kA, 250kA or 300 kA as directed. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.

D. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V or 208Y/120 V as directed, three-phase, four-wire circuits shall not exceed the following:

1. Line to Neutral: 1200 V for 480Y/277 V or 700 V for 208Y/120 V as directed.
2. Line to Ground: 1200 V for 480Y/277 V or 1200 V for 208Y/120 V as directed.
3. Line to Line: 2000 V for 480Y/277 V or 1000 V for 208Y/120 V as directed.

E. Protection modes and UL 1449 VPR for 240/120 V, single-phase, three-wire circuits shall not exceed the following:

1. Line to Neutral: 700 V.
2. Line to Ground: As directed, 700 V or 1000 V.
3. Line to Line: 1000 V.

F. SCCR: Equal or exceed 100 kA or 200 kA as directed.

G. Nominal Rating: 20 kA.

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with series-connected rating or interrupting capacity to meet available fault currents as directed.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:

    a. Instantaneous trip.
    b. Long- and short-time pickup levels.
    c. Long and short time adjustments.
    d. Ground-fault pickup level, time delay, and I squared t response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
6. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
7. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
8. MCCB Features and Accessories:

    a. Standard frame sizes, trip ratings, and number of poles.
    b. Lugs: As directed, Mechanical or Compression style, suitable for number, size, trip ratings, and conductor material.
    c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
    d. Ground-Fault Protection: As directed, Integrally mounted or Remote-mounted as relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
    e. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
    f. Communication Capability: As directed, Circuit-breaker-mounted, Universal-mounted, Integral or Din-rail-mounted communication module with functions and features compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."
    g. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 or 75 percent of rated voltage as directed.
    h. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
    i. Auxiliary Contacts: As directed, One SPDT switch or Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.

j. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

B. Insulated-Case Circuit Breaker (ICCB): As directed, 80 or 100 percent rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current.

1. As directed, Fixed or Drawout circuit-breaker mounting.
2. Two-step, stored-energy closing.
3. As directed, Standard or Full-function, microprocessor-based trip units with interchangeable rating plug, trip indicators, and the following field-adjustable settings:

   a. Instantaneous trip.
   b. Time adjustments for long- and short-time pickup.
   c. Ground-fault pickup level, time delay, and I squared t response.

4. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
5. Remote trip indication and control.
6. Communication Capability: Web enabled integral Ethernet communication module and embedded Web server with factory-configured Web pages (HTML file format). Provide functions and features compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."
7. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
8. Control Voltage: As directed, 40-V dc, 125-V dc, 250-V dc or 120-V ac.

C. Bolted-Pressure Contact Switch: Operating mechanism uses rotary-mechanical-bolting action to produce and maintain high clamping pressure on the switch blade after it engages the stationary contacts.

1. Main-Contact Interrupting Capability: Minimum of 12 times the switch current rating.
2. Operating Mechanism: Manual handle operation to close switch; stores energy in mechanism for opening and closing.

   a. Electrical Trip: Operation of lever or push-button trip switch, or trip signal from ground-fault relay or remote-control device, causes switch to open.
   b. Mechanical Trip: Operation of mechanical lever, push button, or other device causes switch to open.

3. Auxiliary Switches: Factory installed, SPDT, with leads connected to terminal block, and including one set more than quantity required for functional performance indicated.
4. Service-Rated Switches: Labeled for use as service equipment.
5. Ground-Fault Relay: Comply with UL 1053; self-powered type with mechanical ground-fault indicator, test function, tripping relay with internal memory, and three-phase current transformer/sensor.

   a. Configuration: As directed, Integrally mounted or Remote-mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

6. Open-Fuse Trip Device: Arranged to trip switch open if a phase fuse opens.

D. High-Pressure, Butt-Type Contact Switch: Operating mechanism uses butt-type contacts and a spring-charged mechanism to produce and maintain high-pressure contact when switch is closed.
   1. Main-Contact Interrupting Capability: Minimum of 12 times the switch current rating.
   2. Operating Mechanism: Manual handle operation to close switch; stores energy in mechanism for opening and closing.
      a. Electrical Trip: Operation of lever or push-button trip switch, or trip signal from ground-fault relay or remote-control device, causes switch to open.
      b. Mechanical Trip: Operation of mechanical lever, push button, or other device causes switch to open.
   3. Auxiliary Switches: Factory installed, SPDT, with leads connected to terminal block, and including one set more than quantity required for functional performance indicated.
   4. Service-Rated Switches: Labeled for use as service equipment.
   5. Ground-Fault Relay: Comply with UL 1053; self-powered type with mechanical ground-fault indicator, test function, tripping relay with internal memory, and three-phase current transformer/sensor.
      a. Configuration: As directed, Integrally mounted or Remote-mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
   6. Open-Fuse Trip Device: Arranged to trip switch open if a phase fuse opens.

E. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

F. Fuses are specified in Section 262813 "Fuses."

2.5 INSTRUMENTATION

A. Instrument Transformers: NEMA EI 21.1, and the following:
   1. Potential Transformers: As directed, NEMA EI 21.1; 120 V, 60 Hz, single, tapped or double secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.
   2. Current Transformers: As directed, NEMA EI 21.1; 5 A, 60 Hz, secondary; wound, bushing, bar or window type; single or double secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
   3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.
   4. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:

    a. Phase Currents, Each Phase: Plus or minus 0.5 percent.
    b. Phase-to-Phase Voltages, Three Phase: Plus or minus 0.5 percent.
    c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 0.5 percent.
    d. Megawatts: Plus or minus 1 percent.
    e. Megavars: Plus or minus 1 percent.
    f. Power Factor: Plus or minus 1 percent.
    g. Frequency: Plus or minus 0.1 percent.
    h. Accumulated Energy, Megawatt Hours: Plus or minus 1 percent; accumulated values unaffected by power outages up to 72 hours.
    i. Megawatt Demand: Plus or minus 1 percent; demand interval programmable from five to 60 minutes.
    j. Contact devices to operate remote impulse-totalizing demand meter.

2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

C. Watt-Hour Meters and Wattmeters:

1. Comply with ANSI C12.1.
2. Three-phase induction type with two stators, each with current and potential coil, rated 5 A, 120 V, 60 Hz.
3. Suitable for connection to three- and four-wire circuits.
4. Potential indicating lamps.
5. Adjustments for light and full load, phase balance, and power factor.
6. Four-dial clock register.
7. Ratchets to prevent reverse rotation.
8. Removable meter with drawout test plug.
9. Semiflush mounted case with matching cover.
10. Appropriate multiplier tag.

D. Impulse-Totalizing Demand Meter:

1. Comply with ANSI C12.1.
2. Suitable for use with switchboard watt-hour meter, including two-circuit totalizing relay.
3. Cyclometer.
4. Four-dial, totalizing kilowatt-hour register.
5. Positive chart drive mechanism.
6. Capillary pen holding a minimum of one month's ink supply.
7. Roll chart with minimum 31-day capacity; appropriate multiplier tag.
8. Capable of indicating and recording five, 15 or 30-minute integrated demand of totalized system as directed.

2.6 CONTROL POWER

A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.

B. Electrically Interlocked Main and Tie Circuit Breakers: Two control-power transformers in separate compartments, with interlocking relays, connected to the primary side of each control-power transformer at the line side of the associated main circuit breaker. 120-V secondaries connected through automatic transfer relays to ensure a fail-safe automatic transfer scheme.

C. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

D. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2.7 ACCESSORY COMPONENTS AND FEATURES

A. Portable Test Set: For testing functions of solid-state trip devices without removing from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.

B. Spare-Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented steel box or cabinet. Arrange for wall mounting.

C. Mounting Accessories: For anchors, mounting channels, bolts, washers, and other mounting accessories, comply with requirements in Section 260548.16 "Seismic Controls for Electrical Systems" or manufacturer's instructions.

2.8 IDENTIFICATION

A. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Receive, inspect, handle, and store switchboards according to NECA 400 or NEMA PB 2.1 as directed.

B. Install switchboards and accessories according to NECA 400 or NEMA PB 2.1 as directed.

C. Equipment Mounting: Install switchboards on concrete base, 4-inch (100-mm) nominal thickness. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed

1. Install conduits entering underneath the switchboard, entering under the vertical section where the conductors will terminate. Install with couplings flush with the concrete base. Extend 2 inches (50-mm) above concrete base after switchboard is anchored in place.

2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to switchboards.
6. Anchor switchboard to building structure at the top of the switchboard if required or recommended by the manufacturer.

D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, straps and brackets, and temporary blocking of moving parts from switchboard units and components.

E. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

F. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.

G. Install filler plates in unused spaces of panel-mounted sections.

H. Install overcurrent protective devices, surge protection devices, and instrumentation.

1. Set field-adjustable switches and circuit-breaker trip ranges.

I. Install spare-fuse cabinet.

J. Comply with NECA 1.

K. Comply with requirements for terminating feeder bus specified in Section 262500 "Enclosed Bus Assemblies." Drawings indicate general arrangement of bus, fittings, and specialties.

L. Comply with requirements for terminating cable trays specified in Section 260536 "Cable Trays for Electrical Systems." Drawings indicate general arrangement of cable trays, fittings, and specialties.

3.2 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Acceptance Testing:

    a. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit. Open control and metering circuits within the switchboard and remove neutral connection to surge protection and other electronic devices prior to insulation test. Reconnect after test.
    b. Test continuity of each circuit.

2. Test ground-fault protection of equipment for service equipment per NFPA 70.
3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
4. Correct malfunctioning units on-site where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
5. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

B. Switchboard will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.4 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories.

END OF SECTION 262413

SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Distribution panelboards.
2. Lighting and appliance branch-circuit panelboards.

1.2 DEFINITIONS

A. MCCB: Molded-case circuit breaker.

B. SPD: Surge protective device.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of panelboard.

B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details.
2. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
3. Detail bus configuration, current, and voltage ratings.
4. Short-circuit current rating of panelboards and overcurrent protective devices.
5. Include evidence of NRTL listing for series rating of installed devices.
6. Include evidence of NRTL listing for SPD as installed in panelboard.
7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
8. Include wiring diagrams for power, signal, and control wiring.
9. Key interlock scheme drawing and sequence of operations.
10. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards.

1.4 INFORMATIONAL SUBMITTALS

A. Panelboard schedules for installation in panelboards.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 FIELD CONDITIONS

A. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet (2000 m).

1.7 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.

1. Panelboard Warranty Period: 18 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PANELBOARDS COMMON REQUIREMENTS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NEMA PB 1.

D. Comply with NFPA 70.

E. Enclosures: Flush and Surface-mounted, dead-front cabinets.

1. Rated for environmental conditions at installed location.

a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
b. Outdoor Locations: NEMA 250, Type 3R.
c. Kitchen or Wash-Down Areas as directed: NEMA 250, Type 4X or stainless steel as directed.
d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
e. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 5 or Type 12 as directed.

2. Height: 84 inches (2.13 m) maximum.
3. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box. Trims shall cover all live parts and shall have no exposed hardware.
4. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.

F. Incoming Mains Location: Top, Bottom or Convertible between top and bottom as directed.

G. Phase, Neutral, and Ground Buses: Tin-plated aluminum or Hard-drawn copper, 98 percent conductivity as directed.

H. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Tin-plated aluminum or Hard-drawn copper, 98 percent conductivity.
2. Main and Neutral Lugs: As directed, Compression or Mechanical type, with a lug on the neutral bar for each pole in the panelboard.
3. Ground Lugs and Bus-Configured Terminators: As directed, Compression or Mechanical type, with a lug on the bar for each pole in the panelboard.
4. Feed-Through Lugs: As directed, Compression or Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
5. Subfeed (Double) Lugs: As directed, Compression or Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.

I. NRTL Label: Panelboards shall be labeled by an NRTL acceptable to authority having jurisdiction for use as service equipment with one or more main service disconnecting and overcurrent protective devices. Panelboards shall have meter enclosures, wiring, connections, and other provisions for utility metering. Coordinate with utility company for exact requirements.

J. Future Devices: Panelboards shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

K. Panelboard Short-Circuit Current Rating: Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by an NRTL. Include label or manual with size and type of allowable upstream and branch devices listed and labeled by an NRTL for series-connected short-circuit rating.

L. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

B. Surge Suppression: Factory installed as an integral part of indicated panelboards, complying with UL 1449 SPD Type 1 or Type 2 as directed.

2.3 POWER PANELBOARDS

A. Panelboards: NEMA PB 1, distribution type.

B. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

1. For doors more than 36 inches (914 mm) high, provide two latches, keyed alike.

C. Mains: As directed, Circuit breaker, Fused switch or Lugs only.

D. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: As directed, Plug-in circuit breakers, Bolt-on circuit breakers or Plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: As directed, Bolt-on circuit breakers or Plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

F. Branch Overcurrent Protective Devices: Fused switches.

G. Contactors in Main Bus: As directed, NEMA ICS 2, Class A, electrically or mechanically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.

1. External Control-Power Source: As directed, 120-V branch circuit or 24-V control circuit.

2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

B. Mains: Circuit breaker or lugs only.

C. Branch Overcurrent Protective Devices: As directed, Plug-in or Bolt-on circuit breakers, replaceable without disturbing adjacent units.

D. Contactors in Main Bus: As directed, NEMA ICS 2, Class A, electrically or mechanically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.

1. External Control-Power Source: As directed, 120-V branch circuit or 24-V control circuit.

E. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

F. Column-Type Panelboards: Single row of overcurrent devices with narrow gutter extension and overhead junction box equipped with ground and neutral terminal buses.

2.5 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. MCCB: As directed, comply with UL 489, with series-connected rating or interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers:

a. Inverse time-current element for low-level overloads.
b. Instantaneous magnetic trip element for short circuits.

c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic Trip Circuit Breakers:

   a. RMS sensing.
   b. Field-replaceable rating plug or electronic trip.
   c. Digital display of settings, trip targets, and indicated metering displays.
   d. Multi-button keypad to access programmable functions and monitored data.
   e. Ten-event, trip-history log. Each trip event shall be recorded with type, phase, and magnitude of fault that caused the trip.
   f. Integral test jack for connection to portable test set or laptop computer.
   g. Field-Adjustable Settings:

      1) Instantaneous trip.
      2) Long- and short-time pickup levels.
      3) Long and short time adjustments.
      4) Ground-fault pickup level, time delay, and I squared T response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
5. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
6. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
7. Arc-Fault Circuit Interrupter Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
8. Subfeed Circuit Breakers: Vertically mounted.
9. MCCB Features and Accessories:

   a. Standard frame sizes, trip ratings, and number of poles.
   b. Breaker handle indicates tripped status.
   c. UL listed for reverse connection without restrictive line or load ratings.
   d. Lugs: As directed, Compression or Mechanical style, suitable for number, size, trip ratings, and conductor materials.
   e. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and HID lighting circuits.
   f. Ground-Fault Protection: As directed, Integrally mounted or Remote-mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
   g. Communication Capability: As directed, Circuit-breaker-mounted, Universal-mounted, Integral or Din-rail-mounted communication module with functions and features compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."
   h. Shunt Trip: As directed, 120-V or 24-V trip coil energized from separate circuit, set to trip at 55 or 75 percent of rated voltage.
   i. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on, off or on or off position as directed.

j. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

B. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

1. Fuses and Spare-Fuse Cabinet: Comply with requirements specified in Section 262813 "Fuses."

2.6 IDENTIFICATION

A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.

B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.

C. Circuit Directory: Directory card inside panelboard door, mounted in transparent card holder or metal frame with transparent protective cover as directed.

2.7 ACCESSORY COMPONENTS AND FEATURES

A. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Install panelboards and accessories according to NECA 407 or NEMA PB 1.1 as directed.

C. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

D. Mount top of trim 90 inches (2286 mm) above finished floor unless otherwise indicated.

E. Mount panelboard cabinet plumb and rigid without distortion of box.

F. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

G. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.

H. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.

I. Install filler plates in unused spaces.

J. Stub four 1-inch (27-EMT) empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch (27-EMT) empty conduits into raised floor space or below slab not on grade.

K. Arrange conductors in gutters into groups and bundle and wrap with wire ties.

3.2 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

E. Install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems" identifying source of remote circuit.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

D. Panelboards will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

END OF SECTION 262416

SECTION 262416.16 - ELECTRONICALLY OPERATED CIRCUIT-BREAKER PANELBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Panelboards using electronically controlled, electrically operated circuit breakers.

1.2 DEFINITIONS

A. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

B. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.

C. RS-485: A serial network protocol, similar to RS-232, complying with TIA-485-A.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For each electronically operated, circuit-breaker panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
2. Detail bus configuration, current, and voltage ratings.
3. Short-circuit current rating of panelboards and overcurrent protective devices.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For panelboards, accessories, and components, from manufacturer.

B. Field quality-control reports.

C. Sample Warranty: For manufacturer's special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain electrically operated circuit breakers and power distribution components from single manufacturer.

2.2 SYSTEM DESCRIPTION

A. Input signal from field-mounted or on-board signal source shall open or close one or more electrically operated circuit breakers in the electronically operated, circuit-breaker panelboards. Any combination of inputs shall be programmable to any combination outputs.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with 47 CFR, Subpart A and Subpart B, for Class A digital devices.

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Component Importance Factor: 1.5 or 1.0 as directed.

2.4 PANELBOARDS

A. Electronically operated, circuit-breaker panelboards may contain remotely operated circuit breakers and standard branch circuit breakers specified in Section 262416 "Panelboards."

B. Assemblies: Comply with UL 67 and NEMA PB 1.

C. Surge Protective Device: Field mounted, complying with Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."

D. Surge Protective Device: Integrally mounted, complying with UL 1449 Type 1.

1. Comply with IEEE C62.41, Category C, 200-kA short-circuit current rating.
2. Non-modular type with the following features and accessories:

a. Digital-display indicator lights for power and protection status.

E. Enclosures: Comply with UL 50 and NEMA 250.

F. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

G. Panelboard Short-Circuit Current Rating: Fully rated to interrupt 10-kA symmetrical short-circuit current available at terminals.

2.5 CIRCUIT BREAKERS

A. Remotely operated branch circuit breakers shall provide branch circuit overcurrent protection.

B. Labeled with SWD and HID Ratings: Comply with UL 489 for 15- and 20-A, single-pole branch devices. 15- and 20-A circuit breakers, if scheduled, shall be a product of same manufacturer, and be of same class as the rated circuit breakers.

C. Switching Endurance Rating: As directed, not less than 50,000 or 200,000 full-load open/close/open remote operations.

D. Remotely Operated Circuit Breakers: Manual override switch or handle position shall enable or disable the remote operation of the device and allow breaker handle to manually control the breaker's on-off status.

2.6 CONTROLLERS

A. Description: Controllers shall contain the power supply and electronic control for operating and monitoring remotely operated branch circuit breakers.

1. Comply with UL 916 (CSA C22.2, No. 205); with a microprocessor-based, solid-state, 365-day timing and control unit.

2. Power Supply: Powered from the panelboard, sized to provide control power for the operation of the remotely operated circuit breakers, controller, bus system, low-voltage inputs, and field-installed sensors.
3. Integral keypad and digital-display front panel for local setup, including the following:

    a. Log and display remotely operated breaker on-time.
    b. Provision to accept downloadable firmware so that the latest features may be added in the future without replacing the module.

4. Nonvolatile memory shall retain all setup configurations. After a power failure, the controller shall automatically reboot and return to normal system operation.
5. Time Synchronization: The timing unit shall be updated not less than every hour(s) with the network time server as directed.

B. Timing Unit:

1. 365-day calendar, astronomical clock, and automatic adjustments for daylight savings and leap year.
2. Clock configurable for 12-hour (A.M./P.M.) or 24-hour format.
3. 16 independent schedules, each having 24 time periods.
4. Schedule periods settable to the minute.
5. Day of week, day of month, day of year with one-time or repeating capability.
6. 32 special date periods.

C. With eight or 16 inputs as directed, each configurable to the following parameters:

1. Normally open, normally closed, two-wire maintained toggle, two-wire momentary toggle, two-wire momentary on, two-wire momentary off, or three-wire momentary operation.
2. On and off-delay timers for local override operation, adjustable from five minutes to 12 hours. Local override shall be by field-installed, two-wire momentary toggle switch.

2.7 MANUAL SWITCHES AND PLATES

A. Keypads: Programmable, designed to control functions associated with the equipment of this Section. The units shall be able to control any system output device.

B. Push-Button Switches: Modular, momentary-contact, low-voltage type.

1. Match color specified in Section 262726 "Wiring Devices."
2. As directed, Integral green digital-display or neon pilot light to indicate when circuit is on.
3. As directed, Internal white digital-display or neon locator light to illuminate when circuit is off.

C. Manual, Maintained Contact, Full- or Low-Voltage Switch: Comply with Section 262726 "Wiring Devices."

D. Wall Plates: Single and multigang plates as specified in Section 262726 "Wiring Devices."

E. Legend: Engraved or permanently silk-screened on wall plate where indicated. Use designations indicated on Drawings.

2.8 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Class 2 Power Source: Not smaller than No. 12 AWG. Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Class 2 and Class 3 Control Cables: Multiconductor cable with copper conductors not smaller than No. 18, No. 22 or No. 24 AWG as directed. Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cables: Multiconductor cable with copper conductors not smaller than No. 14, No. 16 or No. 18 AWG as directed. Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Twisted-Pair Data Cable: As directed, Category 5e, Category 6 or Category 6a. Comply with requirements for twisted pair cabling in Section 260523 "Control-Voltage Electrical Power Cables."

E. Twisted-Pair Data Cable: As directed, Category 5e, Category 6 or Category 6a. Comply with requirements in Section 271513 "Communications Copper Horizontal Cabling."

PART 3 - EXECUTION

3.1 WIRING INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for cable trays specified in Section 260536 "Cable Trays for Electrical Systems."
3. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

C. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

D. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.2 PANELBOARD INSTALLATION

A. Comply with NECA 1.

B. Install panelboards and accessories according to NECA 407 or NEMA PB 1.1 as directed.

C. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

D. Mounting Height: 90 inches (2286 mm) to top of trim above finished floor unless otherwise indicated.

E. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

F. Install filler plates in unused spaces.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Section 260553 "Identification for Electrical Systems."

C. Create a directory to indicate loads served by each circuit; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are unacceptable.

D. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Testing Agency: As directed, Owner will engage or Engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:

    a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.

b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
c. Instruments and Equipment:

1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

C. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

D. Panelboard will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies panelboards included and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain control modules.

END OF SECTION 262416.16

SECTION 262419 - MOTOR-CONTROL CENTERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes MCCs for use with ac circuits rated 600 V and less, with combination controllers and having the following factory-installed components:

1. Automatic power transfer.
2. Feeder-tap units.
3. Measurement and control.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

C. Shop Drawings: As directed, for each MCC, manufacturer's approval, custom and production drawings as defined in UL 845. In addition to requirements specified in UL 845, include dimensioned plans, elevations, and sections; and conduit entry locations and sizes, mounting arrangements, and details, including required clearances and service space around equipment.

1. Show tabulations of installed devices, equipment features, and ratings. Include the following:

    a. Each installed unit's type and details.
    b. Factory-installed devices.
    c. Enclosure types and details.
    d. Nameplate legends.
    e. Short-circuit current (withstand) rating of complete MCC, and for bus structure and each unit.
    f. Features, characteristics, ratings, and factory settings of each installed controller and feeder device, and installed devices.
    g. Specified optional features and accessories.

2. Schematic and Connection Wiring Diagrams: For power, signal, and control wiring for each installed controller.
3. Nameplate legends.
4. Vertical and horizontal bus capacities.
5. Features, characteristics, ratings, and factory settings of each installed unit.

1.3 INFORMATIONAL SUBMITTALS

A. Standard Drawings: For each MCC, as defined in UL 845.

B. Seismic Qualification Data: Certificates, for MCCs, accessories, and components, from manufacturer.

C. Product Certificates: For each MCC.

D. Source quality-control reports.

E. Field quality-control reports.

F. Load-Current and Overload Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

G. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that switch settings for motor running overload protection suit actual motors to be protected.

H. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace MCC and SPD that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 SYSTEM DESCRIPTION

A. NEMA Compliance: Fabricate and label MCCs to comply with NEMA ICS 18.

B. Ambient Environment Ratings:

1. Ambient Temperature Rating: Not less than 0 deg F (minus 18 deg C) and not exceeding 104 deg F (40 deg C), with an average value not exceeding 95 deg F (35 deg C) over a 24-hour period.
2. Ambient Storage Temperature Rating: Not less than minus 4 deg F (minus 20 deg C) and not exceeding 140 deg F (60 deg C)
3. Humidity Rating: Less than 95 percent (noncondensing).
4. Altitude Rating: Not exceeding 6600 feet (2000 m), or 3300 feet (1000 m) if MCC includes solid-state devices.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: MCCs shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the system will remain in place without separation of any parts when subjected to the seismic forces specified and the system will be fully operational after the seismic event."
2. Component Importance Factor: As directed, 1.5 or 1.0.
3. Component Amplification Factor: 2.5.
4. Component Response Modification Factor: 6.0.

B. Capacities and Characteristics:

1. MCC Enclosure and Assembly:

a. Nominal System Voltage: As directed.
b. Service Equipment Rated: Yes or No as directed.
c. Enclosure: NEMA 250, Type As directed.
d. Integrated Short-Circuit Rating for MCC:

1) Combination series rated; As directed.
2) Fully rated; As directed.

e. Integrated Short-Circuit Rating for Each Unit:

1) Combination series rated; As directed.
2) Fully rated; As directed.

f. Wiring Class: As directed.
g. Bus:

1) Horizontal Bus: As directed.
2) Neutral Bus: None, 50 percent, Full size or 150 percent as directed.

2. Main Disconnect Device:

a. Main Disconnect: As directed, MCCB, UL 489, Fusible switch, UL 98, three poles, A. Manually operated, electrically tripped.
b. SPD: As directed, UL 1449, Type 1 or Type 2.
c. Optional Features: As directed.

3. Automatic Power Transfer: Electrically operated MCCBs, three poles, As directed.
4. Magnetic Controllers:

a. Tag Number: As directed.

1) Classification by Starting Method: As directed.
2) Controller Size: Complying with NEMA ICS 2 As directed.
3) Optional Features: As directed.

5. Reduced-Voltage Solid-State Controllers:

a. Tag Number: As directed.

1) Starting Configuration: As directed.
2) Starting Mode: As directed.
3) Stopping Mode: As directed.
4) Controller Size: Complying with NEMA ICS 2 As directed.
5) Bypass Contactor: Comply with NEMA ICS 2.
6) Acceleration Control: As directed.
7) Overload Relays: Melting alloy, Bimetallic or Solid state. Class 10, 20 or 30 as directed.
8) Isolated Overload Alarm Contact: NC or NO as directed.
9) Optional Features: As directed.

6. VFCs:

a. Tag Number: As directed.

1) Bypass Mode: As directed, Manual or Field selectable, manual or automatic.
2) Bypass Style: As directed, Two or Three contactor style.
3) Bypass Contactor Classification: As directed, Full-voltage (across-the-line), Reduced-voltage autotransformer, open transition or Reduced-voltage autotransformer, closed transition.
4) Overload Relays: As directed, Melting alloy, Bimetallic or Solid state. Class As directed, 10, 20 or 30.
5) Isolated Overload Alarm Contact: As directed, NC or NO.
6) Optional Features: As directed.

7. Controller-Mounted Auxiliary Devices:

a. Push Buttons and Selector Switches: As directed, Heavy or Standard-duty, oiltight type.
b. Feeder Tap Units: Main Disconnect: As directed, MCCB, UL 489, Fusible switch, UL 98, three poles. Manually operated, electrically tripped.

8. Panelboards: Tag Number As directed.

a. Mains: MCCB or Main lugs only as directed
b. As directed, Plug-in or Bolt-on circuit breakers.

9. Transformer(s): As directed.

a. Primary Circuit Breaker: MCCB, As directed.

10. Transfer Switch: As directed.

2.4 ENCLOSURES

A. Indoor Enclosures: Freestanding steel cabinets unless otherwise indicated. NEMA 250, Type 1, Type 1A, Type 2 or Type 12 unless otherwise indicated to comply with environmental conditions at installed location.

B. Space Heaters: Factory-installed electric space heaters of sufficient wattage in each vertical section to maintain enclosure temperature above expected dew point.

1. Space-Heater Control: Thermostats to maintain temperature of each section above expected dew point or Manual switching of branch-circuit protective device as directed.
2. Space-Heater Power Source: As directed, Transformer, factory installed in MCC or 120-V external branch circuit.

C. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray or custom color finish over a rust-inhibiting primer on treated metal surface as directed.

D. Outdoor Enclosures: Type 3R, non-walk-in aisle.

1. Finish: As directed, Factory-applied finish in manufacturer's standard or custom color; undersurfaces treated with corrosion-resistant undercoating.
2. Enclosure: As directed, Flat or Downward, rearward sloping roof; bolt-on rear covers or rear hinged doors for each section, with provisions for padlocking.
3. Doors: Personnel door at each end of aisle, minimum width of 30 inches (762 mm); opening outwards; with panic hardware and provisions for padlocking or cylinder lock as directed.
4. Accessories: Fluorescent lighting fixtures, ceiling mounted; wired to a three-way light switch at each end of aisle; GFCI duplex receptacle; emergency battery pack lighting fixture installed on wall of aisle midway between personnel doors.
5. Power for Space Heaters, Ventilation, Lighting, and Receptacle: Include a CPT within the switchboard. Supply voltage shall be 120, 120/240 or 120/208-V ac as directed.
6. Power for space heaters, ventilation, lighting, and receptacle supplied from a remote source.

2.5 ASSEMBLY

A. Structure:

1. Comply with UL requirements for service entrance equipment.
2. Units up to and including Size 3 shall have drawout mountings with connectors that automatically line up and connect with vertical-section buses while being racked into their normal, energized positions.
3. Units in Type B and Type C MCCs shall have pull-apart terminal strips for external control connections.
4. Pull Boxes:

    a. Include provisions for ventilation to maintain temperature in pull box within same limits as the MCC.
    b. Set the box back from front to clear circuit-breaker removal mechanism.
    c. Covers: Removable covers forming top, front, and sides.

d. Insulated bottom of fire-resistive material with separate holes for cable drops into MCC.
e. Cable Supports: Arranged to facilitate cabling and adequate to support cables, including supports for future cables.
f. When equipped with barriers, supply with access to check bus bolt tightness.

B. Compartments: Modular; individual lift-off doors with concealed hinges and quick-captive screw fasteners.

1. Interlock compartment door to require that the disconnecting means is "off" before door can be opened or closed, except by operating a concealed release device.
2. Compartment construction shall allow for removal of units without opening adjacent doors, disconnecting adjacent compartments, or disturbing operation of other units in MCC.
3. The same-size compartments shall be interchangeable to allow rearrangement of units, such as replacing three single units with a unit requiring three spaces, without cutting or welding.

C. Bus Transition and Incoming Pull Sections: Included and aligned with the structure of the MCC.

D. Utility Metering Compartment: Fabricated, barrier compartment and section complying with utility company's requirements; hinged sealed door; buses provisioned for mounting utility company's current transformers and PTs or potential taps as required by utility company. If separate vertical section is required for utility metering, match and align with basic MCC. Install service entrance label and applicable service entrance features. Comply with requirements in Section 262713 "Electricity Metering."

E. Owner's Metering Compartment: A separate customer metering compartment and section with front hinged door, metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks. Include PTs having primary and secondary fuses with disconnecting means and secondary wiring terminated on terminal blocks.

F. Interchangeability: Compartments constructed to allow for removal of units without opening adjacent doors, disconnecting adjacent compartments, or disturbing operation of other units in MCC; same-size compartments to permit interchangeability and ready rearrangement of units, such as replacing three single units with a unit requiring three spaces, without cutting or welding.

G. Wiring Spaces:

1. Vertical wireways in each vertical section for vertical wiring to each unit compartment; supports to hold wiring in place.
2. Horizontal wireways in bottom and top of each vertical section for horizontal wiring between vertical sections; supports to hold wiring in place.

H. Provisions for Future:

1. Compartments marked "future" shall be bused, wired and equipped with guide rails or equivalent, and ready for insertion of drawout units.

2. Compartments marked "spare" shall include provisions for connection to the vertical bus.

I. Integrated Short-Circuit Rating:

1. Short-Circuit Current Rating for Each Unit: As directed, Combination series rated, Fully rated; 22, 42, 65 or 100 kA as directed.
2. Short-Circuit Current Rating of MCC: Combination series rated or Fully rated with its main overcurrent device; 22, 42, 65 or 100 kA as directed.

J. Control Power:

1. 120-V ac, supplied centrally from a CPT or from a remote branch circuit as directed.
2. 24 or 120-V ac; obtained from CPT integral with controller; with primary and secondary fuses. The CPT shall be of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.

    a. CPT Spare Capacity: As directed, 50, 100 or 200 VA.

3. Control Circuits: 24-V dc, supplied centrally from two redundant, automatically switched power supplies.
4. CPT Spare Capacity: As directed, 50, 100 or 200 VA.

K. Factory-Installed Wiring: Factory installed, with bundling, lacing, and protection included. Use flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

1. Wiring Class: As directed, NEMA ICS 18, Class I, Type A, Type B, for starters larger than Size 3 or Type B-T, for starters Size 3 and smaller.
2. Control and Load Wiring: Factory installed, with bundling, lacing, and protection included. Use flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

L. Bus:

1. Main Horizontal and Equipment Ground Buses: Uniform capacity for entire length of MCC's main and vertical sections. Provide for future extensions from both ends.
2. Vertical Phase and Equipment Ground Buses: Uniform capacity for entire usable height of vertical sections, except for sections incorporating single units.
3. Phase- and Neutral-Bus Material as directed: Hard-drawn copper of 98 percent minimum conductivity or silver or tin-plated alloy, with mechanical or compression connectors for outgoing conductors as directed.
4. Phase- and Neutral-Bus Material as directed: Hard-drawn copper of 98 percent minimum conductivity or tin-plated, high-strength, electrical-grade aluminum alloy, with mechanical or compression connectors for outgoing conductors as directed.
5. Ground Bus: Hard-drawn copper of 98 percent minimum conductivity, with pressure connector for ground conductors, minimum size 1/4-by-2 inches (6 by 50 mm). Equip with mechanical or compression connectors for outgoing conductors as directed.
6. Neutral Disconnect Link: Bolted, uninsulated, 1/4-by-2-inch (6-by-50-mm) copper bus, arranged to connect neutral bus to ground bus.

7. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Insulation temperature rating shall not be less than 105 deg C.

2.6 MAIN DISCONNECT AND OVERCURRENT PROTECTIVE DEVICE(S)

A. MCCB (to 1600 A): Fixed mounted, manually operated air-circuit breaker. Comply with UL 489.

1. MCCB shall have quick-make, quick-break, over-center switching mechanism that is mechanically trip-free, its position shall be shown by the position of the handle, and manual push-to-trip push button.
2. Solid-state monitoring and tripping system to show system status monitoring, adjustable time-current protection, and shunt trip.

    a. Interchangeable current sensors and timing circuits for adjustable time-current protection settings and status signals.
    b. Trip-setting dials or interchangeable plugs to establish the continuous trip of the circuit breaker. Plugs shall not be interchangeable between frames, and the breaker may not be closed without the plug. With neutral ground-fault sensor.
    c. Time-current adjustments to achieve protective-device coordination as follows:

        1) Adjustable long-time delay.
        2) Adjustable short-time setting and delay to shape the time-current curve.
        3) Adjustable instantaneous setting.
        4) Individually adjustable ground-fault setting and time delay.

    d. Built-in connector to test the long-time delay, instantaneous, and ground-fault functions of the breaker. Provide one test set for testing the installed circuit breakers 225-A frame and higher.
    e. Built-in digital ammeter display, showing load current and tripping cause.

3. Switch operator power shall be from control power specified in "Assembly" Article.

B. MCC Main Disconnect Device: Fusible switch; fixed-mounted, manually operated, electrically tripped, quick-make, quick-break switch. Comply with UL 98.

1. Indication whether the switch is open or closed, and provisions for padlocking the operating handle.
2. Fuse clips and fuses.
3. Electrically tripped switches shall include the following:

    a. Shunt trip.
    b. Ground-fault protection, with adjustable time delay and test panel.
    c. Single-phase protection, tripping the switch on loss of a source phase.
    d. Blown fuse protection, tripping the switch on a blown fuse, with blown fuse indication.
    e. Switch operator power shall be from control power specified in "Assembly" Article.

C. Surge Suppression: Factory installed as an integral part of the incoming feeder, complying with UL 1449, SPD Type 1 or Type 2 as directed.

2.7 MAGNETIC CONTROLLERS

A. Controller Units: Combination controllers.

B. Disconnects:

1. MCP:

a. UL 489, with interrupting capacity complying with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
b. Lockable Handle: For three padlocks and interlocks with cover in closed position.
c. Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
d. NC or NO alarm contact that operates only when MCP has tripped as directed.
e. Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.

2. MCCB:

a. UL 489, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
b. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
c. Lockable Handle: For three padlocks and interlocks with cover in closed position.
d. Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
e. As directed, NC or NO alarm contact that operates only when MCCB has tripped.

3. Molded-Case Switch:

a. UL 489, with in-line fuse block for UL 248-8 Class J or UL 248-10 Class L power fuses (depending on ampere rating), providing an interrupting capacity to comply with available fault currents as directed; MCCB with fixed, high-set instantaneous trip only.
b. Lockable Handle: For three padlocks and interlocks with cover in closed position.
c. Auxiliary contacts "a" and "b" arranged to activate with molded-case switch handle.
d. NC or NO alarm contact that operates only when molded-case switch has tripped as directed.

C. Controllers: Comply with UL 508.

1. Full-Voltage Magnetic Controllers: Electrically held, full voltage, NEMA ICS 2, general purpose, Class A.

a. Classification: Nonreversing and reversing.

2. Multispeed Magnetic Controllers: Electrically held, full voltage, NEMA ICS 2, general purpose, Class A.

    a. Classification: Nonreversing; consequent pole or two winding as directed.

        1) Two speed, with compelling relays to ensure that motor will start only at low speed.
        2) Timer Relays: Accelerating, for properly timed acceleration through speeds lower than that selected.
        3) Timer Relays: Decelerating, for automatically timed deceleration through each speed.

    b. Classification: Reversing; consequent pole or two winding as directed.

        1) Two speed, with compelling relay to ensure that motor will start only at low speed.

    c. Timer Relays: Accelerating, for properly timed acceleration through speeds lower than that selected.
    d. Timer Relays: Decelerating, for automatically timed deceleration through each speed.
    e. Antiplugging Relays: Time delay when transferring from FORWARD to REVERSE and back.

D. Overload Relays:

1. Melting-Alloy Overload Relays:

    a. Inverse-time-current characteristic.
    b. Class 10, Class 20 or Class 30 tripping characteristic as directed.
    c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.

2. Bimetallic Overload Relays:

    a. Inverse-time-current characteristic.
    b. Class 10, Class 20 or Class 30 tripping characteristic as directed.
    c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
    d. Ambient compensated.
    e. Automatic resetting.

3. Solid-State Overload Relays:

    a. Switch or dial selectable for motor-running overload protection.
    b. Sensors in each phase.
    c. Class 10, Class 20 or Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing as directed.
    d. UL 1053 Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
    e. Analog communication module.

4. NC or NO isolated overload alarm contact as directed.
5. External overload reset push button.

2.8 REDUCED-VOLTAGE SOLID-STATE CONTROLLERS

A. Controller Units: An integrated unit with disconnects, power SCRs, heat sink, microprocessor logic board, door-mounted digital display and keypad, bypass contactor, and overload relays. Comply with UL 508.

1. Suitable for use with NEMA MG 1 Design B, polyphase induction motors.
2. MCP:

    a. UL 489, with interrupting capacity complying with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
    b. Lockable Handle: For three padlocks and interlocks with cover in closed position.
    c. Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
    d. NC or NO alarm contact that operates only when MCP has tripped as directed.
    e. Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.

3. MCCB:

    a. UL 489, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
    b. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
    c. Lockable Handle: For three padlocks and interlocks with cover in closed position.
    d. Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
    e. NC or NO alarm contact that operates only when MCCB has tripped as directed.

4. Molded-Case Switch:

    a. UL 489, with in-line fuse block for UL 248-8 Class J or UL 248-10 Class L power fuses (depending on ampere rating) as directed, providing an interrupting capacity to comply with available fault currents; MCCB with fixed, high-set instantaneous trip only.
    b. Lockable Handle: For three padlocks and interlocks with cover in closed position.
    c. Auxiliary contacts "a" and "b" arranged to activate with molded-case switch handle.
    d. As directed, NC or NO alarm contact that operates only when molded-case switch has tripped.

B. Configuration: Standard or Severe duty as directed; nonreversible or reversible as directed.

C. Starting Mode: As directed, Voltage ramping, Current limit, Torque control or Torque control with voltage boost; field selectable.

D. Stopping Mode: Coast to stop, Adjustable torque deceleration or Adjustable braking; field selectable.

E. Bypass Contactor: Shall operate automatically to bypass the SCRs when the motor has reached rated speed and full voltage is applied to motor. Solid-state controller protective features shall remain active when the bypass relay is in the bypass mode.

1. Bypass Contactor: Manufacturer's standard product.
2. Bypass Contactor: NEMA ICS 2, general-purpose, Class A contactor, rated to start the load across the line.
3. Bypass Contactor Coils: Pressure-encapsulated type; manufacturer's standard operating voltage, matching control power or line voltage, depending on contactor size and line-voltage rating.

F. Acceleration Control: Adjustable, using voltage or current ramp, and adjustable starting torque control with up to 400 percent current limitation for 20 seconds.

G. SCR Bridge: At least two SCRs per phase, for stable and smooth acceleration with or without external feedback from the motor or driven equipment as directed.

H. Keypad: Front accessible; for programming the controller parameters, functions, and features; shall be manufacturer's standard and include not less than the following functions:

1. Adjusting motor full-load amperes, as a percentage of the controller's rating.
2. Adjusting current limitation on starting, as a percentage of the motor full-load current rating.
3. Adjusting linear acceleration and deceleration ramps, in seconds.
4. Setting initial torque, as a percentage of the nominal motor torque.
5. Adjusting torque limit, as a percentage of the nominal motor torque.
6. Adjusting maximum start time, in seconds.
7. Adjusting voltage boost, as a percentage of the nominal supply voltage.
8. Selecting stopping mode and adjusting parameters.
9. Selecting motor thermal-overload protection class between 5 and 30.
10. Activating and deactivating protection modes.
11. Selecting or activating communications modes.

I. Digital Display: Front accessible; for showing motor, controller, and fault status; shall be manufacturer's standard and include not less than the following:

1. Controller Condition: Ready, starting, running, stopping.
2. Motor Condition: Amperes, voltage, power factor, power, and thermal state.
3. Fault Conditions: Controller thermal fault, motor overload alarm and trip, motor underload, overcurrent, shorted SCRs, line or phase loss, phase reversal, and line frequency over or under normal.

J. Controller Diagnostics and Protection:

1. Microprocessor-based thermal protection system for monitoring SCR and motor thermal characteristics and providing controller overtemperature and motor overload alarm and trip; settings selectable via the keypad.

2. Protection from line-side reverse phasing; line-side and motor-side phase loss; motor jam, stall, and underload conditions; and line frequency excursions to over- or under-normal. Accomplish protection by the following:

    a. Input isolation contactor that opens when the controller diagnostics detect a faulted solid-state component, or when the motor is stopped.
    b. Shunt trip that opens the disconnecting means when the controller diagnostics detect a faulted solid-state component.

K. Remote Output Features:

1. All outputs prewired to terminal blocks.
2. Form C status contacts that change state when controller is running.
3. Form C alarm contacts that change state when a fault condition occurs.

L. Overload Relays:

1. Melting-Alloy Overload Relays:

    a. Inverse-time-current characteristic.
    b. Class 10, Class 20 or Class 30 tripping characteristic as directed.
    c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.

2. Bimetallic Overload Relays:

    a. Inverse-time-current characteristic.
    b. Class 10, Class 20 or Class 30 tripping characteristic as directed.
    c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
    d. Ambient compensated.
    e. Automatic resetting.

3. Solid-State Overload Relays:

    a. Switch or dial selectable for motor-running overload protection.
    b. Sensors in each phase.
    c. Class 10, Class 20 or Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing as directed.
    d. UL 1053, Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
    e. Analog communication module.

M. Optional Features:

1. Analog output for field-selectable assignment of motor operating characteristics; 0- to 10-V dc or 4- to 20-mA dc as directed.
2. Two additional field-assignable Form C contacts for alarm outputs.
3. Full-voltage/BYPASS selector switch. Power contacts shall be totally enclosed, double break, made of silver-cadmium oxide, and assembled to allow inspection and replacement without disturbing line or load wiring.

2.9 VFC

A. Controller Units: Combination controllers, consisting of variable-frequency power converter that is factory packaged in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged for self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency. Comply with NEMA ICS 7, NEMA ICS 61800-2, UL 508C, and UL 508E.

1. Units suitable for operation of NEMA MG 1, Design A and Design B motors as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."
2. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
3. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.
4. Listed and labeled for single-phase use by an NRTL acceptable to authorities having jurisdiction.

B. Disconnects:

1. MCP:

a. UL 489, with interrupting capacity complying with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
b. Lockable Handle: For three padlocks and interlocks with cover in closed position.
c. Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
d. NC or NO alarm contact that operates only when MCP has tripped as directed.
e. Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.

2. MCCB:

a. UL 489, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
b. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
c. Lockable Handle: For three padlocks and interlocks with cover in closed position.
d. Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
e. NC or NO alarm contact that operates only when MCCB has tripped as directed.

3. Molded-Case Switch:

a. As directed, UL 489, with in-line fuse block for UL 248-8 Class J or UL 248-10 Class L power fuses (depending on ampere rating), providing an interrupting capacity to comply with available fault currents; MCCB with fixed, high-set instantaneous trip only.
b. Lockable Handle: For three padlocks and interlocks with cover in closed position.

c. Auxiliary contacts "a" and "b" arranged to activate with molded-case switch handle.
d. As directed, NC or NO alarm contact that operates only when molded-case switch has tripped.

4. Disconnect Rating: Not less than 115 percent of VFC input current rating.
5. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFC input current rating, whichever is larger.
6. Auxiliary Contacts: As directed, NC or NO, arranged to activate before switch blades open.
7. Auxiliary contacts "a" and "b" arranged to activate with circuit-breaker handle.
8. As directed, NC or NO alarm contact that operates only when circuit breaker has tripped.

C. Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus 10 or 15 percent of VFC input voltage rating as directed.
2. Input AC Voltage Unbalance: Not exceeding 3 or 5 percent as directed.
3. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
4. Minimum Efficiency: 96 or 97 percent at 60 Hz, full load as directed.
5. Minimum Displacement Primary-Side Power Factor: 96 or 98 percent under any load or speed condition as directed.
6. Overload Capability:

a. For variable-torque controllers, 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
b. For constant-torque controllers, 1.5 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.

7. Starting Torque: Minimum of 100 percent of rated torque from 3 to 60 Hz.
8. Speed Regulation: Plus or minus 5 or 10 percent as directed.
9. Output Carrier Frequency: Field selectable.
10. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.
11. Internal Adjustability Capabilities:

a. Minimum Speed: 5 to 25 percent of maximum rpm.
b. Maximum Speed: 80 to 100 percent of maximum rpm.
c. Acceleration: 0.1 to 999.9 seconds.
d. Deceleration: 0.1 to 999.9 seconds.
e. Current Limit: 30 to a minimum of 150 percent of maximum rating.

12. Self-Protection and Reliability Features:

a. Input surge protection by means of SPDs for three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
b. Loss of Input Signal Protection: Selectable response strategy including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
c. Under- and overvoltage trips.
d. Inverter overcurrent trips.

e. VFC and Motor Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC overtemperature and motor overload alarm and trip; settings selectable via the keypad; NRTL approved and listed and labeled by an NRTL.
f. Critical frequency rejection, with three selectable, adjustable deadbands.
g. Instantaneous line-to-line and line-to-ground overcurrent trips.
h. Loss-of-phase protection.
i. Reverse-phase protection.
j. Short-circuit protection.
k. Motor overtemperature fault.

13. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.
14. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

D. Operator Station:

1. Inverter Logic: Microprocessor based, 16 or 32 bit as directed, isolated from all power circuits.
2. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.
3. Panel-mounted, manufacturer's standard front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

a. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
b. Security Access: Electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.

E. Displays:

1. Historical Logging Information and Displays:

a. Real-time clock with current time and date.
b. Running log of total power versus time.
c. Total run time.
d. Fault log, maintaining last four faults with time and date stamp for each.

2. Indicating Devices: Digital display and additional readout devices as required, mounted flush in VFC door and connected to display VFC parameters including the following:

a. Output frequency (Hz).
b. Motor speed (rpm).
c. Motor status (running, stop, fault).
d. Motor current (amperes).
e. Motor torque (percentage).

f. Fault or alarming status (code).
g. PID feedback signal (percentage).
h. DC-link voltage (V dc).
i. Set-point frequency (Hz).
j. Motor output voltage (V ac).

F. Bypass Systems:

1. Bypass Operation: Safely transfers motor between power converter output and bypass circuit, manually, automatically, or both. Selector switches set modes, and indicator lights indicate mode selected. Unit is capable of stable operation (starting, stopping, and running) with motor completely disconnected from power converter.
2. Bypass Mode: Manual operation only; requires local operator selection at VFC. Transfer between power converter and bypass contactor and retransfer shall only be allowed with the motor at zero speed.
3. Bypass Mode: Field-selectable automatic or manual, allows local and remote transfer between power converter and bypass contactor and retransfer, either via manual operator interface or automatic control system feedback.
4. Bypass Controller: Two-contactor-style bypass allows motor operation via the power converter or the bypass controller; with input isolating switch and barrier arranged to isolate the power converter and permit safe troubleshooting and testing, both energized and de-energized, while motor is operating in bypass mode.

    a. Bypass Contactor: Load-break, IEC or NEMA-rated contactor as directed.
    b. Output Isolating Contactor: Non-load-break, IEC or NEMA-rated contactor.
    c. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.

5. Bypass Controller: Three-contactor-style bypass allows motor operation via the power converter or the bypass controller; with input isolating switch and barrier arranged to isolate the power converter input and output and permit safe testing and troubleshooting of the power converter, both energized and de-energized, while motor is operating in bypass mode.

    a. Bypass Contactor: Load-break, IEC or NEMA-rated contactor as directed.
    b. Input and Output Isolating Contactors: Non-load-break, IEC or NEMA-rated contactors as directed.
    c. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.

6. Bypass Contactor Classification: Full-voltage (across-the-line), Reduced-voltage autotransformer, open transition or Reduced-voltage autotransformer, closed transition type as directed.
7. NORMAL/BYPASS selector switch.

    a. HAND/OFF/AUTO selector switch.

b. NORMAL/TEST Selector Switch: Allows testing and adjusting of VFC while the motor is running in the bypass mode.
c. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.

1) Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
2) Power Contacts: Totally enclosed, double break, and silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.

8. Overload Relays: NEMA ICS 2.

a. Melting-Alloy Overload Relays:

1) Inverse-time-current characteristic.
2) Class 10, Class 20 or Class 30 tripping characteristic.
3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.

b. Bimetallic Overload Relays:

1) Inverse-time-current characteristic.
2) Class 10, Class 20 or Class 30 tripping characteristic as directed.
3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
4) Ambient compensated.
5) Automatic resetting.

c. Solid-State Overload Relays:

1) Switch or dial selectable for motor-running overload protection.
2) Sensors in each phase.
3) Class 10, Class 20 or Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing as directed.
4) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
5) Analog communication module.

d. NC or NO isolated overload alarm contact as directed.
e. External overload reset push button.

G. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

H. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.

I. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

J. Firefighter's Override (Smoke Purge) Input: On a remote contact closure from the firefighter's control station or smoke-control fan controller as directed, the following password-protected input:

1. Overrides all other local and external inputs (analog/digital, serial communication, and all keypad commands).
2. Forces VFC to operate motor, without any other run or speed command, at a field-adjustable, preset speed.
3. Forces VFC to transfer to bypass mode and operate motor at full speed.
4. Causes display of override mode on the VFC display.
5. Reset VFC to normal operation on removal of override signal automatically or manually as directed.

K. Communication Port: Ethernet, RS-232 port or USB 2.0 port or equivalent connection Capable of connecting a printer and a notebook computer.

2.10 CONTROLLER-MOUNTED AUXILIARY DEVICES

A. Control-Circuit and Pilot Devices: Factory installed in controller enclosure cover unless otherwise indicated. Comply with NEMA ICS 5.

1. Push Buttons, Pilot Lights, and Selector Switches: Heavy, Standard-duty, oiltight type as directed.

a. Push Buttons: Covered, Lockable, Recessed, Shielded, Shrouded or Unguarded types; maintained or momentary contact unless otherwise indicated.
b. Pilot Lights: LED, Resistor or Transformer types; push to test.
c. Selector Switches: Rotary type.

B. Elapsed-Time Meters: Heavy duty with digital readout in hours; nonresettable; resettable.

C. Meters: Panel type, 2-1/2-inch (64-mm) minimum size with 90- or 120-degree scale and plus or minus 2 percent accuracy, with selector switches having an off position.

D. Auxiliary Dry Contacts: NC, NO or Reversible NC/NO as directed.

E. Control Relays:

1. Time Delay: Auxiliary and adjustable pneumatic or solid-state time-delay relays.
2. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections and adjustable undervoltage, overvoltage, and time-delay settings.

2.11 MEASUREMENT AND CONTROL DEVICES

A. Instrument Transformers: IEEE C57.13, NEMA EI 21.1, and the following:

1. PTs: IEEE C57.13; 120 V, 60 Hz, single, tapped or double secondary as directed; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.
2. Current Transformers: IEEE C57.13; 5 A, 60 Hz, secondary; wound, bushing or bar or window type as directed; single or double secondary winding and secondary shorting device as directed. Burden and accuracy shall be consistent with connected metering and relay devices.
3. CPTs: Dry type, mounted in separate compartments for units larger than 3 kVA.
4. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, for selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker and ground-fault protection.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

1. Listed or recognized by a nationally recognized testing laboratory.
2. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.
3. Switch-selectable digital display of the following values with the indicated maximum accuracy tolerances:

    a. Phase Currents, Each Phase: Plus or minus 1 percent.
    b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
    c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
    d. Three-Phase Real Power (Megawatts): Plus or minus 2 percent.
    e. Three-Phase Reactive Power (Megavars): Plus or minus 2 percent.
    f. Power Factor: Plus or minus 2 percent.
    g. Frequency: Plus or minus 0.5 percent.
    h. Accumulated Energy, Megawatt Hours: Plus or minus 2 percent; accumulated values unaffected by power outages up to 72 hours.
    i. Megawatt Demand: Plus or minus 2 percent; demand interval programmable from 5 to 60 minutes.
    j. Contact devices to operate remote impulse-totalizing demand meter.

4. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

C. Ammeters, Voltmeters, and Power-Factor Meters: ANSI C39.1. 4-inch (100-mm) diameter or 6 inches (150 mm) square, flush or semiflush, with antiparallax 250-degree scale and external zero adjustment.

1. Voltmeters: Cover an expanded-scale range of nominal voltage plus 10 percent.
2. Feeder Ammeters: 2-1/2-inch (64-mm) minimum size with 90- or 120-degree scale. Meter and transfer device with off position, located on overcurrent device door for feeder circuits, unless otherwise indicated.

D. Instrument Switches: Rotary type with off position.

1. Voltmeter Switches: Permit reading of all phase-to-phase voltages and phase-to-neutral voltages where a neutral is included.

2. Ammeter Switches: Permit reading of current in each phase and maintain current-transformer secondaries in a closed-circuit condition at all times.

E. Watt-Hour Meters and Wattmeters:

1. Comply with ANSI C12.1.
2. Three-phase induction type with two stators, each with current and potential coil, rated 5 A, 120 V, 60 Hz.
3. Suitable for connection to three- and four-wire circuits.
4. Potential indicating lamps.
5. Adjustments for light and full load, phase balance, and power factor.
6. Four-dial clock register.
7. Integral demand indicator.
8. Contact devices to operate remote impulse-totalizing demand meter.
9. Ratchets to prevent reverse rotation.
10. Removable meter with drawout test plug.
11. Semiflush mounted case with matching cover.
12. Appropriate multiplier tag.

F. Impulse-Totalizing Demand Meter:

1. Comply with ANSI C12.1.
2. Suitable for use with MCC watt-hour meter, including two-circuit totalizing relay.
3. Cyclometer.
4. Four-dial, totalizing kilowatt-hour register.
5. Positive chart drive mechanism.
6. Capillary pen holding a minimum of one month's ink supply.
7. Roll chart with minimum 31-day capacity; appropriate multiplier tag.
8. Capable of indicating and recording five, 15 or 30-minute integrated demand of totalized system as directed.

G. Control Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

2.12 FEEDER TAP UNITS

A. MCCBs (to 1200 A): Fixed mounted, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger. Comply with UL 489, and NEMA AB 3, with interrupting capacity to comply with available fault currents.

1. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
2. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:

    a. Instantaneous trip.
    b. Long- and short-time pickup levels.
    c. Long- and short-time time adjustments.
    d. Ground-fault pickup level, time delay, and I^2t response.

3. Communication Capability: As directed, Circuit-breaker-mounted, Universal-mounted, Integral or Din-rail-mounted communication module with functions and features compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."
4. With built-in digital ammeter and a digital display, showing tripping cause.
5. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
7. Auxiliary Contacts: As directed, One SPDT switch or Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
8. Alarm Switch: As directed, One NC or NO contact that operates only when circuit breaker has tripped.
9. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
10. Zone-Selective Interlocking: Integral with electronic or ground-fault trip unit as directed; for interlocking ground-fault protection function.
11. Electrical Operator: Remote control for on, off, and reset operations.

B. Fusible Switches (to 600 A): Fixed-mounted, manually operated, electrically tripped, fusible, quick-make, quick-break switch with 200-kA interrupting and short-circuit current rating when fitted with UL 248-8 Class J fuses. Comply with UL 98.

1. Indication whether the switch is open or closed, and provisions for padlocking the operating handle.
2. Include fuse clips and fuses.
3. Electrically tripped switches shall include the following:

    a. Shunt trip.
    b. Ground-fault protection, with adjustable time delay and test panel.
    c. Single-phase protection, tripping the switch on loss of a source phase.
    d. Blown fuse protection, tripping the switch on a blown fuse, with blown fuse indication.

2.13 SOURCE QUALITY CONTROL

A. MCC Testing: Test and inspect MCCs according to requirements in NEMA ICS 18.

B. MCCs will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION

A. NEMA Industrial Control and Systems Standards: Comply with parts of NEMA ICS 2.3 for installation and startup of MCCs.

B. Floor Mounting: Install MCCs on 4-inch (100-mm) nominal-thickness concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed

C. Seismic Bracing: Comply with requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

E. Install fuses in control circuits if not factory installed. Comply with requirements in Section 262813 "Fuses."

F. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.

G. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

H. Install power factor correction capacitors. As directed, Connect to the line or load side of overload relays. If connected to the load side of overload relays, adjust overload heater sizes to accommodate the reduced motor full-load currents.

I. Comply with NECA 1.

J. Comply with requirements in Section 260553 "Identification for Electrical Systems" for identification of MCC, MCC components, and control wiring.

1. Identify field-installed conductors, interconnecting wiring, and components.
2. Install required warning signs.
3. Label MCC and each cubicle with engraved nameplate.
4. Label each enclosure-mounted control and pilot device.

3.2 CONTROL WIRING INSTALLATION

A. Install wiring between enclosed controllers or master terminal boards and remote devices and facility's BAS and facility's central-control system as directed. Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic-control selection devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switch is in manual-control position.
2. Connect selector switches within enclosed controller circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.3 CONNECTIONS

A. Comply with requirements for installation of conduit in Section 260533 "Raceways and Boxes for Electrical Systems." Drawings indicate general arrangement of conduit, fittings, and specialties.

B. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed controller, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
4. Perform the following infrared (thermographic) scan tests and inspections and prepare reports:

    a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each multipole enclosed controller. Remove front panels so joints and connections are accessible to portable scanner.
    b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each multipole enclosed controller 11 months after date of Substantial Completion.
    c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Submit calibration record for device.

5. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
6. Mark up a set of manufacturer's drawings with all field modifications incorporated during construction and return to manufacturer for inclusion in Record Drawings.

D. MCCs will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.5 ADJUSTING

A. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload relay pickup and trip ranges.

B. Adjust overload relay heaters or settings if power factor correction capacitors are connected to the load side of the overload relays.

C. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to six times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Architect, Construction Manager or Owner before increasing settings.

D. Set the taps on reduced-voltage autotransformer controllers at 50, 65 or 80 percent as directed.

E. Set field-adjustable switches and program microprocessors for required start and stop sequences in reduced-voltage, solid-state controllers.

F. Program microprocessors in VFCs for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

G. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573.16 "Coordination Studies."

3.6 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers, and to use and reprogram microprocessor-based, reduced-voltage, solid-state controller.

END OF SECTION 262419

SECTION 262500 - ENCLOSED BUS ASSEMBLIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Feeder-bus assemblies.
2. Plug-in bus assemblies.
3. Bus plug-in devices.

1.2 ACTION SUBMITTALS

A. Shop Drawings: For each type of product.

1. Show fabrication and installation details for enclosed bus assemblies. Include plans, elevations, and sections of components. Designate components and accessories, including clamps, brackets, hanger rods, connectors, straight lengths, and fittings.
2. Show fittings, materials, fabrication, and installation methods for listed firestop barriers and or weather barriers.
3. Indicate required clearances, method of field assembly, and location and size of each field connection.
4. Detail connections to switchgear, switchboards, transformers, and panelboards.
5. Cable and conductor terminal sizes for bus and plug-in device terminations.
6. Wiring Diagrams: Power and signal and control, signal, and control wiring.

B. Delegated-Design Submittal: For seismic-restraint details, signed and sealed by a qualified professional engineer.

1. Include design calculations for selecting seismic restraints.
2. Detail fabrication, including anchorages and attachments to structure and to supported equipment.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and sections, drawn to scale. Include scaled bus-assembly layouts and relationships between components and adjacent structural, mechanical, and electrical elements.

B. Qualification Data: For testing agency.

C. Seismic Qualification Certificates: For enclosed bus assemblies, plug-in devices, accessories, and components.

D. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle enclosed bus assemblies according to NEMA BU 1.1, "General Instructions for Handling, Installation, Operation, and Maintenance of Busway Rated 600 Volts or Less."

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTIONS

A. Source Limitations: Obtain enclosed bus assemblies and plug-in devices from single source from single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency and marked for intended location and application.

C. Comply with UL 857.

2.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design enclosed bus assemblies, plug-in devices, and components.

B. Seismic Performance: Enclosed bus assemblies, plug-in devices, and components shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 or 1.0 as directed.

C. Derate enclosed bus assemblies for continuous operation at indicated ampere ratings for ambient temperature not exceeding 122 deg F (50 deg C) or 140 deg F (60 deg C) as directed.

2.3 ENCLOSED BUS ASSEMBLIES

A. Feeder-Bus Assemblies: Low-impedance bus assemblies in totally enclosed, nonventilated housing; single-bolt joints; ratings as indicated.

1. Seismic Fabrication Requirements: Fabricate mounting provisions and attachments for feeder-bus assemblies with reinforcement strong enough to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems" when mounting provisions and attachments are anchored to building structure
2. Electrical Characteristics:

    a. Voltage: 120/208, 240, 480 or 277/480 V as directed.
    b. Phase: Three; 3 wire or 4 wire as directed.
    c. Percent of Neutral Capacity: 50, 100 or 200 as directed.

3. Short-Circuit Interrupting Rating:

    a. For Bus Amperage of 800: 85 symmetrical kAIC.
    b. For Bus Amperage of 1200: 100 symmetrical kAIC.
    c. For Bus Amperage of 1600: 125 symmetrical kAIC.
    d. For Bus Amperage of 2500: 150 symmetrical kAIC.
    e. For Bus Amperage of 5000: 200 symmetrical kAIC.

4. Temperature Rise: 55 deg C above 40 deg C ambient maximum for continuous rated current.
5. Bus Materials: As directed, Current-carrying copper or aluminum conductors, fully insulated with Class 130C insulation except at joints; plated surface at joints.
6. Voltage Drop:

    a. Measure voltage drop at 30 deg C ambient with bus thermally stabilized at full rated load.
    b. Three-phase, line-to-line voltage drop less than 3.1 V per 100 feet (30.5 m) at 40 percent power factor.

7. Ground: 50 percent capacity, integral with housing.
8. Ground: 50 percent capacity, internal bus bar of material matching bus material.
9. Ground: 50 percent capacity, isolated, internal bus bar of material matching bus material.
10. Enclosure: As directed, Steel or Aluminum, with manufacturer's standard finish. Weatherproof, sealed seams, drains, and removable closures.
11. Fittings and Accessories: Manufacturer's standard.
12. Firestop: Comply with UL 1479 firestop system, listed and labeled by an NRTL acceptable to authorities having jurisdiction for penetrations of fire-rated walls, ceilings, and floors.
13. Mounting: Arranged flat, edgewise, or vertically without derating. Rated for hanger spacing of up to 10 feet (3 m) for horizontally mounted runs and up to 16 feet (5 m) for vertically mounted runs.
14. Expansion Section: Manufacturer's standard expansion fitting for the provided busway with expansion capability to accommodate thermal expansion of bus and enclosure, and to accommodate movement across building expansion joints.

B. Plug-in Bus Assemblies: Low-impedance bus assemblies in totally enclosed, nonventilated housing; single-bolt joints; ratings as indicated.

1. Electrical Characteristics:

    a. Voltage: 120/208, 240, 480 or 277/480 V as directed.
    b. Phase: Three; 3 wire or 4 wire as directed.
    c. Percent of Neutral Capacity: 100 or 200 as directed.

2. Short-Circuit Interrupting Rating:

    a. For Bus Amperage of 800: 85 symmetrical kAIC.
    b. For Bus Amperage of 1200: 100 symmetrical kAIC.
    c. For Bus Amperage of 1600: 125 symmetrical kAIC.
    d. For Bus Amperage of 2500: 150 symmetrical kAIC.
    e. For Bus Amperage of 5000: 200 symmetrical kAIC.

3. Temperature Rise: 55 deg C above 40 deg C ambient maximum for continuous rated current.
4. Bus Materials: As directed, Current-carrying copper or aluminum conductors, fully insulated with Class 130C insulation except at stabs and joints; plated surface at stabs and joints.
5. Ground: 50 percent capacity, integral with housing.
6. Ground: 50 percent capacity, internal bus bar of material matching bus material.
7. Ground: 50 percent capacity, isolated, internal bus bar of material matching bus material.
8. Enclosure: As directed, Steel or Aluminum, with manufacturer's standard finish.
9. Plug-in Openings: 24 inches (600 mm) o.c. on each side of bus, and hinged covers over unused openings. Plug-in openings shall be finger-safe with covers open or closed.
10. Fittings and Accessories: Manufacturer's standard.
11. Firestop: Comply with UL 1479 firestop system, listed and labeled by an NRTL acceptable to authorities having jurisdiction for penetrations of fire-rated walls, ceilings, and floors.
12. Mounting: Arranged flat, edgewise, or vertically without derating. Rated for hanger spacing of up to 10 feet (3 m) for horizontally mounted runs and up to 16 feet (5 m) for vertically mounted runs.
13. Expansion Section: Manufacturer's standard expansion fitting for the provided busway with expansion capability to accommodate thermal expansion of bus and enclosure, and to accommodate movement across building expansion joints.

C. Joints:

1. Busway joints shall use one high-strength steel bolt with Belleville washers.
2. Bolts shall be torque indicating type and at ground potential.
3. Bolts shall be two-headed design to indicate when proper torque has been applied and require only a standard long handle wrench to be properly activated.
4. Access shall be required to only one side of the busway for tightening joint bolts.
5. Joint connection assemblies shall be removable without disturbing adjacent busway lengths.
6. Joint connection assemblies that rely on the joint cover to provide ground continuity are unacceptable.

2.4 PLUG-IN DEVICES

A. Fusible Switches: As directed, NEMA KS 1, heavy duty; with R-type rejection, J-type or L-type fuse clips to accommodate specified fuses; hookstick-operated handle, lockable with two padlocks, and interlocked with cover in closed position. Interlocked to prevent plug-in device insertion into or removal from bus with switch in closed position. See Section 262813 "Fuses" for fuses and fuse installation requirements.

B. Molded-Case Circuit Breakers: UL 489; hookstick-operated handle, lockable with two padlocks, and interlocked with cover in closed position. Interlocked to prevent plug-in device insertion into or removal from bus with switch in closed position.

C. Accessories: Hookstick operator, adjustable to maximum extension of 14 feet (4.3 m).

PART 3 - EXECUTION

3.1 INSTALLATION

A. Coordinate layout and installation of enclosed bus assemblies and suspension system with other construction that penetrates ceilings or floors or is supported by them, including luminaires, HVAC equipment, fire-suppression system, and partition assemblies.

B. Equipment Mounting:

1. Install enclosed bus assemblies on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed
2. Coordinate size and location of concrete curbs around openings for vertical bus. Concrete, reinforcement, and formwork requirements are specified with concrete.

C. Support bus assemblies independent of supports for other elements such as equipment enclosures at connections to panelboards and switchboards, pipes, conduits, ceilings, and ducts.

1. Design each fastener and support to carry load indicated by seismic requirements and to comply with seismic-restraint details according to Section 260548.16 "Seismic Controls for Electrical Systems."
2. Design each fastener and support to carry 200 lb (90 kg) or 4 times the weight of bus assembly, whichever is greater.
3. Support bus assembly to prevent twisting from eccentric loading.
4. Support bus assembly with not less than 3/8-inch (10-mm) steel rods. Install side bracing to prevent swaying or movement of bus assembly. Modify supports after completion to eliminate strains and stresses on bus bars and housings.
5. Fasten supports securely to building structure according to Section 260529 "Hangers and Supports for Electrical Systems."
6. Bolts and nuts that are loosened for any reason after tightening to manufacturer's recommended torque setting shall be discarded and replaced with new bolts and nuts.

D. Install expansion fittings at locations where bus assemblies cross building expansion joints. Install at other locations so distance between expansion fittings does not exceed manufacturer's recommended distance between fittings.

E. Construct rated firestop assemblies where bus assemblies penetrate fire-rated elements such as walls, floors, and ceilings. Seal around penetrations according to Section 078413 "Penetration Firestopping."

F. Install weatherseal fittings and flanges where bus assemblies penetrate exterior elements such as walls or roofs. Seal around openings to make weathertight. See Section 079200 "Joint Sealants" for materials and application.

G. Coordinate bus-assembly terminations to equipment enclosures to ensure proper phasing, connection, and closure.

H. Tighten bus-assembly joints with torque wrench or similar tool recommended by bus-assembly manufacturer. Tighten joints again after bus assemblies have been energized for 30 days.

I. Install bus-assembly, plug-in units. Support connecting conduit independent of plug-in unit.

J. Comply with NECA 1.

3.2 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Terminate to transformer enclosures with matching bus assemblies according to Section 262200 "Low-Voltage Transformers."

D. Terminate to switchgear enclosures with matching bus assemblies according to Section 262300 "Low-Voltage Switchgear."

E. Terminate to switchboard enclosures with matching bus assemblies according to Section 262413 "Switchboards."

F. Terminate to panelboard enclosures with matching bus assemblies according to Section 262416 "Panelboards."

G. Terminate to motor-control centers enclosures with matching bus assemblies according to Section 262419 "Motor-Control Centers."

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. After installing equipment test, for compliance with requirements according to NETA ATS.
2. Visual and Mechanical Inspection:

    a. Compare equipment nameplate data with Drawings and Specifications.
    b. Inspect physical and mechanical condition.
    c. Inspect anchorage, alignment, and grounding.
    d. Verify correct connection according to single-line diagram.
    e. Inspect bolted electrical connections for high resistance using one or more of the following methods:

        1) Use of low-resistance ohmmeter.
        2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data.
        3) Perform thermographic survey.

3. Electrical Tests:

    a. Perform insulation resistance measurements through bolted connections and bus joints with low-resistance ohmmeter.
    b. Perform insulation resistance tests of each busway, phase to phase, and phase to ground.
    c. Perform a dielectric withstand voltage test on each busway, phase to ground with phases not under test grounded for one minute.
    d. Measure resistance of assembled busway sections on insulated busway and compare values with adjacent phases.
    e. Perform phasing test on each busway tie section energized by separate sources.
    f. Verify operation of busway space heaters.

B. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.

1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
2. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
3. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.

C. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

D. Enclosed bus assemblies will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION 262500

SECTION 262713 - ELECTRICITY METERING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes electricity metering, work to accommodate utility company revenue meters, and Owner's electricity meters used to manage the electrical power system.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For electricity-metering equipment.

1. Include elevation views of front panels of control and indicating devices and control stations.
2. Include diagrams for power, signal, and control wiring.
3. Wire Termination Diagrams and Schedules: Include diagrams for power, signal, and control wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features. Differentiate between manufacturer-installed and field-installed wiring.
4. Include series-combination rating data for modular meter centers with main disconnect device.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Submit evidence that meters are compatible with connected monitoring and control devices and systems specified in Section 260913 "Electrical Power Monitoring and Control."

B. Field quality-control reports.

C. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An NRTL.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of metering equipment that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Cost to repair or replace any parts for two years from date of Substantial Completion.
2. Extended Warranty Period: Cost of replacement parts (materials only, f.o.b. the nearest shipping point to Project site), for eight years, that failed in service due to transient voltage surges.

1.7 COORDINATION

A. Electrical Service Connections: Coordinate with utility companies and utility-furnished components.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with UL 916.

2.2 UTILITY METERING INFRASTRUCTURE

A. Install metering accessories furnished by the utility company, complying with its requirements.

B. Utility-Furnished Meters: Connect data transmission facility of metering equipment installed by the Utility.

1. Data Transmission: Transmit pulse data over control-circuit conductors, classified as Class 1 per NFPA 70, Article 725. Comply with Section 260523 "Control-Voltage Electrical Power Cables."

C. Current-Transformer Cabinets: Comply with requirements of electrical-power utility company.

D. Meter Sockets:

1. Comply with requirements of electrical-power utility company.
2. Meter Sockets: Steady-state and short-circuit current ratings shall meet indicated circuit ratings.

E. Modular Meter Center: As directed, Factory-coordinated assembly of a main service terminal box with lugs only or disconnect device, wireways, meter socket modules, and feeder circuit breakers arranged in adjacent vertical sections complete with interconnecting buses.
1. Comply with requirements of utility company for meter center.

a. Comply with UL 67.

2. Housing: NEMA 250, Type 1, Type 3R or Type 4X enclosure as directed.
3. Meter Socket Rating: Coordinated with connected feeder circuit rating.
4. Minimum Short-Circuit Rating: As directed, 22,000, 42,000, 65,000 or 100,000 A symmetrical at rated voltage.
5. Steady-state and short-circuit current ratings shall have ratings that match connected circuit ratings.
6. Main Disconnect Device: Circuit breaker, series-combination rated for use with downstream feeder and branch circuit breakers and having an adjustable magnetic trip setting for circuit-breaker frame sizes of 250 A and larger. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers." Circuit breakers shall be operable from outside the enclosure to disconnect the unit. Configure cover so it can be opened only when the disconnect switch is open.
7. Main Disconnect Device: Fusible switch, UL 98 Type GD, series-combination rated by fuse manufacturer to protect downstream feeder and branch circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers." Switch shall be operable from outside the enclosure to disconnect the unit. Configure cover so that it can be opened only when the disconnect switch is open.
8. Feeder Circuit Breakers: Series-combination-rated molded-case units, rated to protect downstream circuit breakers and to house load centers and panelboards that have 10,000-A interrupting capacity.

    a. Identification: Complying with requirements in Section 260553 "Identification for Electrical Systems."
    b. Physical Protection: Tamper resistant, with hasp for padlock.

9. Surge Protection for Main Disconnect: Factory installed, integrally mounted, UL 1449 Type 1. Comply with Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."
10. Surge Protection at Main Terminal Box: Factory installed, integrally mounted, UL 1449 Type 1. Comply with Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."

F. Arc-Flash Warning Labels:

1. Labels: Comply with requirements for "Arc-Flash Warning Labels" in Section 260573.19 "Arc-Flash Hazard Analysis." Apply a properly sized self-adhesive label at each work location included in the analysis.
2. Labels: Comply with requirements for "Self-Adhesive Equipment Labels" and "Signs" in Section 260553 "Identification for Electrical Systems." Apply a properly sized self-adhesive label for each work location included in the analysis. Labels shall be machine printed, with no field-applied markings.

    a. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:

        1) Location designation.
        2) Nominal voltage.
        3) Flash protection boundary.

4) Hazard risk category.
5) Incident energy.
6) Working distance.
7) Engineering report number, revision number, and issue date.

2.3 ELECTRICITY METERS

A. System Description: Able to meter designated activity loads, with or without external alarm, control, and communication capabilities, or other optional features.

B. Standard: Comply with ANSI C12.1 and ANSI C12.20, 0.2, 0.5 or 1.0 accuracy class as directed.

1. Ambient Temperature: Minus 22 deg F to plus 158 deg F (Minus 30 deg C to plus 70 deg C).
2. Humidity: Zero to 95 percent, noncondensing.
3. Capacities and Characteristics:

    a. Circuit: 120/240-V ac, 100 A.
    b. Measure: kWh, onboard LED display.
    c. Remote-Reading Options: None.

C. General Requirements for Meters:

1. Meters Certification: Certified by California Type Evaluation Program as complying with 4 CCR 4027, Article 2.2.
2. Certify that meters comply with ANSI C12.20 requirements by a laboratory accredited by the National Voluntary Laboratory Accreditation Program (NVLAP) of the National Institute of Standards and Technology (NIST). The laboratory shall use test equipment that is certified annually and is traceable to NIST standards.
3. Enclosure: Supplied by meter manufacturer, NEMA 250, Type 1, Type 3R or Type 4X minimum as directed, with provisions for locking or sealing.
4. Identification: Comply with requirements in Section 260553 "Identification for Electrical Systems."
5. Onboard Nonvolatile Data Storage: kWh, until reset.
6. Sensors: Current-sensing type, supplied by electronic meter manufacturer, with current or voltage output, selected for optimum range and accuracy for meters indicated for this application.

    a. Type: Split and solid core, complying with recommendation of meter manufacturer.

D. kWh Meter: Electronic single-phase and three-phase meters, measuring electricity use.

1. Voltage and Phase Configuration: Meter shall be designed for use on circuits with voltage rating and phase configuration indicated for its application.
2. Display: LCD with characters not less than 0.25 inch (6 mm) high, indicating accumulative kWh and current kilowatt load. Retain accumulated kWh in a nonvolatile memory, until reset.
3. Display: Digital electromechanical counter, indicating accumulative kWh.

E. KY and KYZ Pulse Totalizer:

1. Pulse Totalizer: An instrument for demand and billing applications where one or more utility revenue meters stream KY or KYZ energy pulses. The instrument shall totalize kWh accumulated over the user-selected period and shall log the maximum and minimum kWhd for that period. Record each period with a date/time stamp. Time period shall be user selected from one to 60 minutes.

    a. Pulse Input: One, individually programmable, KYZ Form C (three-wire) contact pulse channels. Pulse interval, pulse rate, and minimum pulse width shall be field adjustable, set for the pulse stream provided by the utility revenue meter.
    b. Data Totalizing Capacity of Each Channel: Not less than 149 days at 15-minute intervals.
    c. Instrument Power: User selectable, 120-V and 277-V ac.
    d. Clock: Line frequency.

F. Remote Reading Options:

1. Pulse Output: As directed, KY or KYZ, complete with optical sensor and interface devices.
2. Serial Interface: RS-232.
3. Serial Interface: RS-485, with Modbus RTU protocol.
4. USB interface.
5. TCP/IP adapter.

G. Current-Transformer Cabinet: Size and configuration as recommended by metering equipment manufacturer for use with indicated connected feeder and sensors.

H. Data Transmission Cable: Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with equipment installation requirements in NECA 1.

B. Install meters furnished by utility company. Install raceways and equipment according to utility company's written instructions. Provide empty conduits for metering leads and extend grounding connections as required by utility company.

C. Install modular meter center according to switchboard installation requirements in NECA 400.

D. Install arc-flash labels as required by NFPA 70.

E. Wiring Method:

1. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

2. Install unshielded, twisted-pair cable for control and signal transmission conductors, complying with Section 271513 "Communications Copper Horizontal Cabling."
3. Minimum conduit size shall be 1/2 inch (13 mm).

F. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.2 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections with the assistance of a factory-authorized service representative.

C. Tests and Inspections:

1. Equipment and Software Setup:

   a. Set meter date and time clock.
   b. Test, calibrate, and connect pulse metering system.
   c. Set and verify billing demand interval for demand meters.
   d. Report settings and calibration results.
   e. Set up reporting and billing software, insert billing location names and initial constant values and variable needed for billing computations.

2. Connect a load of known kilowatt rating, 1.5 kW minimum, to a circuit supplied by metered feeder.
3. Turn off circuits supplied by metered feeder and secure them in off condition.
4. Run test load continuously for eight hours minimum, or longer, to obtain a measurable meter indication. Use test-load placement and setting that ensures continuous, safe operation.
5. Check and record meter reading at end of test period and compare with actual electricity used, based on test-load rating, duration of test, and sample measurements of supply voltage at test-load connection. Record test results.
6. Generate test report and billing for each tenant or activity from the meter reading tests.

D. Electricity metering will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION 262713

SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Standard-grade receptacles, 125 V, 15 or 20 A as directed.
2. USB receptacles.
3. GFCI receptacles, 125 V, 20 A.
4. Toggle switches, 120/277 V, 15 or 20 A as directed.
5. Decorator-style devices, 15 or 20 A as directed.
6. Occupancy sensors.
7. Digital timer light switches.
8. Residential devices.
9. Wall-box dimmers.
10. Wall plates.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: List of legends and description of materials and process used for pre-marking wall plates.

C. Samples: One for each type of device and wall plate specified, in each color specified.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 GENERAL WIRING-DEVICE REQUIREMENTS

A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. Comply with NFPA 70.

C. RoHS compliant.

D. Comply with NEMA WD 1.

E. Device Color:

1. Wiring Devices Connected to Normal Power System: Almond, Black, Brown, Gray, Ivory, White or as selected by Architect unless otherwise indicated or required by NFPA 70 or device listing.
2. Wiring Devices Connected to Essential Electrical System: Red.
3. SPD Devices: Blue.
4. Isolated-Ground Receptacles: Orange or as specified above, with orange triangle on face.

F. Wall Plate Color: For plastic covers, match device color.

G. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 STANDARD-GRADE RECEPTACLES, 125 V, 20 A

A. Duplex Receptacles, 125 V, 20 A:
1. Description: Two pole, three wire, and self-grounding.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Standards: Comply with UL 498 and FS W-C-596.

B. Tamper-Resistant Duplex Receptacles, 125 V, 20 A:
1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Standards: Comply with UL 498 and FS W-C-596.
4. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" Article.

C. Weather-Resistant Duplex Receptacle, 125 V, 20 A:
1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Standards: Comply with UL 498.
4. Marking: Listed and labeled as complying with NFPA 70, "Receptacles in Damp or Wet Locations" Article.

D. Tamper- and Weather-Resistant Duplex Receptacles, 125 V, 20 A:
1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
2. Configuration: NEMA WD 6, Configuration 5-20R.
3. Standards: Comply with UL 498.
4. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" and "Receptacles in Damp or Wet Locations" articles.

2.3 STANDARD-GRADE RECEPTACLES, 125 V, 15 A

A. Duplex Receptacles, 125 V, 15 A:
1. Description: Two pole, three wire, and self-grounding.

2. Configuration: NEMA WD 6, Configuration 5-15R.
3. Standards: Comply with UL 498 and FS W-C-596.

B. Tamper-Resistant Duplex Receptacles, 125 V, 15 A:
1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle.
2. Configuration: NEMA WD 6, Configuration 5-15R.
3. Standards: Comply with UL 498 and FS W-C-596.
4. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" Article.

C. Weather-Resistant Duplex Receptacle, 125 V, 15 A:
1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
2. Configuration: NEMA WD 6, Configuration 5-15R.
3. Standards: Comply with UL 498.
4. Marking: Listed and labeled as complying with NFPA 70, "Receptacles in Damp or Wet Locations" Article.

D. Tamper- and Weather-Resistant Duplex Receptacles, 125 V, 15 A:
1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
2. Configuration: NEMA WD 6, Configuration 5-15R.
3. Standards: Comply with UL 498.
4. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" and "Receptacles in Damp or Wet Locations" articles.

2.4 USB RECEPTACLES

A. USB Charging Receptacles:
1. Description: Single-piece, rivetless, nickel-plated, all-brass grounding system. Nickel-plated, brass mounting strap.
2. USB Receptacles: Dual and quad, USB Type A, 5 V dc, and 2.1 A per receptacle (minimum).
3. Standards: Comply with UL 1310 and USB 3.0 devices.

B. Tamper-Resistant Duplex and USB Charging Receptacles:
1. Description: Single-piece, rivetless, nickel-plated, all-brass grounding system. Nickel-plated, brass mounting strap. Integral shutters that operate only when a plug is inserted in the line voltage receptacle.
2. Line Voltage Receptacles: Two pole, three wire, and self-grounding; NEMA WD 6, Configuration 5-20R.
3. USB Receptacles: Dual USB Type A, 5 V dc, and 2.1 A per receptacle (minimum).
4. Standards: Comply with UL 498, UL 1310, USB 3.0 devices, and FS W-C-596.
5. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" Article.

2.5 GFCI RECEPTACLES, 125 V, 20 A

A. Duplex GFCI Receptacles, 125 V, 20 A:
   1. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding.
   2. Configuration: NEMA WD 6, Configuration 5-20R.
   3. Type: Feed or Non-feed through.
   4. Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.

B. Tamper-Resistant Duplex GFCI Receptacles, 125 V, 20 A:
   1. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle.
   2. Configuration: NEMA WD 6, Configuration 5-20R.
   3. Type: Feed or Non-feed through as directed.
   4. Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.
   5. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" Article.

C. Tamper- and Weather-Resistant, GFCI Duplex Receptacles, 125 V, 20 A:
   1. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
   2. Configuration: NEMA WD 6, Configuration 5-15R.
   3. Type: Feed or Non-feed through as directed.
   4. Standards: Comply with UL 498 and UL 943 Class A.
   5. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" and "Receptacles in Damp or Wet Locations" articles.

2.6 TOGGLE SWITCHES, 120/277 V, 15 A

A. Single-Pole Switches, 120/277 V, 15 A:
   1. Standards: Comply with UL 20 and FS W-S-896.

B. Two-Pole Switches, 120/277 V, 15 A:
   1. Comply with UL 20 and FS W-S-896.
   2. Description: Contact surfaces treated with a coating that kills 99.9 percent of certain common bacteria within two hours when regularly and properly cleaned.
   3. Standards: Comply with UL 20 and FS W-S-896.

C. Three-Way Switches, 120/277 V, 15 A:
   1. Comply with UL 20 and FS W-S-896.

D. Four-Way Switches, 120/277 V, 15 A:
   1. Standards: Comply with UL 20 and FS W-S-896.

E. Pilot-Light, Single-Pole Switches: 120/277 V, 15 A:
   1. Description: Illuminated when switch is on or off as directed.
   2. Standards: Comply with UL 20 and FS W-S-896.

F. Lighted Single-Pole Switches, 120/277 V, 15 A:
   1. Description: Handle illuminated when switch is on or off as directed.
   2. Standards: Comply with NEMA WD 1, UL 20, and FS W-S-896.

2.7 TOGGLE SWITCHES, 120/277 V, 20 A

A. Single-Pole Switches, 120/277 V, 20 A
   1. Standards: Comply with UL 20 and FS W-S-896.

B. Two-Pole Switches, 120/277 V, 20 A:
   1. Comply with UL 20 and FS W-S-896.

C. Three-Way Switches, 120/277 V, 20 A:
   1. Comply with UL 20 and FS W-S-896.

D. Four-Way Switches, 120/277 V, 20 A:
   1. Standards: Comply with UL 20 and FS W-S-896.

E. Lighted Single-Pole Switches, 120/277 V, 20 A:
   1. Description: Handle illuminated when switch is on or off as directed.
   2. Standards: Comply with NEMA WD 1, UL 20, and FS W-S-896.

2.8 DECORATOR-STYLE DEVICES, 15 A

A. Decorator Duplex Receptacles, 125 V, 15 A:
   1. Description: Two pole, three wire, and self-grounding. Square face.
   2. Configuration: NEMA WD 6, Configuration 5-15R.
   3. Standards: Comply with UL 498.

B. Decorator, Tamper-Resistant, Duplex Receptacles, 125 V, 15 A:
   1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
   2. Configuration: NEMA WD 6, Configuration 5-15R.
   3. Standards: Comply with UL 498.
   4. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" Article.

C. Decorator, Tamper- and Weather-Resistant, Duplex Receptacles, 125 V, 15 A:
   1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
   2. Configuration: NEMA WD 6, Configuration 5-15R.
   3. Standards: Comply with UL 498.
   4. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" and "Receptacles in Damp or Wet Locations" articles.

D. Decorator Single-Pole Switches, 120/277 V, 15 A:
   1. Comply with UL 20.

E. Decorator Single-Pole Lighted Switches,120/277 V, 15 A:

1. Description: Square face illuminated when circuit is switched off.
2. Standards: Comply with UL 20.

2.9 DECORATOR-STYLE DEVICES, 20 A

A. Decorator Duplex Receptacles, 125 V, 20 A:
   1. Description: Two pole, three wire, and self-grounding. Square face.
   2. Configuration: NEMA WD 6, Configuration 5-20R.
   3. Standards: Comply with UL 498.

B. Decorator Tamper-Resistant Duplex Receptacles, 125 V, 20 A:
   1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
   2. Configuration: NEMA WD 6, Configuration 5-20R.
   3. Standards: Comply with UL 498.
   4. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" Article.

C. Decorator, Tamper- and Weather-Resistant, Duplex Receptacles, 125 V, 20 A:
   1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
   2. Configuration: NEMA WD 6, Configuration 5-20R.
   3. Standards: Comply with UL 498.
   4. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" and "Receptacles in Damp or Wet Locations" articles.

D. Decorator Single-Pole Switches, 120/277 V, 20 A:
   1. Comply with UL 20.

E. Decorator Single-Pole Lighted Switches,120/277 V, 20 A:
   1. Description: Square face illuminated when circuit is switched off.
   2. Standards: Comply with UL 20.

2.10 OCCUPANCY SENSORS

A. Wall Switch Sensor Light Switch, Dual Technology:
   1. Description: Switchbox-mounted, combination lighting-control sensor and conventional switch lighting-control unit using dual (ultrasonic and passive infrared) technology.
   2. Standards: Comply with UL 20.
   3. Rated 960 W at 120 V ac for tungsten lighting, 10 A at 120 V ac or 10 A at 277 V ac for fluorescent or LED lighting, and 1/4 hp at 120 V ac.
   4. Adjustable time delay of five, 10, 15 or 20 minutes as directed.
   5. Able to be locked to Automatic or Manual-On mode as directed.
   6. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (21.5 to 2152 lux).
   7. Connections: Provisions for connection to BAS.
   8. Connections: RJ-45 communications outlet.
   9. Connections: Integral wireless networking.

B. Wall Sensor Light Switch, Passive Infrared:

1. Description: Switchbox-mounted, combination, lighting-control sensor and conventional switch lighting-control unit using passive infrared technology.
2. Standards: Comply with UL 20.
3. Connections: Provisions for connection to BAS.
4. Connections: Hard wired.
5. Connections: Wireless.
6. Rated 960 W at 120 V ac for tungsten lighting, 10 A at 120 V ac or 10 A at 277 V ac for fluorescent or LED lighting, and 1/4 hp at 120 V ac.
7. Integral relay for connection to BAS.
8. Adjustable time delay of five, 10, 15 or 20 minutes as directed.
9. Able to be locked to Automatic or Manual-On mode as directed.
10. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (21.5 to 2152 lux).

C. Wall Sensor Light Switch, Ultrasonic:
1. Description: Switchbox-mounted, combination, lighting-control sensor and conventional switch lighting-control unit using ultrasonic technology.
2. Standards: Comply with UL 20.
3. Connections: Provisions for connection to BAS.
4. Connections: RJ-45 communications outlet.
5. Connections: Integral wireless networking.
6. Rated 960 W at 120 V ac for tungsten lighting, 10 A at 120 V ac or 10 A at 277 V ac for fluorescent or LED lighting, and 1/4 hp at 120 V ac.
7. Integral relay for connection to BAS.
8. Adjustable time delay of five, 10, 15 or 20 minutes as directed.
9. Able to be locked to Automatic or Manual-On mode as directed.
10. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (21.5 to 2152 lux).

2.11 TIMER LIGHT SWITCH

A. Digital Timer Light Switch:
1. Description: Switchbox-mounted, combination digital timer and conventional switch lighting-control unit, with backlit digital display, with selectable time interval in 10, 20-minute increments as directed.
2. Standards: Comply with UL 20.
3. Rated 960 W at 120 V ac for tungsten lighting, 10 A at 120 V ac or 10 A at 277 V ac for fluorescent or LED lighting, and 1/4 hp at 120 V ac.
4. Integral relay for connection to BAS.

2.12 RESIDENTIAL DEVICES

A. Residential-Grade, Tamper-Resistant, GFCI Receptacles, 125 V, 15 A:
1. Configuration: NEMA WD 6, Configuration 5-15R.
2. Feed-through connectors.
3. Standards: Comply with UL 943 and UL 1699.

B. Residential-Grade, Tamper-Resistant, AFCI Receptacles, 125 V, 15 A:
1. Configuration: NEMA WD 6, Configuration 5-15R.
2. Feed-through connectors.
3. Standards: Comply with UL 943 and UL 1699.

C. Residential-Grade, Tamper-Resistant Receptacles, 125 V, 15 A:
1. Configuration: NEMA WD 6, Configuration 5-15R.
2. Feed-through connectors.
3. Standards: Comply with UL 498.

D. Weather- and Tamper-Resistant Receptacles, 125 V, 15 A:
1. Configuration: NEMA WD 6, Configuration 5-15R.
2. Feed-through connectors.
3. Standards: Comply with UL 498.
4. Marked as "Weather Resistant."

E. Fan-Speed Controls:
1. Description: As directed, Modular, 120 or 277-V ac, full-wave, solid-state units with integral, quiet on-off switches and audible frequency and EMI/RFI filters.
2. Standards: Comply with UL 1917.
3. Continuously adjustable slider, toggle switch, rotary knob, 5 or 1.5 A as directed.
4. As directed, Three-speed adjustable slider or rotary knob, 1.5 A.

F. Telephone Outlet:
1. Description: Single RJ-11 jack for terminating Category 3, balanced twisted pair cable complying with Section 260523 "Control-Voltage Electrical Power Cables."
2. Description: Single RJ-11 jack for terminating Category 3, balanced twisted pair cable complying with Section 271513 "Communications Copper Horizontal Cabling."
3. Standards: Comply with UL 1863.

G. Combination Telephone and Coaxial Outlet:
1. Description: Single RJ-11 jack for terminating Category 3, twisted pair cable complying with Section 260523 "Control-Voltage Electrical Power Cables" and a single BNC connector for terminating coaxial cable.
2. Description: Single RJ-11 jack for terminating Category 3, twisted pair cable complying with Section 271513 "Communications Copper Horizontal Cabling" and a single BNC connector for terminating coaxial cable complying with Section 271533 "Communications Coaxial Horizontal Cabling."
3. Standards: Comply with UL 1863.

2.13 DIMMERS

A. Wall-Box Dimmers:
1. Description: Modular, full-wave, solid-state dimmer switch with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.
2. Control: As directed, Continuously adjustable slider, toggle switch or rotary knob; with single-pole or three-way switching.
3. Standards: Comply with UL 1472.
4. Incandescent Lamp Dimmers: 120 V; control shall follow square-law dimming curve. On-off switch positions shall bypass dimmer module.

a. 600 W; dimmers shall require no derating when ganged with other devices. Illuminated when "off."

5. Fluorescent Lamp Dimmer Switches: Modular; compatible with dimmer ballasts; trim potentiometer to adjust low-end dimming; dimmer-ballast combination capable of consistent dimming with low end not greater than 20 percent of full brightness.
6. LED Lamp Dimmer Switches: Modular; compatible with LED lamps; trim potentiometer to adjust low-end dimming; capable of consistent dimming with low end not greater than 20 percent of full brightness.

2.14 WALL PLATES

A. Single Source: Obtain wall plates from same manufacturer of wiring devices.

B. Single and combination types shall match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: Steel with white baked enamel, suitable for field painting, Smooth, high-impact thermoplastic, 0.035-inch- (1-mm-) thick, satin-finished, Type 302 stainless steel, 0.04-inch- (1-mm-) thick, brushed brass with factory polymer finish, 0.05-inch- (1.2-mm-) thick, anodized aluminum or 0.04-inch- (1-mm-) thick steel with chrome-plated finish as directed.
3. Material for Unfinished Spaces: Galvanized steel or Smooth, high-impact thermoplastic as directed.
4. Material for Damp Locations: As directed, Thermoplastic or Cast aluminum with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.

C. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum or thermoplastic with lockable cover as directed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:

1. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
2. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
3. Install wiring devices after all wall preparation, including painting, is complete.

C. Device Installation:

1. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.

2. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

D. Receptacle Orientation:

1. As directed, install ground pin of vertically mounted receptacles up or down, and on horizontally mounted receptacles to the right or left.
2. Install hospital-grade receptacles in patient-care areas with the ground pin or neutral blade at the top.

E. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

F. Dimmers:

1. Install dimmers within terms of their listing.
2. Verify that dimmers used for fan-speed control are listed for that application.
3. Install unshared neutral conductors online and load side of dimmers according to manufacturers' device, listing conditions in the written instructions.

G. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

H. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. In healthcare facilities, prepare reports that comply with NFPA 99.
2. Test Instruments: Use instruments that comply with UL 1436.
3. Test Instrument for Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

B. Tests for Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.

C. As directed, Test straight-blade convenience outlets in patient-care areas or hospital-grade outlets for the retention force of the grounding blade according to NFPA 99. Retention force shall be not less than 4 oz. (115 g).

D. Wiring device will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION 262726

SECTION 262733 - POWER DISTRIBUTION UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes freestanding, prepackaged power distribution units for transforming, conditioning, and distributing electrical power.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for power distribution units.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting or attachment details as directed.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For manufacturer or testing agency as directed.

B. Seismic Qualification Certificates: For power distribution units, accessories, and components, from manufacturer.

C. Product Certificates: For each type of power distribution unit, signed by product manufacturer.

D. Source quality-control reports.

E. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For power distribution units to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: A qualified manufacturer. Maintain a service center capable of providing training, parts, and emergency on-site repairs in less than eight hours' maximum response time.

B. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.6 FIELD CONDITIONS

A. Environmental Conditions: Units shall be capable of operating continuously in the following environmental conditions without mechanical or electrical damage or degradation of operating capability.

1. Storage Temperature Range: Minus 67 to plus 185 deg F (Minus 55 to plus 85 deg C).
2. Operating Temperature Range: 32 to 104 deg F (0 to 40 deg C).
3. Relative Humidity Range: 0 to 95 percent, noncondensing.
4. Altitude: Sea level to 3600 feet (1100 m) above sea level.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain power distribution unit and associated components specified in this Section from a single manufacturer with responsibility for entire power distribution unit installation.

2.2 MANUFACTURED UNITS

A. Description: Integrated and coordinated assembly of power-line-conditioning and distribution components packaged in a single cabinet or modular assembly of cabinets each with full-swivel casters mounted to bottom frame. Include the following components:

1. Input-power, circuit-breaker section.
2. Isolation transformer.
3. Surge protection device (SPD) system.
4. Output panelboard(s).
5. Alarm, monitoring, and control system.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NFPA 70.

D. Constructed to withstand seismic forces specified in Section 260548.16 "Seismic Controls for Electrical Systems."

E. Unit Capacity Rating: Carry indicated rms kilovolt-ampere load continuously without affecting the normal operation of the circuit breakers, monitoring system, or unit controls and without exceeding rated insulation temperature for the following input voltage and load current:

1. Input Voltage: Within rated input-voltage tolerance band of unit.
2. Load Current: Minimum of 3.0 crest factor and 85 percent total harmonic distortion.

2.3 INPUT-POWER, CIRCUIT-BREAKER SECTION

A. Description: Three-pole, shunt-tripped, thermal-magnetic-type circuit breaker, rated for indicated interrupting capacity and 125 percent of input current of unit at 100 percent rated load at unit capacity rating.

B. Static Transfer Switch: Three-pole, double-throw; solid-state, automatic transfer switch.

2.4 ISOLATION TRANSFORMER SECTION

A. Description: Dry-type, electrostatically shielded, three-phase, common-core, convection-air-cooled isolation transformer.

1. Comply with UL 1561 including requirements for non-sinusoidal load-current-handling capability defined by designated K-factor.
2. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses, one leg per phase.
3. Coil Material and Insulation: Aluminum or Copper windings, 220 deg C insulation class.
4. Temperature Rise: As directed Designed for 80, 115 or 150 deg C rise above 40 deg C ambient.
5. Output Impedance: 3.5 plus or minus 0.5 percent.
6. Regulation: 2 to 4 percent maximum, at full-resistive load; 5 percent maximum, at rated nonlinear load.
7. Taps: Six full-capacity compensation taps at 2.5 percent increments; two above and four below nominal voltage.

2.5 SPD SYSTEM

A. Description: Integrated SPD system, complying with Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits," to protect unit panelboard, and having the following features:

1. Disconnect Device: Manual, three-pole, fused disconnect switch to de-energize SPD system while permitting power distribution units to continue operation. Fuses are rated at 200-kA interrupting capacity.
2. Nonlinear Loading: System shall accommodate rated-load current with a minimum 3.0 crest factor and 85 percent total harmonic distortion.

2.6 OUTPUT PANELBOARDS

A. Description: Panelboards complying with Section 262416 "Panelboards" except for mounting provisions. As directed Mount single or double panelboards on power distribution unit behind flush doors. Include the following features:

1. Construction: As directed 30 or 42 pole, 208 V or 240 V, three phase; capable of accepting branch circuit breakers rated to 100 A.
2. Panelboard Rating: 225 A, with main circuit breaker.
3. Panelboard Phase, Neutral, and Ground Buses: Copper, with neutral bus at least 1.732or two times the nominal phase bus rating.
4. Isolated Ground Bus: Copper, adequate for branch-circuit equipment ground conductors; insulated from supports.
5. Branch Circuit Breakers: Bolt or Plug on as directed.
6. Cable Racks: Removable and arranged for supporting and routing cables for panelboard entrance.
7. Access Panels: Arranged so additional branch-circuit wiring can be installed and connected in the future.

2.7 POWER DISTRIBUTION UNIT CONTROLS

A. Include the following control features:

1. Emergency, power-off (EPO) switch integral with power distribution unit.
2. Power-off input terminals for connection to remote EPO switch.
3. Shutdown with automatic unit disconnection for the following alarm conditions:

    a. High temperature in transformer coil.
    b. High or low input or output voltage.
    c. Phase loss.
    d. Ground fault.
    e. Reverse-phase rotation.

4. Alarm Contacts: Electrically isolated, Form C (one normally open and one normally closed), summary alarm; contact set shall change state if any monitored function goes into alarm mode.
5. Auxiliary Control Outputs:

2.8 MONITORING, STATUS, AND ALARM ANNUNCIATION

A. Description: Microprocessor-based monitoring, status, and alarm annunciation panel mounted flush in front of power distribution unit to provide status display and failure-indicating interface for the following:

1. Power Monitoring:

    a. Input Voltage: Line to line, rms.
    b. Output Voltage: Line to line, rms.
    c. Output Voltage: Line to neutral, rms.

d. Output current.

2. Status Indication: Unit on.
3. Alarm Annunciation:

a. High temperature in transformer coil.
b. High and low input voltage.
c. High and low output voltage.
d. Phase loss.
e. Ground fault.
f. Frequency.
g. Phase rotation.
h. SPD module failure.

4. Audible Alarm and Silencing Switch: Alarm sounds when alarm indication occurs. Silencing switch shall silence audible alarm but leave visual indication active until alarm condition is corrected.

2.9 SOUND LEVEL

A. General: Fully assembled products comply with minimum sound-level requirements in NEMA ST 20 for transformers of corresponding ratings when factory tested according to IEEE C57.12.91.

2.10 ENCLOSURE REQUIREMENTS

A. A single, freestanding, galvanized steel, NEMA Type 1 enclosure. Opening of an exterior door shall not provide access to any live parts. Panels and covers that expose hazardous voltages shall require tools to remove.

B. Access from front, top, and side only for all installation, operations, and normal maintenance, including infrared scanning of bus and breakers. All normal operating controls and instrumentation shall be located on the front of the enclosure.

C. Arrange enclosure to allow lifting and moving via forklift.

2.11 SOURCE QUALITY CONTROL

A. Factory Tests: Design and routine tests shall comply with referenced standards.

B. Factory Sound-Level Tests: Conduct sound-level tests on equipment. Comply with IEEE C57.12.91 and NEMA ST 20.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Arrange power distribution units to provide adequate access to equipment and circulation of cooling air. Locate transformers away from corners and not parallel to adjacent wall surface.

B. Equipment Mounting:

1. Install power distribution units on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."
3. Supports shall penetrate and be independent of the access flooring.

C. Identify equipment and install warning signs according to Section 260553 "Identification for Electrical Systems."

3.2 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Testing Agency: As directed Owner will engage or Engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

C. Remove malfunctioning units, replace with new units, and retest as specified above.

D. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of conductor and bus connections.

E. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

F. Prepare test and inspection reports.

G. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

H. Adjust power distribution units to provide optimal voltage to equipment served throughout normal operating cycle of loads served. Record input and output voltages and adjustment settings and incorporate into test results.

END OF SECTION 262733

SECTION 262743 - ELECTRIC-VEHICLE SERVICE EQUIPMENT - AC LEVEL 1 AND LEVEL 2

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes EVSE that provides AC Level 1 and Level 2 EV charging.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: For EVSE.

1. Include plans, elevations, sections, and mounting or attachment details as directed.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of mounting assemblies for EV charging equipment.
4. Include diagrams for power, signal, and control wiring.
5. Include verification of wired or wireless communications service at each location of EVSE as directed.

D. Product Schedule: For EVSE. Use same designations indicated on Drawings.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Area plans and details, drawn to scale, and coordinated with each other, using input from installers of the items involved.

B. Qualification Data: For Installer or factory-authorized service representative as directed.

C. Seismic Qualification Data: Certificates, for EVSE, accessories, and components, from manufacturer.

D. Field quality-control reports.

E. Sample warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

B. Software and Firmware Operational Documentation:

1. Software operating manuals.
2. Program Software Backup: On USB, CD, Cloud, or approved media, complete with configuration files.
3. Device address and password list.
4. Printout of software application and graphic screens.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

1.7 FIELD CONDITIONS

A. Wireless Survey: Complete wireless survey to determine if wireless provider signals meet or exceed manufacturer's recommended minimum values.

1.8 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components of EVSE that fail(s) in materials or workmanship within specified warranty period.

1. Warranty Period: As directed, One, Two or Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain EVSE from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: EVSE shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 or 1.0 as directed.

B. Ambient Temperature: As directed, 41 to 104 deg F (5 to 40 deg C) or 5 to 104 deg F (Minus 15 to plus 40 deg C).

C. Relative Humidity: Zero to 95 percent.

D. Altitude: Sea level to 1000 feet (300 m).

E. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

F. Surge Withstand: 6 kV at 3000 A.

G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

H. EV Charging Levels:

1. Single vehicle, AC Level 1 at up to 1.7 kW per vehicle.
2. Single vehicle, AC Level 2 at up to 19.2 kW per vehicle.

2.3 EVSE DESCRIPTION

A. Comply with NFPA 70.

B. Comply with:

1. UL 2231-1.
2. UL 2594.
3. SAE J1772 for SAE combo chargers.

C. Comply with ADA-ABA Accessibility Guidelines.

D. Metering: Revenue or Nonrevenue grade meter as directed.

E. Control Power: 20 A, 110/120-V ac, 60 Hz, single phase per charger.

F. Input Power:

1. 20 A, 110/120-V ac, 60 Hz, single phase per charger.
2. As directed, 40 A, 60 A, 80 A or 90 A, 208/240-V ac, 60 Hz, single-phase services per charger.

G. Integral GFCI.

H. Auto-GFCI fault retry.

I. EVSE Mounting: Floor mount, Bollard mount, Pedestal mount, Pole mount, Wall mount or As indicated on Drawings.

J. Enclosures:

1. Rated for environmental conditions at installed location.

    a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
    b. Outdoor Locations: NEMA 250, Type 3R.
    c. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
    d. As directed, Stainless steel, Aluminum, Composite or UV-resistant plastic as directed.
    e. As directed, Paint, Powder coat, Thermoset, polyester powder paint or Anodized.
    f. Lockable.
    g. Tamper resistant.

K. EV Cable and Connectors:

1. SAE J1772 connector.
2. Single connectors with locking holster.
3. As directed, 10-foot (3-m), 18-foot (6-m), 20-foot (7-m) or 24-foot (8-m) cable with cable management system.
4. Field-replaceable connector and cable assembly.

L. Status Indicators:

1. LEDs to indicate power, charging, charging complete, system status, faults, and service.

M. Display Screen:

1. Daylight viewable, UV-protected display with human-machine interface capability.
2. Displays power, charging, charging complete, remote control, system status, faults, and service.

N. Networking:

1. WAN Communications: Cellular GSM/GPRS or CDMA as directed.
2. LAN Communications: As directed, Modbus, 802.11b/g/n, Zigbee or 10/100/1000 Base T Ethernet as directed.
3. Capable of remote configuration and reporting.

O. Payment System:

1. As directed, RFID, NFC or Contactless credit card reader.
2. PCI compliant.
3. Capable of remote control and authorization.

P. Charging Network: Compatible with the Aerovironment, Blink, Chargepoint, EV Connect, eVgo, GE Wattstation, PlugShare or SemaConnect EV charging network.

1. Multiple units shall independently connect to charging network.
2. Multiple units shall have one unit designated as a master unit that is configured as a gateway unit between the EVSE and the charging network.
3. Individual units shall be capable of indicating station status and availability, providing or connecting user to customer support or remote control as directed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1 and NECA 413.

B. Concrete Base Mounting:

1. Install EVSE on 6-inch (150-mm) nominal-thickness concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.
2. Install EVSE on 12-inch (300-mm) nominal-diameter and 48-inch- (1200-mm-) deep concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.

C. Wall Mounting:

1. Install EVSE, so that its receptacles or holders are not less than 18 inches (450 mm) and not more than 4 feet (1.2 m) above finished floor.
2. Mount EVSE to steel slotted supports 5/8 inch (16 mm) or 1-1/4 inches (32 mm) in depth. Orient steel slotted supports vertically as directed.

D. Pole Mounting:

1. Allow a minimum of 24 inches (600 mm) of clearance around EVSE.
2. EVSE receptacles or holders shall be not less than 24 inches (600 mm) and not more than 4 feet (1.2 m) above finished grade.

E. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

F. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

G. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

H. Disconnect: Install disconnect in a readily accessible location according to Section 262816 "Enclosed Switches and Circuit Breakers."

I. Circuit Breakers: Comply with Section 262816 "Enclosed Switches and Circuit Breakers."

J. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking from enclosures and components.

K. Secure covers to enclosure.

3.2 CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Comply with grounding requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

C. Comply with requirements for installation of conduit in Section 260533 "Raceways and Boxes for Electrical Systems." Drawings indicate general arrangement of conduit, fittings, and specialties.

D. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

E. Verify that all electrical connections have been made according to the manufacturer's instructions. Remove all burrs, shavings, and detritus from inside the enclosure.

F. After confirming all connections, install covers and tighten fasteners to according to manufacturer's instructions.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections with the assistance of a factory-authorized service representative.

C. Tests and Inspections:

1. For each unit of EVSE, perform the following tests and inspections:

    a. Unit self-test.
    b. Operation test with load bank.
    c. Operation test with EV.
    d. Network communications test.

D. EVSE will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION 262743

SECTION 262746 - ELECTRIC VEHICLE SERVICE EQUIPMENT - DC LEVEL 1 AND LEVEL 2

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes EVSE that provides DC Level 1 and Level 2 EV charging.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: For EVSE.

1. Include plans, elevations, sections, and mounting or attachment details as directed.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of mounting assemblies for EV charging equipment.
4. Include diagrams for power, signal, and control wiring.
5. Include verification of wired or wireless communications service at each location of EV charging equipment as directed.

D. Product Schedule: For EVSE. Use same designations indicated on Drawings.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Area plans and details, drawn to scale, and coordinated with each other, using input from installers of the items involved:

B. Seismic Qualification Data: Certificates, for EVSE, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

D. Sample Warranty: For manufacturer's warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For EVSE to include in operation and maintenance manuals.

B. Software and Firmware Operational Documentation:

1. Software operating manuals.
2. Program Software Backup: On USB, CD, Cloud, or approved media, complete with configuration files.
3. Device address and password list.
4. Printout of software application and graphic screens.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

1.7 FIELD CONDITIONS

A. Wireless Survey: Complete wireless survey to determine if wireless provider signals meet or exceed manufacturer's recommended minimum values.

1.8 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components of EVSE that fail(s) in materials or workmanship within specified warranty period.

1. Warranty Period: As directed, One, Two or Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain EVSE from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: EVSE shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 or 1.0 as directed.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

C. Comply with UL 2231-1 and UL 2594.

D. Surge Withstand: 6 kV at 3000 A.

E. EV Charging Levels:

1. Single vehicle, DC Level 1 at up to 40 kW per vehicle.
2. Single vehicle, DC Level 2 at up to100 kW per vehicle.

2.3 EVSE DESCRIPTION

A. Comply with SAE J1772 and CHAdeMo.

B. Comply with ADA-ABA Accessibility Guidelines.

C. Metering: Revenue or Nonrevenue grade meter as directed.

D. Control Power: 20 A, 110/120-V ac, 60 Hz, single phase per charger.

E. Input Power: As directed, 50 A, 480-V ac, 60 Hz, three phase per charger. 120 A, 480-V ac, 60 Hz, three phase per charger.

F. Integral GFCI.

G. Auto-GFCI fault retry.

H. EV Charging Equipment Mounting: As directed, Floor mount, Bollard mount, Pedestal mount, Pole mount, Wall mount or as indicated on Drawings.

I. Enclosures:

1. Rated for environmental conditions at installed location.

a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
b. Outdoor Locations: NEMA 250, Type 3R.
c. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
d. Stainless steel, Aluminum, Composite or UV-resistant plastic as directed.
e. Paint, Powder coat, Thermoset, polyester powder paint or Anodized as directed.
f. Lockable.
g. Tamper resistant.

J. EV Cable and Connectors:

1. SAE J1772 Combo or CHAdeMO connector as directed.
2. As directed, Single or Double connectors with locking holster.
3. As directed, 10-foot (3-m), 18-foot (6-m), 20-foot (7-m) or 24-foot (8-m) cable with cable management system.
4. Field-replaceable connector and cable assembly.

K. Status Indicators:

1. LEDs to indicate power, charging, charging complete, system status, faults, and service.

L. Display Screen:

1. Daylight viewable, UV-protected display with human-machine interface capability.
2. Displays power, charging, charging complete, remote control, system status, faults, and service.

M. Networking:

1. WAN Communications: Cellular GSM/GPRS or CDMA as directed.
2. LAN Communications: As directed, Modbus, 802.11b/g/n, Zigbee or 10/100/1000 Base T Ethernet.
3. Capable of remote configuration and reporting.

N. Payment System:

1. As directed, RFID, NFC or Contactless credit card reader.
2. PCI compliant.
3. Capable of remote control and authorization.

O. Charging Network: Compatible with the Aerovironment, Blink, Chargepoint, EV Connect, eVgo, GE Wattstation, PlugShare or SemaConnect EV charging network as directed.

1. Individual units shall be capable of indicating station status and availability, providing or connecting user to customer support or remote control as directed.

2.4 DISCONNECT

A. Comply with requirements for disconnect in Section 262816 "Enclosed Switches and Circuit Breakers."

B. Lockable open, in NEMA 3R or NEMA 4X enclosure as directed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1 and NECA 413.

B. Concrete Base Mounting:

1. Install EVSE on 6-inch (150-mm) nominal-thickness concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed
2. Install EVSE on 12-inch (300-mm) nominal-diameter and 48-inch- (1200-mm-) deep concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.

C. Wall Mounting:

1. Install EVSE so that its receptacles or holders are not less than 18 inches (450 mm) and not more than 4 feet (1.2 m) above finished floor.
2. Ensure that EVSE is plumb and rigid without distortion of box.
3. Secure EVSE according to manufacturer's written instructions.

D. Pole Mounting:

1. Allow a minimum of 24 inches (600 mm) of clearance around EV charging equipment.
2. EVSE receptacles or holders shall be not less than 24 inches (600 mm) and not more than 4 feet (1.2 m) above finished grade.
3. Mount EVSE plumb and rigid without distortion of enclosure.
4. Secure EVSE according to manufacturer's written instructions.

E. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

F. Wiring Method: Install cables in raceways and cable trays. Conceal raceway and cables, except in unfinished spaces.

1. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."
2. Comply with requirements for underground raceways and enclosures specified in Section 260543 "Underground Ducts and Raceways for Electrical Systems."

G. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

H. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

I. Disconnect: Install disconnect in a readily accessible location according to Section 262816 "Enclosed Switches and Circuit Breakers." Confirm voltage levels at disconnect.

J. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking from enclosures and components.

K. Secure covers to enclosure.

L. Cybersecurity:

1. Software:

    a. Coordinate security requirements with IT department or CIO as directed.
    b. Ensure that latest stable software release is installed and properly operating.
    c. Disable or change default passwords to password using a combination of uppercase and lower letters, numbers, and symbols at least eight characters in length. Record passwords and turn over to party responsible for system operation and administration.

2. Hardware:

    a. Coordinate location and access requirements with IT department or CIO as directed.
    b. Enable highest level of wireless encryption that is compatible with Owner's ICT network.
    c. Disable dual network connections.

3.2 CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Comply with grounding requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

C. Comply with requirements for installation of conduit in Section 260533 "Raceways and Boxes for Electrical Systems." Drawings indicate general arrangement of conduit, fittings, and specialties.

D. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

E. Verify that all electrical connections have been made according to the manufacturer's instructions. Remove all burrs, shavings, and detritus from inside the enclosure.

F. For liquid-cooled chargers, confirm that all cooling lines are properly connected.

G. After confirming all connections, install covers and tighten fasteners to according to manufacturer's instructions.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections with the assistance of a factory-authorized service representative.

C. Tests and Inspections:

1. For each unit of EV charging equipment, perform the following tests and inspections:

   a. Unit self-test.
   b. Operation test with load bank.
   c. Operation test with EV.
   d. Network communications test.

D. EVSE will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION 262746

SECTION 262813 - FUSES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cartridge fuses rated 600 V ac and less for use in the following:

a. Control circuits.
b. Motor-control centers.
c. Panelboards.
d. Switchboards.
e. Enclosed controllers.
f. Enclosed switches.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

1. Type RK-1: As directed, 250 or 600-V, zero- to 600-A rating, 200 kAIC, time delay.
2. Type RK-5: As directed, 250 or 600-V, zero- to 600-A rating, 200 kAIC, time delay.
3. Type CC: 600-V, zero- to 30-A rating, 200 kAIC, fast acting, time delay.
4. Type CD: 600-V, 31- to 60-A rating, 200 kAIC, fast acting, time delay.
5. Type J: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
6. Type L: 600-V, 601- to 6000-A rating, 200 kAIC, time delay.
7. Type T: As directed, 250-V, zero- to 1200-A or 600-V, zero- to 800-A rating, 200 kAIC, very fast acting, time delay.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

E. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Install spare-fuse cabinet(s) in location shown on the Drawings or as indicated in the field by Architect, Construction Manager or Owner as directed.

3.2 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems" and indicating fuse replacement information inside of door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION 262813

SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Non-fusible switches.
3. Receptacle switches.
4. Shunt trip switches.
5. Molded-case circuit breakers (MCCBs).
6. Molded-case switches.
7. Enclosures.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include nameplate ratings, dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

1. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in PDF and electronic format.

B. Shop Drawings: For enclosed switches and circuit breakers.

1. Include plans, elevations, sections, details, and attachments to other work.
2. Include wiring diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Seismic Qualification Certificates: For enclosed switches and circuit breakers, accessories, and components, from manufacturer.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

1.6 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: One year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.2 GENERAL REQUIREMENTS

A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single manufacturer.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

D. Comply with NFPA 70.

2.3 FUSIBLE SWITCHES

A. Type HD, Heavy Duty:

1. As directed, Single or Double throw.
2. As directed, Three or six pole.
3. As directed, 240 or 600-V ac.
4. As directed, 1200 A and smaller or 200 A and smaller.

5. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified or indicated fuses as directed.
6. Lockable handle with capability to accept three padlocks and interlocked with cover in closed position.

B. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Service-Rated Switches: Labeled for use as service equipment.

2.4 NONFUSIBLE SWITCHES

A. Type GD, General Duty, Three Pole, Single Throw, 240-V ac, 600 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

B. Type HD, Heavy Duty, Three Pole, Single Throw, 240 or 600-V ac, 1200 A and Smaller as directed: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Type HD, Heavy Duty, Six Pole, Single Throw, 240 or 600-V ac, 200 A and Smaller as directed: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

D. Type HD, Heavy Duty, Three Pole, Double Throw, 240 or 600-V ac, 1200 A and Smaller as directed: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

E. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Service-Rated Switches: Labeled for use as service equipment.

2.5 RECEPTACLE SWITCHES

A. Type HD, Heavy-Duty, Three Pole, Single-Throw Fusible Switch: As directed, 240 or 600-V ac, 30, 60 or 100 A; UL 98 and NEMA KS 1; horsepower rated, with clips or bolt pads to

accommodate specified or indicated fuses as directed; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

B. Type HD, Heavy-Duty, Three Pole, Single-Throw Non-fusible Switch: As directed, 240 or 600-V ac, 30, 60 or 100 A; UL 98 and NEMA KS 1; horsepower rated, lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

C. Interlocking Linkage: Provided between the receptacle and switch mechanism to prevent inserting or removing plug while switch is in the on position, inserting any plug other than specified, and turning switch on if an incorrect plug is inserted or correct plug has not been fully inserted into the receptacle.

D. Receptacle: Polarized, three-phase, four-wire receptacle (fourth wire connected to enclosure ground lug).

E. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Auxiliary Contact Kit: As directed, One or Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 24-V ac, 120-V ac, 208-V ac, 240-V ac, 6-V dc, 12-V dc or 24-V dc as directed.
6. Hookstick Handle: Allows use of a hookstick to operate the handle.
7. Lugs: As directed, Mechanical or Compression type, suitable for number, size, and conductor material.
8. Service-Rated Switches: Labeled for use as service equipment.

2.6 SHUNT TRIP SWITCHES

A. General Requirements: Comply with ASME A17.1, UL 50, and UL 98, with Class J fuse block and 200-kA interrupting and short-circuit current rating.

B. Type HD, Heavy-Duty, Three Pole, Single-Throw Fusible Switch: As directed, 240 or 600-V ac, 30, 60 or 100 A; UL 98 and NEMA KS 1; integral shunt trip mechanism; horsepower rated, with clips or bolt pads to accommodate specified or indicated fuses; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

C. Type HD, Heavy-Duty, Three Pole, Single-Throw Non-fusible Switch: 240 or 600-V ac, 30, 60 or 100 A as directed; UL 98 and NEMA KS 1; integral shunt trip mechanism; horsepower rated, lockable handle with capability to accept three padlocks; interlocked with cover in closed position.

D. Control Circuit: 120-V ac; obtained from integral control power transformer, with primary and secondary fuses, with a control power transformer or source of enough capacity to operate shunt trip, pilot, indicating and control devices as directed.

E. Accessories:

1. Oil-tight key switch for key-to-test function.
2. Oil-tight red, green, white or yellow ON pilot light as directed.
3. Isolated neutral lug; 100 or 200 percent rating as directed.
4. Mechanically interlocked auxiliary contacts that change state when switch is opened and closed.
5. Three-pole, double-throw, fire-safety and alarm relay; As directed, 120-V ac or 24-V dc coil voltage.
6. Three-pole, double-throw, fire-alarm voltage monitoring relay complying with NFPA 72.
7. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
8. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
9. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
10. Service-Rated Switches: Labeled for use as service equipment.

2.7 MOLDED-CASE CIRCUIT BREAKERS

A. Circuit breakers shall be constructed using glass-reinforced insulating material. Current carrying components shall be completely isolated from the handle and the accessory mounting area.

B. Circuit breakers shall have a toggle operating mechanism with common tripping of all poles, which provides quick-make, quick-break contact action. The circuit-breaker handle shall be over center, be trip free, and reside in a tripped position between on and off to provide local trip indication. Circuit-breaker escutcheon shall be clearly marked on and off in addition to providing international I/O markings. Equip circuit breaker with a push-to-trip button, located on the face of the circuit breaker to mechanically operate the circuit-breaker tripping mechanism for maintenance and testing purposes.

C. The maximum ampere rating and UL, IEC, or other certification standards with applicable voltage systems and corresponding interrupting ratings shall be clearly marked on face of circuit breaker. Circuit breakers shall be 100 percent rated, series rated or 100 percent rated or series rated as indicated on the Drawings. As directed, Circuit breaker/circuit breaker or Fuse/circuit breaker combinations for series connected interrupting ratings shall be listed by UL as recognized component combinations. Any series rated combination used shall be marked on the end-use equipment along with the statement "Caution - Series Rated System. _____ Amps Available. Identical Replacement Component Required."

D. MCCBs shall be equipped with a device for locking in the isolated position.

E. Lugs shall be suitable for 140 deg F (60 deg C) rated wire on 125-A circuit breakers and below, 167 deg F (75 deg C) rated wire or 194 deg F (90 deg C) rated wire, sized according to the 167 deg F (75 deg C) temperature rating in NFPA 70 as directed.

F. Standards: Comply with UL 489 with interrupting capacity to comply with available fault currents.

G. Thermal-Magnetic Circuit Breakers: Inverse time-current thermal element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

H. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

I. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:

1. Long- and short-time pickup levels.
2. Long- and short-time time adjustments.
3. Ground-fault pickup level, time delay, and I-squared t response.

J. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.

K. Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
3. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
4. Auxiliary Contacts: As directed, One SPDT switch or Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
5. Alarm Switch: As directed, One NO or NC contact that operates only when circuit breaker has tripped.

2.8 ENCLOSURES

A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

B. Enclosure Finish: The enclosure shall be finished with gray baked enamel paint, electrodeposited on cleaned, phosphatized steel (NEMA 250 Type 1), gray baked enamel paint, electrodeposited on cleaned, phosphatized galvannealed steel (NEMA 250 Types 3R, 12), a brush finish on Type 304 stainless steel (NEMA 250 Type 4-4X stainless steel) or copper-free cast aluminum alloy (NEMA 250 Types 7, 9) as directed.

C. Conduit Entry: NEMA 250 Types 4, 4X, and 12 enclosures shall contain no knockouts. NEMA 250 Types 7 and 9 enclosures shall be provided with threaded conduit openings in both endwalls.

D. Operating Mechanism: The circuit-breaker operating handle shall be externally operable with the operating mechanism being an integral part of the box, not the cover, directly operable through the front cover of the enclosure (NEMA 250 Type 1), directly operable through the dead front trim of the enclosure (NEMA 250 Type 3R) or externally operable with the operating mechanism being an integral part of the cover (NEMA 250 Types 7, 9). The cover interlock

mechanism shall have an externally operated override. The override shall not permanently disable the interlock mechanism, which shall return to the locked position once the override is released. The tool used to override the cover interlock mechanism shall not be required to enter the enclosure in order to override the interlock.

E. Enclosures designated as NEMA 250 Type 4, 4X stainless steel, 12, or 12K shall have a dual cover interlock mechanism to prevent unintentional opening of the enclosure cover when the circuit breaker is ON and to prevent turning the circuit breaker ON when the enclosure cover is open.

F. NEMA 250 Type 7/9 enclosures shall be furnished with a breather and drain kit to allow their use in outdoor and wet location applications.

PART 3 - EXECUTION

3.1 ENCLOSURE ENVIRONMENTAL RATING APPLICATIONS

A. Enclosed Switches and Circuit Breakers: Provide enclosures at installed locations with the following environmental ratings.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
2. Outdoor Locations: NEMA 250, Type 3R or Type 4X as directed.
3. Kitchen or Wash-Down Areas as directed: NEMA 250, Type 4X, stainless steel.
4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
6. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7 or Type 9 with cover attached by Type 316 stainless steel bolts.

3.2 INSTALLATION

A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Architect, Construction Manager or Owner no fewer than seven days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without Architect's, Construction Manager's or Owner's written permission as directed.
4. Comply with NFPA 70E.

B. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

C. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

D. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

E. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

F. Install fuses in fusible devices.

G. Comply with NFPA 70 and NECA 1.

H. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573.16 "Coordination Studies" to values indicated on the Drawings or to values indicated in attached schedule.

3.3 IDENTIFICATION

A. Comply with requirements in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Tests and Inspections for Switches:

1. Visual and Mechanical Inspection:

a. Inspect physical and mechanical condition.
b. Inspect anchorage, alignment, grounding, and clearances.
c. Verify that the unit is clean.
d. Verify blade alignment, blade penetration, travel stops, and mechanical operation.
e. Verify that fuse sizes and types match the Specifications and Drawings.
f. Verify that each fuse has adequate mechanical support and contact integrity.
g. Inspect bolted electrical connections for high resistance using one of the two following methods:

1) Use a low-resistance ohmmeter.

a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.

a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

h. Verify that operation and sequencing of interlocking systems is as described in the Specifications and shown on the Drawings.
i. Verify correct phase barrier installation.
j. Verify lubrication of moving current-carrying parts and moving and sliding surfaces.

2. Electrical Tests:

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
b. Measure contact resistance across each switchblade fuseholder. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
c. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
d. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
e. Perform ground fault test according to NETA ATS 7.14 "Ground Fault Protection Systems, Low-Voltage."

E. Tests and Inspections for Molded Case Circuit Breakers:

1. Visual and Mechanical Inspection:

a. Verify that equipment nameplate data are as described in the Specifications and shown on the Drawings.
b. Inspect physical and mechanical condition.
c. Inspect anchorage, alignment, grounding, and clearances.
d. Verify that the unit is clean.
e. Operate the circuit breaker to ensure smooth operation.
f. Inspect bolted electrical connections for high resistance using one of the two following methods:

1) Use a low-resistance ohmmeter.

a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.

a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

g. Inspect operating mechanism, contacts, and chutes in unsealed units.
h. Perform adjustments for final protective device settings in accordance with the coordination study.

2. Electrical Tests:

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
b. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
c. Perform a contact/pole resistance test. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
d. Perform insulation resistance tests on all control wiring with respect to ground. Applied potential shall be 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable. Test duration shall be one minute. For units with solid state components, follow manufacturer's recommendation. Insulation resistance values shall be no less than two megohms.
e. Determine the following by primary current injection:

1) Long-time pickup and delay. Pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
2) Short-time pickup and delay. Short-time pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
3) Ground-fault pickup and time delay. Ground-fault pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
4) Instantaneous pickup. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances.

f. Test functionality of the trip unit by means of primary current injection. Pickup values and trip characteristics shall be as specified and within manufacturer's published tolerances.
g. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of the shunt trip and close coils shall be as indicated by manufacturer.
h. Verify correct operation of auxiliary features such as trip and pickup indicators; zone interlocking; electrical close and trip operation; trip-free, anti-pump function; and trip unit battery condition. Reset all trip logs and indicators. Investigate units that do not function as designed.
i. Verify operation of charging mechanism. Investigate units that do not function as designed.

3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

F. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports.

1. Test procedures used.
2. Include identification of each enclosed switch and circuit breaker tested and describe test results.
3. List deficiencies detected, remedial action taken, and observations after remedial action.

END OF SECTION 262816

SECTION 262913.03 - MANUAL AND MAGNETIC MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Manual motor controllers.
2. Enclosed full-voltage magnetic motor controllers.
3. Enclosed reduced-voltage magnetic motor controllers.
4. Multispeed magnetic motor controllers.
5. Enclosures.
6. Accessories.
7. Identification.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For each type of magnetic controller.

1. Include plans, elevations, sections, and mounting details.
2. Indicate dimensions, weights, required clearances, and location and size of each field connection.
3. Wire Termination Diagrams and Schedules: Include diagrams for signal, and control wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features. Differentiate between manufacturer-installed and field-installed wiring.
4. Include features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for magnetic controllers, from manufacturer.

B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. UL Compliance: Fabricate and label magnetic motor controllers to comply with UL 508 and UL 60947-4-1.

C. NEMA Compliance: Fabricate motor controllers to comply with ICS 2.

D. Seismic Performance: Magnetic controllers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the controller will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 or 1.0 as directed.

2.2 MANUAL MOTOR CONTROLLERS

A. Motor-Starting Switches (MSS): "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off or on.
1. Standard: Comply with NEMA ICS 2, general purpose, Class A.
2. Configuration: Nonreversing, Reversing or Two speed as directed.
3. Flush or Surface mounting as directed.
4. Red or Green pilot light as directed.
5. Additional Nameplates: FORWARD and REVERSE for reversing switches or HIGH and LOW for two-speed switches.

B. Fractional Horsepower Manual Controllers (FHPMC): "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.
1. Configuration: Nonreversing or Two speed as directed.
2. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button; bimetallic type; melting alloy type.
3. Overload Relays: NEMA ICS 2, bimetallic class as schedule on Drawings.
4. Pilot Light: Red.

2.3 ENCLOSED FULL-VOLTAGE MAGNETIC MOTOR CONTROLLERS

A. Description: Across-the-line start, electrically held, for nominal system voltage of 600-V ac and less.

B. Standard: Comply with NEMA ICS 2, general purpose, Class A.

C. Configuration: Non-reversing.

D. Contactor Coils: Pressure-encapsulated type with coil transient suppressors when indicated.

1. Operating Voltage: Manufacturer's standard, unless indicated.

E. Control Power:

1. For on-board control power, obtain from line circuit or from integral CPT. The CPT shall have capacity to operate integral devices and remotely located pilot, indicating, and control devices.

a. Spare CPT Capacity as Indicated on Drawings: As directed, 50, 100 or 200 VA.

F. Overload Relays:

1. Thermal Overload Relays:

a. Inverse-time-current characteristic.
b. As directed, Class 10, Class 20 or Class 30 tripping characteristic.
c. Heaters in each phase shall be matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
d. Ambient compensated.
e. Automatic resetting.

2. Solid-State Overload Relay:

a. Switch or dial selectable for motor-running overload protection.
b. Sensors in each phase.
c. As directed, Class 10, Class 20, Class 30 or Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
d. Class II ground-fault protection shall comply with UL 1053 to interrupt low-level ground faults. The ground-fault detection system shall include circuitry that will prevent the motor controller from tripping when the fault current exceeds the interrupting capacity of the controller. Equip with start and run delays to prevent nuisance trip on starting, and a trip indicator.

G. Digital communication module, using RS-485 Modbus, RTU protocol, 2 or 4-wire connection to host devices with a compatible port to transmit the following to the LAN:

1. Instantaneous rms current each phase, and 3-phase average.
2. Voltage: L-L for each phase, L-L 3-phase average, L-N each phase and L-N 3-phase average - rms.

3. Active Energy (kWh): 3-phase total.
4. Power Factor: Each phase and 3-phase total.

2.4 ENCLOSED REDUCED-VOLTAGE MAGNETIC MOTOR CONTROLLERS

A. Description: Electrically held; closed-transition; adjustable time delay on transition, 600-V ac or less.

B. Standard: Comply with NEMA ICS 2, general purpose, Class A.

C. Configuration:

1. Wye-Delta Controller: Four contactors, with a three-phase starting resistor/reactor bank.
2. Part-Winding Controller: Separate START and RUN contactors, field-selectable for 1/2- or 2/3-winding start mode, with either six- or nine-lead motors; with separate overload relays for starting and running sequences.
3. Autotransformer Reduced-Voltage Controller: Medium-duty service, with integral overtemperature protection; taps for starting at 50, 65, and 80 percent of line voltage; two START and one RUN contactors.

D. Contactor Coils: Pressure-encapsulated type with coil transient suppressors when indicated.

1. Operating Voltage: Manufacturer's standard, unless indicated.

E. Control Power: As directed, 24 or 120-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.

1. Spare CPT Capacity: As directed, 50, 100 or 200 VA as directed.

F. Overload Relays:

1. Thermal Overload Relays: Melting alloy type or Bimetallic type as directed.

a. Inverse-time-current characteristic.
b. Class 10, Class 20 or Class 30 tripping characteristic as directed.
c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
d. Ambient compensated.
e. Automatic resetting.

2. Solid-State Overload Relay:

a. Switch or dial selectable for motor-running overload protection.
b. Sensors in each phase.
c. As directed, Class 10, Class 20, Class 30 or Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing as directed.
d. Class II Ground-Fault Protection: Comply with UL 1053 to interrupt low-level ground faults. The ground-fault detection system shall include circuitry that will

prevent the motor controller from tripping when the fault current exceeds the interrupting capacity of the controller. Equip with start and run delays to prevent nuisance trip on starting, and a trip indicator.

G. Digital Communication Module: As directed, RS-485 Modbus, RTU protocol, 2 or 4-wire connection to host devices with a compatible port to transmit the following to the LAN:

1. Instantaneous rms current each phase, and 3-phase average.
2. Voltage: L-L for each phase, L-L 3-phase average, L-N each phase and L-N 3-phase average - rms.
3. Active Energy (kWh): 3-phase total.
4. Power Factor: Each phase and 3-phase total.

2.5 MULTISPEED MAGNETIC CONTROLLERS

A. Description: Two speed, full voltage, across the line, electrically held. Show controller pole quantities on Drawings. See "Multispeed Magnetic Motor Controllers" Article in the Evaluations for selection considerations. The Section Text includes only two-speed controllers; however, most manufacturers catalog controllers offering more than two speeds. Multispeed motor controllers supporting more than two speeds may be added to meet Project requirements.

B. Standard: Comply with NEMA ICS 2, general purpose, Class A.

1. Configuration: Non-reversing, multispeed.
2. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.
    a. Operating Voltage: Manufacturer's standard, unless indicated.
3. Power Contacts: Totally enclosed, double break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
4. Control Power: As directed, 24 or 120-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
    a. Spare CPT Capacity: 50, 100 or 200 VA as directed.
5. Compelling relays shall ensure that motor will start only at low speed.
6. Accelerating timer relays shall ensure properly timed acceleration through speeds lower than that selected.
7. Decelerating timer relays shall ensure automatically timed deceleration through each speed.
8. Anti-plugging timer relays shall ensure a time delay when transferring from FORWARD to REVERSE and back.

C. Overload Relays:

1. Thermal Overload Relays: Melting alloy type or Bimetallic type as directed.
    a. Inverse-time-current characteristic.
    b. As directed, Class 10, Class 20 or Class 30 tripping characteristic as directed.

c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
d. Ambient compensated.
e. Automatic resetting.

2. Solid-State Overload Relay:

a. Switch or dial selectable for motor-running overload protection.
b. Sensors in each phase.
c. As directed, Class 10, Class 20, Class 30 or Class 10/20 selectable tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
d. Class II ground-fault protection shall comply with UL 1053 to interrupt low-level ground faults. The ground-fault detection system shall include circuitry that will prevent the motor controller from tripping when the fault current exceeds the interrupting capacity of the controller. Equip with start and run delays to prevent nuisance trip on starting, and a trip indicator.
e. As directed, digital communication module, using RS-485 Modbus, RTU protocol, 2 or 4-wire connection to host devices with a compatible port to transmit the following to the LAN:

1) Instantaneous rms current each phase, and 3-phase average.
2) Voltage: L-L for each phase, L-L 3-phase average, L-N each phase and L-N 3-phase average - rms.
3) Active Energy (kWh): 3-phase total.
4) Power Factor: 3-phase total.

2.6 ENCLOSURES

A. Comply with NEMA 250, type designations as indicated on Drawings, complying with environmental conditions at installed location.

B. The construction of the enclosures shall comply with NEMA ICS 6.

2.7 ACCESSORIES

A. General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.

1. Push Buttons, Pilot Lights, and Selector Switches: Standard-duty, except as needed to match enclosure type. Heavy-duty or oil-tight where indicated in the controller schedule.

a. Push Buttons: As indicated in the controller schedule.
b. Pilot Lights: As indicated in the controller schedule.

2. Elapsed Time Meters: Heavy duty with digital readout in hours; nonresettable; resettable.
3. Meters: Panel type, 2-1/2-inch (64-mm) minimum size with 90- or 120-degree scale and plus or minus two percent accuracy. Where indicated, provide selector switches with an off position.

B. Motor protection relays shall be with solid-state sensing circuit and isolated output contacts for hardwired connections.

1. Phase-failure.
2. Phase-reversal, with bicolor LED to indicate normal and fault conditions. Automatic reset when phase reversal is corrected.
3. Under/overvoltage, operate when the circuit voltage reaches a preset value, and drop out when the operating voltage drops to a level below the preset value. Include adjustable time-delay setting.

2.8 IDENTIFICATION

A. Controller Nameplates: As directed, Baked enamel signs, Metal backed butyrate signs or Laminated acrylic or melamine plastic signs, as described in Section 260553 "Identification for Electrical Systems," for each compartment, mounted with corrosion-resistant screws.

B. Arc-Flash Warning Labels:

1. Comply with requirements in Section 260573.19 "Arc-Flash Hazard Analysis." Produce a 3.5-by-5-inch (89-by-127-mm) self-adhesive equipment label for each work location included in the analysis.
2. Comply with requirements in Section 260553 "Identification for Electrical Systems." Produce a 3.5-by-5-inch (89-by-127-mm) self-adhesive equipment label for each work location included in the analysis. Labels shall be machine printed, with no field-applied markings.

a. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:

1) Location designation.
2) Nominal voltage.
3) Flash protection boundary.
4) Hazard risk category.
5) Incident energy.
6) Working distance.
7) Engineering report number, revision number, and issue date.

b. Labels shall be machine printed, with no field-applied markings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Wall-Mounted Controllers: Install magnetic controllers on walls with tops at uniform height indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems" unless otherwise indicated.

C. Floor-Mounted Controllers: Install controllers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.

D. Comply with requirements for seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."

E. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

F. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

G. Setting of Overload Relays: Select and set overloads on the basis of full-load current rating as shown on motor nameplate. Adjust setting value for special motors as required by NFPA 70 for motors that are high-torque, high-efficiency, and so on.

3.2 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. Tests and Inspections:

1. Comply with the provisions of NFPA 70B, "Testing and Test Methods" Chapter.
2. Visual and Mechanical Inspection

    a. Compare equipment nameplate data with drawings and specifications.
    b. Inspect physical and mechanical condition.
    c. Inspect anchorage, alignment, and grounding.
    d. Verify the unit is clean.
    e. Inspect contactors:

        1) Verify mechanical operation.
        2) Verify contact gap, wipe, alignment, and pressure are according to manufacturer's published data.

    f. Motor-Running Protection:

1) Verify overload element rating is correct for its application.
2) If motor-running protection is provided by fuses, verify correct fuse rating.

g. Inspect bolted electrical connections for high resistance using one of the two following methods:

1) Use a low-resistance ohmmeter. Compare bolted connection resistance values with values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or NETA ATS Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

h. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

3. Electrical Tests

a. For the contactor and circuit breaker, perform or Perform insulation-resistance tests for one minute on each pole as directed, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Insulation-resistance values shall be according to manufacturer's published data or NETA ATS Table 100.1. In the absence of manufacturer's published data, use Table 100.5. Values of insulation resistance less than those of this table or manufacturer's recommendations shall be investigated and corrected.
b. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
c. Test motor protection devices according to manufacturer's published data.
d. Test circuit breakers as follows:

1) Operate the circuit breaker to ensure smooth operation.
2) For adjustable circuit breakers, adjust protective device settings according to the coordination study. Comply with coordination study recommendations.

e. Perform operational tests by initiating control devices.

C. Motor controller will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.4 SYSTEM FUNCTION TESTS

A. System function tests shall prove the correct interaction of sensing, processing, and action devices. Perform system function tests after field quality control tests have been completed and all components have passed specified tests.

1. Develop test parameters and perform tests for the purpose of evaluating performance of integral components and their functioning as a complete unit within design requirements and manufacturer's published data.
2. Verify the correct operation of interlock safety devices for fail-safe functions in addition to design function.
3. Verify the correct operation of sensing devices, alarms, and indicating devices.

B. Motor controller will be considered defective if it does not pass the system function tests and inspections.

C. Prepare test and inspection reports.

3.5 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain switchgear.

END OF SECTION 262913.03

SECTION 262913.06 - SOFT-START MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes soft-start motor controllers that are designed for reduced-voltage start and full-voltage run duty.

1. Enclosed soft-start controllers.
2. Combination soft-start controllers.
3. Enclosures.
4. Accessories.
5. Identification.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For each type of controller.

1. Include plans, elevations, sections, and mounting details.
2. Indicate dimensions, weights, required clearances, and location and size of each field connection.
3. Wire Termination Diagrams and Schedules: Include diagrams for signal and control wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features. Differentiate between manufacturer-installed and field-installed wiring.
4. Include features, characteristics, ratings, and factory settings of individual OCPD and auxiliary components.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for soft-start controllers, from manufacturer.

B. Source quality-control reports.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

PART 2 - PRODUCTS

2.1 MOTOR CONTROLLER PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. UL Compliance: Fabricate and label enclosed controllers to comply with UL 508.

C. NEMA Compliance: Fabricate motor controllers to comply with NEMA ICS 2.

D. Seismic Performance: Soft-start controllers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 or 1.0 as directed.

2.2 ENCLOSED SOFT-START MOTOR CONTROLLERS

A. Description: Controllers designed for reduced-voltage start, full-voltage run, and optional soft stop. The controller shall be an integrated unit with power SCRs, heat sink, microprocessor logic board, door-mounted digital display and user interface module, run-bypass contactor, and overload relay(s); suitable for use with NEMA MG 1, Design B, polyphase, medium induction motors.

1. Run-Bypass Contactor: Magnetic contactor in parallel with the SCR of the soft-start controller, bypassing the SCR when full voltage is achieved.

B. Standard: Comply with NEMA ICS 2, general purpose, Class A.

C. Configuration: Standard duty.

1. At least two SCRs per phase to control the starting and stopping of the motor.
2. Microprocessor control shall continuously monitor current and proper operation of the SCRs.
3. Bypass Contactor: Operates automatically when full voltage is applied to motor and bypasses the SCRs. Soft-start controller protective features and deceleration controls shall remain active when this contactor is in the bypass mode.
4. Power Electronics Disconnect Contactor. Where indicated, installed ahead of the power electronics equipment, and shall open automatically when the motor is stopped, or a controller fault is detected, or when an SCR shorts.

5. Logic Board: Identical for all ampere ratings and voltage classes, with environmental protective coating.
6. Surge Protection: Comply with NEMA ICS 2 requirements for surge suppression.

D. Control Power:

1. For on-board control power, obtain from line circuit or from integral CPT. The CPT shall have capacity to operate integral devices and remotely located pilot, indicating, and control devices.
2. Spare CPT Capacity: As indicated on Drawings, available in increments of 100 VA, from 100 to 500 VA.

E. Controller Diagnostics and Protection:

1. Microprocessor-based thermal-protection system for monitoring SCR and motor thermal characteristics, and providing controller overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
2. Protection from line-side reverse phasing; line-side and motor-side phase loss; motor jam, stall, and under-load conditions; and line frequency over or under normal.
3. Input isolation contactor that opens when the controller diagnostics detect a faulted soft-start component or when the motor is stopped.

F. Cover mounted-controller status panel with LED lights or alphanumeric display to show the following:

1. Starter Status: "Ready," "starting," "stopping," or "run."
2. Motor current in amperes.
3. Faults:

    a. Motor overcurrent trip.
    b. Motor thermal overload.
    c. Starter thermal fault.
    d. Low line voltage.
    e. Loss of a phase.
    f. Phases reversed.
    g. Maximum stating time exceeded.
    h. Serial communications error.

G. Interface Panel: Mounted on controller door or Mounted remotely within 50 feet (15 m) With plug-in connector and removable as directed.

1. Guarded adjustable set points, not readily accessible.

    a. Motor FLA, adjustable from 40 to 110 percent of the controller's rating.
    b. Current limitation on starting, adjustable from 200 to 500 percent of FLA, typically set at 300 percent.
    c. NEMA ICS 2 overload class. Selections shall include the following tripping classes: Class 5, Class 10, Class 15, Class 20, and Class 30.

2. Adjustable set points, readily accessible, password protected.

a. Linear acceleration, adjustable from 1 to 60 s.
b. Maximum start time, adjustable from 1 to 250 s.
c. Selector switch; select coast to stop or soft stop.
d. Linear deceleration, adjustable from 1 to 60 s.

H. Remote Output Features. All outputs shall be prewired to terminal blocks.

1. Analog output for field-selectable assignment of motor operating characteristics; 0- to 10-V dc or 4- to 20-mA dc as directed.
2. Form C status contacts that change state when controller is running.
3. Form C alarm contacts that change state when a fault condition occurs.

I. Digital Communication Module: RS-485 Modbus, RTU protocol, 2 or 4-wire connection to host devices with a compatible port to transmit the following to the LAN:

1. Instantaneous root mean square (rms) current each phase, and three-phase average.
2. Voltage: L-L for each phase, L-L three-phase average, L-N each phase, and L-N three-phase average - rms.
3. Active Energy (kilowatt-hour): Three-phase total.
4. Power Factor: Each phase and three-phase total.

2.3 COMBINATION SOFT-START MOTOR CONTROLLERS

A. Description: Factory-assembled, combination, reduced-voltage soft-start controller with a disconnecting means, SCPD and OCPD, in a single enclosure. The reduced-voltage soft-start controller shall consist of an integrated unit with power SCRs, heat sink, microprocessor logic board, door-mounted digital display and user interface module, run-bypass contactor, and overload relay(s); suitable for use with NEMA MG 1, Design B, polyphase, medium induction motors.

1. Run-Bypass Contactor: Magnetic contactor in parallel with the SCR of the soft-start controller, bypassing the SCR when full voltage is achieved.

B. Standard: Comply with NEMA ICS 2, general purpose, Class A.

C. Configuration: Standard duty.

1. At least two SCRs per phase to control the starting and stopping of the motor.
2. Microprocessor control shall continuously monitor current and proper operation of the SCRs.
3. Bypass Contactor: Operates automatically when full voltage is applied to motor, and bypasses the SCRs. Soft-start controller protective features and deceleration controls shall remain active when this contactor is in the bypass mode.
4. Power Electronics Disconnect Contactor. Where indicated, installed ahead of the power electronics equipment, and shall open automatically when the motor is stopped, or a controller fault is detected, or when an SCR shorts.
5. Logic Board: Identical for all ampere ratings and voltage classes, with environmental protective coating.
6. Surge Protection: Comply with NEMA ICS 2 requirements for surge suppression.

D. Control Power:

1. For on-board control power, obtain from line circuit or from integral CPT. The CPT shall have capacity to operate integral devices and remotely located pilot, indicating, and control devices.
2. Spare CPT Capacity: As indicated on Drawings, available in increments of 100 VA, from 100 to 500 VA.

E. Controller Diagnostics and Protection:

1. Microprocessor-based thermal-protection system for monitoring SCR and motor thermal characteristics and providing controller overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
2. Protection from line-side reverse phasing; line-side and motor-side phase loss; motor jam, stall, and under-load conditions; and line frequency over or under normal.
3. Input isolation contactor that opens when the controller diagnostics detect a faulted soft-start component or when the motor is stopped.

F. Cover mounted-controller status panel with LED lights or alphanumeric display to show the following:

1. Starter Status: "Ready," "starting," "stopping," or "run."
2. Motor current in amperes.
3. Faults:

    a. Motor overcurrent trip.
    b. Motor thermal overload.
    c. Starter thermal fault.
    d. Low line voltage.
    e. Loss of a phase.
    f. Phases reversed.
    g. Maximum stating time exceeded.
    h. Serial communications error.

G. Interface Panel: Mounted on controller door, mounted remotely within 50 feet (15 m) With plug-in connector and removable as directed.

1. Guarded adjustable set points, not readily accessible.

    a. Motor FLA, adjustable from 40 to 110 percent of the controller's rating.
    b. Current limitation on starting, adjustable from 200 to 500 percent of FLA, typically set at 300 percent.
    c. NEMA ICS 2 overload class. Selections shall include the following tripping classes: Class 5, Class 10, Class 15, Class 20, and Class 30.

2. Adjustable set points, readily accessible, password protected.

    a. Linear acceleration, adjustable from 1 to 60 s.
    b. Maximum start time, adjustable from 1 to 250 s.
    c. Selector switch; select coast to stop or soft stop.
    d. Linear deceleration, adjustable from 1 to 60 s.

H. Remote Output Features: All outputs shall be prewired to terminal blocks.

1. Analog output for field-selectable assignment of motor operating characteristics; 0- to 10-V dc or 4- to 20-mA dc as directed.
2. Form C status contacts that change state when controller is running.
3. Form C alarm contacts that change state when a fault condition occurs.

I. Digital Communication Module: As directed, RS-485 Modbus, RTU protocol, 2 or 4-wire connection to host devices with a compatible port to transmit the following to the LAN:

1. Instantaneous rms current each phase, and three-phase average.
2. Voltage: L-L for each phase, L-L three-phase average, L-N each phase, and L-N three-phase average - rms.
3. Active Energy (kilowatt-hour): Three-phase total.
4. Power Factor: Each phase and three-phase total.

J. Fusible Disconnecting Means:

1. NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class J, Class L or indicated fuses as directed.
2. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
3. Auxiliary Contacts: NO or NC, arranged to activate before switch blades open.

K. MCP Disconnecting Means:

1. UL 489 and NEMA AB 3 (with interrupting capacity to comply with available fault currents) instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
2. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
3. Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
4. As directed, NC or NO alarm contact that operates only when MCP has tripped.
5. Current-limiting module to increase controller SCCR (withstand) to 100 kA.

L. MCCB Disconnecting Means:

1. UL 489 and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
2. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
3. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
4. Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
5. As directed, NC or NO alarm contact that operates only when MCCB has tripped.

M. Molded-Case Switch Disconnecting Means:

1. UL 489 and NEMA AB 3, with in-line fuse block for Class J or Class L power fuses (depending on ampere rating), providing an interrupting capacity to comply with available fault currents; MCCB with fixed, high-set instantaneous trip only.
2. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

3. Auxiliary contacts "a" and "b" arranged to activate with molded-case switch handle.
4. As directed, NC or NO alarm contact that operates only when molded-case switch has tripped.

2.4 ENCLOSURES

A. Comply with NEMA 250, Type designations as indicated on Drawings, to comply with environmental conditions at installed location.

B. Construction of the enclosures shall comply with NEMA ICS 6.

2.5 ACCESSORIES

A. General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.

1. Push Buttons, Pilot Lights, and Selector Switches: Standard duty, except as needed to match enclosure type. Heavy-duty or oiltight where indicated in the controller schedule.

    a. Push Buttons: As indicated in the controller schedule.
    b. Pilot Lights: As indicated in the controller schedule.

2. Elapsed Time Meters: Heavy duty with digital readout in hours; nonresettable; resettable as directed.
3. Meters: Panel type, 2-1/2-inch (64-mm) minimum size with 90- or 120-degree scale and plus or minus 2 percent accuracy. Where indicated, provide selector switches with an off position.

2.6 IDENTIFICATION

A. Controller Nameplates: As directed, Baked-enamel, Metal-backed, butyrate or Laminated acrylic or melamine plastic signs, as described in Section 260553 "Identification for Electrical Systems," for each compartment, mounted with corrosion-resistant screws.

B. Arc-Flash Warning Labels;

1. Comply with requirements in Section 260573.19 "Arc-Flash Hazard Analysis." Produce a 3-1/2-by-5-inch (89-by-127-mm) self-adhesive label for each work location included in the analysis.
2. Comply with requirements in Section 260553 "Identification for Electrical Systems." Produce a 3-1/2-by-5-inch (89-by-127-mm) self-adhesive equipment label for each work location included in the analysis. Labels shall be machine printed, with no field-applied markings.

a. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:

1) Location designation.
2) Nominal voltage.
3) Flash protection boundary.
4) Hazard risk category.
5) Incident energy.
6) Working distance.
7) Engineering report number, revision number, and issue date.

b. Labels shall be machine printed, with no field-applied markings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Wall-Mounted Controllers: Install controllers on walls with tops at uniform height indicated, and by bolting units to wall or mounting on slotted support systems complying with Section 260529 "Hangers and Supports for Electrical Systems," and bolted to wall.

C. Freestanding Controllers: Provide slotted support systems complying with Section 260529 "Hangers and Supports for Electrical Systems."

D. Floor-Mounted Controllers: Install controllers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.

E. Comply with requirements for seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."

F. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

G. Control Wiring: Separate control wiring from power wiring. Where unavoidable, use twisted pair cabling or shielded cables for control wiring.

H. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

I. Setting of Overload Relays: Select and set overloads on the basis of FLA rating as shown on motor nameplate. Adjust setting value for special motors as required by NFPA 70 for high-torque, high-efficiency, and so on motors.

3.2 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.3 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Tests and Inspections:

1. Comply with provisions of NFPA 70B, Chapter "Testing and Test Methods."
2. Visual and Mechanical Inspection:

    a. Compare equipment nameplate data with Drawings and the Specifications.
    b. Inspect physical and mechanical condition.
    c. Inspect anchorage, alignment, and grounding.
    d. Verify that the unit is clean.
    e. Ensure that vent path openings are free from debris and that heat-transfer surfaces are clean.
    f. Verify correct connections of circuit boards, wiring, disconnects, and ribbon cables.
    g. Inspect Contactors:

        1) Verify mechanical operation.
        2) Verify that contact gap, wipe, alignment, and pressure are according to manufacturer's published data.

    h. Motor-Running Protection:

        1) Verify that motor FLA is at, or under, the controller current rating.
        2) Verify that overload element setting is correct for its application.
        3) Apply minimum- and maximum-speed set points. Verify that set points are within limitations of the load coupled to the motor.
        4) If motor-running protection is provided by fuses, verify correct fuse rating.

    i. Inspect bolted electrical connections for high resistance using one of the following two methods:

        1) Use a low-resistance ohmmeter. Compare bolted-connection-resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
        2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or

NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.

j. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

3. Electrical Tests:

a. As directed, For the contactor and circuit breaker, perform or Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Insulation-resistance values shall be according to manufacturer's published data or NETA ATS, Table 100.1. In the absence of manufacturer's published data, use Table 100.5. Values of insulation resistance less than this table or manufacturer's written instructions shall be investigated and corrected.
b. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
c. Test motor protection devices according to manufacturer's published data.
d. Test circuit breakers as follows:

1) Operate the circuit breaker to ensure smooth operation.
2) For adjustable circuit breakers, adjust protective device settings according to the coordination study. Comply with coordination study recommendations.

e. Test the electronic motor overload relay elements by injecting primary current through the overload circuit and monitoring trip time of the overload element.
f. Test the following parameters according to NETA relay calibration procedures, or as recommended by manufacturer:

1) ANSI No. 49R, Overtemperature Protection:

a) Determine time delay at 300 percent of setting.
b) Determine a second point on the operating curve.
c) Determine pickup.

2) ANSI No. 47, Input Phase Loss and Reversed Phases Protection:

a) Determine positive sequence voltage to close the NO contact.
b) Determine positive sequence voltage to open the NC contact (undervoltage trip).
c) Verify negative sequence trip.
d) Determine time delay to close the NO contact with sudden application of 120 percent of pickup.
e) Determine time delay to close the NC contact on removal of voltage when previously set to rated system voltage.

3) ANSI No. 81, Overfrequency Protection:

a) Verify frequency set points.
b) Determine time delay.

c) Determine undervoltage cutoff.

4) Fault Alarm Outputs: Verify that each relay contact performs its intended function in the control scheme including breaker trip tests, close inhibit tests, lockout tests, and alarm functions.

g. Perform operational tests by initiating control devices.

E. Motor controllers will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.4 SYSTEM FUNCTION TESTS

A. System function tests shall prove the correct interaction of sensing, processing, and action devices. Perform system function tests after field quality-control tests have been completed and all components have passed specified tests.

1. Develop test parameters and perform tests for the purpose of evaluating performance of integral components and their functioning as a complete unit within design requirements and manufacturer's published data.
2. Verify the correct operation of interlock safety devices for fail-safe functions in addition to design function.
3. Verify the correct operation of sensing devices, alarms, and indicating devices.

B. Motor controllers will be considered defective if they do not pass the system function tests and inspections.

C. Prepare test and inspection reports.

3.5 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain motor controllers.

END OF SECTION 262913.06

SECTION 262923 - VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes separately enclosed, preassembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

B. Related Requirements:

1. Section 262419 "Motor-Control Centers" for VFCs installed in motor-control centers.

1.2 DEFINITIONS

A. CE: Conformite Europeene (European Compliance).

B. CPT: Control power transformer.

C. DDC: Direct digital control.

D. EMI: Electromagnetic interference.

E. OCPD: Overcurrent protective device.

F. PID: Control action, proportional plus integral plus derivative.

G. RFI: Radio-frequency interference.

H. VFC: Variable-frequency motor controller.

1.3 ACTION SUBMITTALS

A. Product Data: For each type and rating of VFC indicated.

B. Shop Drawings: For each VFC indicated.

1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Seismic Qualification Data: Certificates, for each VFC, accessories, and components, from manufacturer.

1. Certificate of compliance.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based, and their installation requirements.

C. Product certificates.

D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace VFCs that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 SYSTEM DESCRIPTION

A. General Requirements for VFCs:

1. VFCs and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508A or UL 508C as directed.

B. Application: Constant torque and variable torque.

C. VFC Description: Variable-frequency motor controller, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as

a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.

1. Units suitable for operation of NEMA MG 1 motors.
2. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

D. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

E. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range or 66 Hz, with torque constant as speed changes as directed; maximum voltage equals input voltage.

F. Unit Operating Requirements:

1. Input AC Voltage Tolerance: As directed, Plus 10 and minus 10 or 15 percent of VFC input voltage rating.
2. Input AC Voltage Unbalance: Not exceeding 3 or 5 percent as directed.
3. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
4. Minimum Efficiency: As directed, 96 or 97 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: As directed, 96 or 98 percent under any load or speed condition as directed.
6. Minimum Short-Circuit Current (Withstand) Rating: As directed, 10, 22, 65 or 100 kA.
7. Ambient Temperature Rating: Not less than 32 deg F (0 deg C) and not exceeding 104 deg F (40 deg C).
8. Humidity Rating: Less than 95 percent (noncondensing).
9. Altitude Rating: Not exceeding 3300 feet (1000 m).
10. Vibration Withstand: Comply with NEMA ICS 61800-2.
11. Overload Capability: As directed, 1.1 or 1.5 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
12. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
13. Speed Regulation: Plus or minus 5 or 10 percent as directed.
14. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.
15. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.

G. Inverter Logic: Microprocessor based, 16 or 32 bit as directed, isolated from all power circuits.

H. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.

1. Signal: Electrical.

I. Internal Adjustability Capabilities:

1. Minimum Speed: 5 to 25 percent of maximum rpm.
2. Maximum Speed: 80 to 100 percent of maximum rpm.
3. Acceleration: 0.1 to 999.9 seconds.
4. Deceleration: 0.1 to 999.9 seconds.
5. Current Limit: 30 to minimum of 150 percent of maximum rating.

J. Self-Protection and Reliability Features:

1. Surge Suppression: Factory installed as an integral part of the VFC, complying with UL 1449 SPD, Type 1 or Type 2.
2. Surge Suppression: Field-mounted surge suppressors complying with Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits," UL 1449 SPD, Type 2.
3. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
4. Under- and overvoltage trips.
5. Inverter overcurrent trips.
6. VFC and Motor-Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
7. Critical frequency rejection, with three selectable, adjustable deadbands.
8. Instantaneous line-to-line and line-to-ground overcurrent trips.
9. Loss-of-phase protection.
10. Reverse-phase protection.
11. Short-circuit protection.
12. Motor-overtemperature fault.

K. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

L. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.

M. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

N. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

O. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

P. Integral Input Disconnecting Means and OCPD: As directed, UL 489, instantaneous-trip circuit breaker, UL 489, molded-case switch, with power fuse block and current-limiting fuses, UL 489, thermal-magnetic circuit breaker, NEMA KS 1, non-fusible switch, with power fuse block and current-limiting fuses or NEMA KS 1, fusible switch with pad-lockable, door-mounted handle mechanism.

1. Disconnect Rating: Not less than 115 percent of VFC input current rating.
2. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFC input current rating, whichever is larger.
3. Auxiliary Contacts: NO or NC, arranged to activate before switch blades open.
4. Auxiliary contacts "a" and "b" arranged to activate with circuit-breaker handle.
5. As directed, NC or NO alarm contact that operates only when circuit breaker has tripped.

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: VFCs shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. The designated VFCs shall be tested and certified by an NRTL as meeting the ICC-ES AC 156 test procedure requirements.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.4 CONTROLS AND INDICATION

A. Status Lights: Door-mounted LED indicators displaying the following conditions:

1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.
6. External fault.

B. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
2. Security Access: Provide electronic security access to controls through identification and password with at least one level of access: View only; view and operate; and view, operate, and service.

    a. Control Authority: Supports at least four conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.

C. Historical Logging Information and Displays:

1. Real-time clock with current time and date.
2. Running log of total power versus time.
3. Total run time.
4. Fault log, maintaining last four faults with time and date stamp for each.

D. Indicating Devices: Digital display and additional readout devices as required, mounted flush in VFC door and connected to display VFC parameters including, but not limited to:

1. Output frequency (Hz).
2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).
5. Motor torque (percent).

6. Fault or alarming status (code).
7. PID feedback signal (percent).
8. DC-link voltage (V dc).
9. Set point frequency (Hz).
10. Motor output voltage (V ac).

E. Control Signal Interfaces:

1. Electric Input Signal Interface:

   a. A minimum of two programmable analog inputs: As directed, 0- to 10-V dc, 4- to 20-mA dc or Operator-selectable "x"- to "y"-mA dc.
   b. A minimum of six multifunction programmable digital inputs.

2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the DDC system for HVAC or other control systems:

   a. 0- to 10-V dc.
   b. 4- to 20-mA dc.
   c. Potentiometer using up/down digital inputs.
   d. Fixed frequencies using digital inputs.

3. Output Signal Interface: As directed, A minimum of one programmable analog output signal(s) 0- to 10-V dc, 4- to 20-mA dc or operator-selectable "x"- to "y"-mA dc, which can be configured for any of the following:

   a. Output frequency (Hz).
   b. Output current (load).
   c. DC-link voltage (V dc).
   d. Motor torque (percent).
   e. Motor speed (rpm).
   f. Set point frequency (Hz).

F. PID Control Interface: Provides closed-loop set point, differential feedback control in response to dual feedback signals. Allows for closed-loop control of fans and pumps for pressure, flow, or temperature regulation.

1. Number of Loops: As directed, One or Two.

2.5 BYPASS SYSTEMS

A. Bypass Operation: Manually transfers motor between power converter output and bypass circuit. Unit is capable of stable operation (starting, stopping, and running) with motor completely disconnected from power converter.

B. Bypass Mode: Manual operation only; requires local operator selection at VFC. Transfer between power converter and bypass contactor, and retransfer shall only be allowed with the motor at zero speed.

C. Bypass Controller: Two-contactor-style bypass allows motor operation via the power converter or the bypass controller; with input isolating switch and barrier arranged to isolate the power converter and permit safe troubleshooting and testing, both energized and de-energized, while motor is operating in bypass mode.

1. Bypass Contactor: As directed, Load-break, IEC or NEMA-rated contactor.
2. Output Isolating Contactor: As directed, Non-load-break, IEC or NEMA-rated contactor.
3. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.

D. Bypass Contactor Configuration: As directed, full-voltage (across-the-line) or Reduced-voltage (autotransformer) type.

1. NORMAL/BYPASS selector switch.
2. HAND/OFF/AUTO selector switch.
3. NORMAL/TEST Selector Switch: Allows testing and adjusting of VFC while the motor is running in the bypass mode.
4. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.

    a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
    b. Power Contacts: Totally enclosed, double break, and silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.

5. Control Circuits: As directed, 120-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT or control power source of sufficient capacity to operate all integral devices and remotely located pilot, indicating, and control devices.

    a. CPT Spare Capacity: 100 VA.

6. Overload Relays: NEMA ICS 2.

2.6 OPTIONAL FEATURES

A. Damper control circuit with end-of-travel feedback capability.

B. Firefighter's Override (Smoke Purge) Input: As directed, on a remote contact closure from the firefighter's control station or smoke-control fan controller, this password-protected input:

1. Overrides all other local and external inputs (analog/digital, serial communication, and all keypad commands).
2. Forces VFC to operate motor, without any other run or speed command, at a field-adjustable, preset speed.
3. Forces VFC to transfer to bypass mode and operate motor at full speed.
4. Causes display of override mode on the VFC display.
5. Reset VFC to normal operation on removal of override signal automatically or manually as directed.

C. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a printer and a notebook computer.

2.7 ENCLOSURES

A. VFC Enclosures: NEMA 250, to comply with environmental conditions at installed location.

1. Dry and Clean Indoor Locations: Type 1.
2. Outdoor Locations: As directed, Type 3R or Type 4X.
3. As directed, Kitchen or Wash-Down Areas: As directed, Type 4X as stainless steel.
4. Other Wet or Damp Indoor Locations: Type 4.
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.

B. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFC as "Plenum Rated."

2.8 ACCESSORIES

A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in VFC enclosure cover unless otherwise indicated.

1. Push Buttons: As directed, Covered or Unguarded.
2. Pilot Lights: Push to test.
3. Selector Switches: Rotary type.

B. As directed, NC, NO or Reversible NC/NO bypass contactor auxiliary contact(s).

C. Control Relays: As directed, Auxiliary and adjustable pneumatic or solid-state time-delay relays.

D. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.

1. Current Transformers: Continuous current rating, basic impulse insulating level (BIL) rating, burden, and accuracy class suitable for connected circuitry. Comply with IEEE C57.13.

E. Supplemental Digital Meters:

1. Elapsed-time meter.
2. Kilowatt meter.
3. Kilowatt-hour meter.

F. Breather and drain assemblies, to maintain interior pressure and release condensation in NEMA 250, Type 4, Type 4X or Type 12 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings as directed.

G. Space heaters, with NC auxiliary contacts, to mitigate condensation in NEMA 250, Type 3R, Type 4X or Type 12 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings as directed.

H. Cooling Fan and Exhaust System: As directed, for NEMA 250, Type 1 or Type 12; UL 508 component recognized: Supply fan, with composite or stainless-steel intake and exhaust grills and filters; 120-V ac; obtained from integral CPT.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Wall-Mounting Controllers: Install with tops at uniform height and with disconnect operating handles not higher than 79 inches (2000 mm) above finished floor, unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."

B. Roof-Mounting Controllers: Install VFC on roofs with tops at uniform height and with disconnect operating handles not higher than 79 inches (2000 mm) above finished roof surface unless otherwise indicated, and by bolting units to curbs or mounting on freestanding, lightweight, structural-steel channels bolted to curbs. Seal roof penetrations after raceways are installed.

1. Curbs and roof penetrations are specified in Section 077200 "Roof Accessories."
2. Structural-steel channels are specified in Section 260529 "Hangers and Supports for Electrical Systems."

C. Seismic Bracing: Comply with requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

E. Install fuses in each fusible-switch VFC.

F. Install fuses in control circuits if not factory installed. Comply with requirements in Section 262813 "Fuses."

G. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors are installed.

H. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

I. Comply with NECA 1.

3.2 CONTROL WIRING INSTALLATION

A. Install wiring between VFCs and remote devices and facility's central-control system. Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."

B. Bundle, train, and support wiring in enclosures.

3.3 IDENTIFICATION

A. Identify VFCs, components, and control wiring. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each VFC with engraved nameplate.
3. Label each enclosure-mounted control and pilot device.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative

B. Acceptance Testing Preparation:

1. Test insulation resistance for each VFC element, bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Inspect VFC, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
2. Test insulation resistance for each VFC element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at VFC locations are within 10 percent of motor nameplate rated voltages. As directed, if outside this range for any motor, notify Architect, Construction Manager or Owner before starting the motor(s).
5. Test each motor for proper phase rotation.
6. Perform tests according to the Inspection and Test Procedures for Adjustable Speed Drives stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
8. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. VFCs will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies the VFC and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.5 ADJUSTING

A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

C. Adjust the trip settings of instantaneous-only circuit breakers and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to 6 times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed 8 times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Architect, Construction Manager or Owner before increasing settings as directed.

D. Set the taps on reduced-voltage autotransformer controllers.

E. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573.16 "Coordination Studies."

F. Set field-adjustable pressure switches.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFCs.

END OF SECTION 262923

SECTION 262933 - CONTROLLERS FOR FIRE-PUMP DRIVERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Full-service, full or reduced-voltage controllers rated 600 V and less as directed.
2. Limited-service controllers rated 600 V and less.
3. Controllers for diesel-drive fire pumps.
4. Controllers for pressure-maintenance pumps.
5. Remote alarm panels.

1.2 DEFINITIONS

A. ATS: Automatic transfer switch(es).

B. ECM: Electronic control module.

C. MCCB: Molded-case circuit breaker.

D. NO: Normally open.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For each type of product indicated.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Show tabulations of the following:

    a. Each installed unit's type and details.
    b. Enclosure types and details for types other than NEMA 250, Type 2.
    c. Factory-installed devices.
    d. Nameplate legends.
    e. Short-circuit current (withstand) rating of integrated unit.
    f. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices.
    g. Specified modifications.

4. Include diagrams for power, signal, alarm, control wiring, and pressure-sensing tubing.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For each type of product indicated, from manufacturer.

B. Source quality-control reports.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 FIELD CONDITIONS

A. Environmental Limitations:

1. Ambient Temperature Rating: Not less than 40 deg F (5 deg C) and not exceeding 122 deg F (50 deg C) unless otherwise indicated.
2. Altitude Rating: Not exceeding 6600 feet (2010 m) unless otherwise indicated.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with NFPA 20 and NFPA 70.

B. IEEE Compliance: Fabricate and test enclosed controllers according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."

C. Seismic Performance: Fire-pump controllers and alarm panels shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 FULL-SERVICE CONTROLLERS

A. General Requirements for Full-Service Controllers:

1. Comply with NFPA 20 and UL 218.
2. As directed, Combined automatic and nonautomatic or Nonautomatic operation.
3. Factory assembled, wired, and tested; continuous-duty rated.

B. Method of Starting:

1. As directed, Pressure or Non-pressure-switch actuated.

    a. Water-pressure-actuated switch and pressure transducer with independent high- and low-calibrated adjustments responsive to water pressure in fire-suppression piping.
    b. System pressure recorder, electric ac driven, with spring backup.
    c. Programmable minimum-run-time relay to prevent short cycling.
    d. Programmable timer for weekly tests.

2. Magnetic Controller: Across-the-line, Autotransformer, Part-winding, Primary-resistor, Primary-reactor, Wye-delta (open transition) or Wye-delta (closed transition) type as directed.
3. Solid-State Controller: Reduced-voltage type.
4. Emergency Start: Mechanically operated start handle that closes and retains the motor RUN contactor independent of all electric or pressure actuators.

C. Method of Stopping: Automatic and nonautomatic shutdown after automatic starting or Nonautomatic as directed.

D. Capacity: Rated for fire-pump-driver horsepower and short-circuit-current (withstand) rating equal to or greater than short-circuit current available at controller location.

E. Method of Isolation and Overcurrent Protection: Interlocked isolating switch and nonthermal MCCB; with a common, externally mounted operating handle, and providing locked-rotor protection.

F. Door-Mounted Operator Interface and Controls:

1. Monitor, display, and control the devices, alarms, functions, and operations listed in NFPA 20 as required for drivers and controller types used.
2. Method of Control and Indication:

    a. Microprocessor-based logic controller, with multiline digital readout.
    b. Membrane keypad.
    c. LED alarm and status indicating lights.

3. Local and Remote Alarm and Status Indications:

    a. Controller power on.
    b. Motor running condition.
    c. Loss-of-line power.
    d. Line-power phase reversal.
    e. Line-power single-phase condition.

4. Audible alarm, with silence push button.
5. Nonautomatic START and STOP push buttons or switches.

G. Optional Features:

1. Extra Output Contacts:

    a. One NO contact(s) for motor running condition.
    b. One set(s) of contacts for loss-of-line power.
    c. One each, Form C contacts for high and low reservoir level.

2. Local alarm bell.
3. Door-mounted thermal or impact printer for alarm and status logs.
4. Operator Interface Communications Ports: USB, Ethernet, and RS485.

H. ATS:

1. Complies with NFPA 20, UL 218, and UL 1008.
2. Integral with controller as a listed combination fire-pump controller and power transfer switch.
3. Automatically transfers fire-pump controller from normal power supply to alternate power supply in event of power failure.
4. Allows manual transfer from one source to the other.
5. Alternate-Source Isolating and Disconnecting Means: Integral molded-case switch, with an externally mounted operating handle.
6. Alternate-Source Isolating and Disconnecting Means: Mechanically interlocked isolation switch and circuit breaker rated at a minimum of 115 percent of rated motor full-load current, with an externally mounted operating handle; circuit breaker shall be provided with nonthermal sensing, instantaneous-only short-circuit overcurrent protection to comply with available fault currents.
7. Local and Remote Alarm and Status Indications:

    a. Normal source available.
    b. Alternate source available.
    c. In normal position.
    d. In alternate position.
    e. Isolating means open.

8. Audible alarm, with silence push button.
9. Nonautomatic (manual, nonelectric) means of transfer.
10. Engine test push button.
11. Start generator output contacts.
12. Timer for weekly generator tests.

2.3 LIMITED-SERVICE CONTROLLERS

A. General Requirements for Limited-Service Controllers:

1. Comply with NFPA 20 and UL 218.
2. Combined automatic and nonautomatic or Nonautomatic operation as directed.
3. Factory assembled, wired, and tested; continuous-duty rated.

B. Method of Starting:

1. Pressure or Non-pressure-switch actuated as directed.

a. Water-pressure-actuated switch and pressure transducer with independent high- and low-calibrated adjustments responsive to water pressure in fire-suppression piping.
b. System pressure recorder, electric ac driven, with spring backup.
c. Programmable minimum-run-time relay to prevent short cycling.
d. Programmable timer for weekly tests.

2. Across-the-line magnetic controller.
3. Emergency Start: Mechanically operated start handle that closes and retains the motor RUN contactor independent of all electric or pressure actuators.

C. Method of Stopping: Automatic and nonautomatic shutdown after automatic starting or Nonautomatic as directed.

D. Capacity: Rated for fire-pump-driver horsepower and short-circuit-current (withstand) rating equal to or greater than short-circuit current available at controller location.

E. Method of Isolation and Overcurrent Protection: Inverse-time, nonadjustable MCCB, with an externally mounted operating handle.

F. Door-Mounted Operator Interface and Controls:

1. Monitor, display, and control the devices, alarms, functions, and operations listed in NFPA 20 as required for drivers and controller types used.
2. Method of Control and Indication:

a. Microprocessor-based logic controller, with multiline LCD digital readout.
b. Membrane keypad.
c. LED alarm and status indicating lights.

3. Local and Remote Alarm and Status Indications:

a. Controller power on.
b. Motor running condition.
c. Loss-of-line power.
d. Line-power phase reversal.
e. Line-power single-phase condition.

4. Audible alarm, with silence push button.
5. Nonautomatic START and STOP push buttons.

G. Optional Features:

1. Extra Output Contacts:

a. One NO contact(s) for motor running condition.
b. One set(s) of contacts for loss-of-line power.
c. One each, Form C contacts for high and low reservoir level.

2. Local alarm bell.
3. Door-mounted thermal or impact printer for alarm and status logs.

4. Operator Interface Communications Ports: USB, Ethernet, and RS485.

H. ATS:

1. Complies with NFPA 20, UL 218, and UL 1008.
2. Integral with controller as a listed combination fire-pump controller and power transfer switch.
3. Automatically transfers fire-pump controller from normal power supply to alternate power supply in event of power failure.
4. Allows manual transfer from one source to the other.
5. Alternate-Source Isolating and Disconnecting Means: Integral molded-case switch, with an externally mounted operating handle.
6. Alternate-Source Isolating and Disconnecting Means: Mechanically interlocked isolation switch and circuit breaker rated at a minimum of 115 percent of rated motor full-load current, with an externally mounted operating handle; circuit breaker shall be provided with nonthermal sensing, instantaneous-only, short-circuit overcurrent protection to comply with available fault currents.
7. Local and Remote Alarm and Status Indications:

    a. Normal source available.
    b. Alternate source available.
    c. In normal position.
    d. In alternate position.
    e. Isolating means open.

8. Audible alarm, with silence push button.
9. Nonautomatic (manual, nonelectric) means of transfer.
10. Engine test push button.
11. Start generator output contacts.
12. Timer for weekly generator tests.

2.4 STANDALONE ATS

A. General Requirements for Standalone ATS:

1. Complies with NFPA 20, UL 218, and UL 1008.
2. Automatic and nonautomatic operation.
3. Separate from controller and individually listed as a fire-pump-controller power transfer switch.
4. Automatically transfers fire-pump controller from normal power supply to alternate power supply in event of power failure.
5. Allows manual transfer from one source to the other; factory assembled, wired, and tested.

B. Capacity: Rated for fire-pump-driver horsepower and short-circuit-current (withstand) rating equal to or greater than short-circuit current available at ATS location.

C. Alternate-Source Isolating and Disconnecting Means: Integral molded-case switch, with an externally mounted operating handle.

D. Door-Mounted Operator Interface and Controls:

1. Monitor, display, and control devices, alarms, functions, and operations listed in NFPA 20 as required for drivers and controller types used.
2. Method of Control and Indication:

    a. Microprocessor-based logic controller, with multiline LCD readout.
    b. Membrane keypad.
    c. LED alarm and status indicating lights.

3. Local and Remote Alarm and Status Indications:

    a. Normal source available.
    b. Alternate source available.
    c. In normal position.
    d. In alternate position.
    e. Isolating means open.

4. Audible alarm, with silence push button.
5. Nonautomatic (manual, nonelectric) means of transfer.
6. Engine test push button.
7. Start generator output contacts.
8. Timer for weekly generator tests.

E. Optional Features:

1. Extra Output Contacts:

    a. One each, Form A; isolating means open.
    b. One each, Form C; in normal or alternate position.

2. Door-mounted thermal or impact printer for alarm and status logs.
3. Operator Interface Communications Ports: USB, Ethernet, and RS485.

2.5 CONTROLLERS FOR DIESEL-DRIVE FIRE PUMPS

A. General Requirements for Controllers:

1. Comply with NFPA 20 and UL 218.
2. Combined automatic and nonautomatic or Nonautomatic operation as directed.
3. Factory assembled, wired, and tested.

B. Method of Starting:

1. As directed, Pressure or Non-pressure-switch actuated.

    a. Water-pressure-actuated switch and pressure transducer with independent high- and low-calibrated adjustments responsive to water pressure in fire-suppression piping.
    b. System pressure recorder, electric ac driven, with spring backup.
    c. Programmable minimum-run-time relay to prevent short cycling.

d. Programmable timer for weekly tests.

2. Dual, redundant dc-voltage battery units, with automatic changeover.
3. Emergency Control: Bypasses all automatic control circuits during manual starting and running.
4. Automatic engine start on loss of ac power to the controller.

C. Method of Stopping: Automatic and nonautomatic shutdown after automatic starting or Nonautomatic as directed.

D. Door-Mounted Operator Interface and Controls:

1. Monitor, display, and control devices, alarms, functions, and operations listed in NFPA 20 as required for drivers and controller types used.
2. Method of Control and Indication:

a. Microprocessor-based logic controller, with multiline LCD readout.
b. Membrane keypad.
c. LED alarm and status indicating lights.

3. Local and Remote Alarm and Status Indications:

a. Controller power on.
b. Engine-lubrication-system critically low oil pressure.
c. Engine-jacket coolant high temperature.
d. Engine fail-to-start.
e. Engine overspeed shutdown.
f. Low fuel level.
g. Missing or failed battery.
h. Battery charger failure.
i. System overpressure.
j. ECM selector switch in alternate ECM position.
k. Fuel injector malfunction.

4. Audible alarm.
5. Nonautomatic START and STOP push buttons or switches.

E. Optional Features:

1. Extra Output Contacts:

a. One Form C contacts for low pump-room temperature.
b. One each, Form C contacts for high and low fuel levels.
c. One each, Form C contacts for high and low reservoir levels.

2. Door-mounted thermal or impact printer for alarm and status logs.
3. Operator Interface Communications Ports: USB, Ethernet, and RS485.
4. Powered louver contacts.
5. Powered engine-oil heater contacts.

F. Battery Charger System:

1. Built-in, independent, dual battery chargers with automatic changeover; 12-V dc or 24-V dc for lead-acid or nickel-cadmium batteries as directed.
2. Standard: UL 1236.

2.6 CONTROLLERS FOR PRESSURE-MAINTENANCE PUMPS

A. General Requirements for Pressure-Maintenance-Pump Controllers:

1. Type: UL 508, factory-assembled, -wired, and -tested, across-the-line controller; for combined automatic and manual operation.
2. Enclosure: UL 508 and NEMA 250, Type 2 for wall-mounting.
3. Factory assembled, wired, and tested.
4. Finish: Manufacturer's standard color paint.

B. Rate controller for scheduled horsepower and include the following:

1. Fusible disconnect switch.
2. Pressure switch.
3. Hand-off-auto selector switch.
4. Pilot light.
5. Running period timer.

2.7 REMOTE ALARM PANELS

A. General Requirements for Remote Alarm Panels: Factory assembled, wired, and tested; and complying with NFPA 20 and UL 218.

B. Supervisory and Normal Control Voltage: 120-V ac or 240-V ac; single or dual source as directed.

C. Audible and Visual Alarm and Status Indications:

1. Driver running.
2. Loss of phase.
3. Phase reversal.
4. Supervised power on.
5. Common or Separate trouble on the controller.

6. Controller connected to alternate power source.

D. Audible and Visual Alarm and Status Indications: Manufacturer's standard indicating lights; push-to-test or non-push-to-test, with separate test push button as directed.

1. Engine running.
2. Controller main switch turned to the off or manual position.
3. Supervised power on.
4. As directed, Common or Separate trouble on the controller or engine.

5. Common pump room trouble.
6. Controller connected to alternate power source.

E. Audible alarm, with silence push button.

F. Pump REMOTE START push button.

2.8 ENCLOSURES

A. Fire-Pump Controllers, ATS, Remote Alarm Panels, and Low-Suction-Shutdown Panels: NEMA 250, to comply with environmental conditions at installed locations and NFPA 20.

1. Indoor, Dry and Clean Locations: Type 1 (IEC IP10).
2. Indoor Locations Subject to Dripping Noncorrosive Liquids: Type 2 (IEC IP11).
3. Outdoor Locations: Type 3R (IEC IP14), Type 4 (IEC IP56) or Type 4X (IEC IP56) as directed.
4. Other Wet or Damp, Indoor Locations: Type 4 (IEC IP56) or Type 4X (IEC IP56) as directed.
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12 (IEC IP12).

B. Enclosure Color: Manufacturer's standard "fire-pump-controller red".

C. Nameplates: Comply with NFPA 20; complete with capacity, characteristics, approvals, listings, and other pertinent data.

D. Optional Features:

1. Floor stands, 12 inches (305 mm) high, for floor-mounted controllers.
2. Space heater, 120-V ac, 240-V ac, with humidistat, with thermostat as directed.
3. Tropicalization.

2.9 SOURCE QUALITY CONTROL

A. Testing: Test and inspect fire-pump controllers according to requirements in NFPA 20 and UL 218.

1. Verification of Performance: Rate controllers according to operation of functions and features specified.

B. Fire-pump controllers will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 CONTROLLER INSTALLATION

A. Coordinate installation of controllers with other construction including conduit, piping, fire-pump equipment, and adjacent surfaces. Maintain required clearances for workspace and

equipment access doors and panels. Ensure that controllers are within sight of fire-pump drivers.

B. Coordinate sizes and locations of concrete bases with actual equipment provided.

C. Install controllers within sight of their respective drivers.

D. Connect controllers to their dedicated pressure-sensing lines.

E. Wall-Mounting Controllers: Install controllers on walls with disconnect operating handles not higher than 79 inches (2006 mm) above finished floor, and bottom of enclosure not less than 12 inches (305 mm) above finished floor unless otherwise indicated. Bolt units to wall or mount on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."

F. Floor-Mounting Controllers: Install controllers on concrete base(s), using floor stands high enough so that the bottom of enclosure cabinet is not less than 12 inches (305 mm) above finished floor. Comply with requirements for concrete bases specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed

1. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
2. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
3. Install anchor bolts to elevations required for proper attachment to supported equipment.

G. Seismic Bracing: Comply with requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

H. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

I. Comply with NEMA ICS 15.

3.2 STANDALONE ATS INSTALLATION

A. Wall-Mounting ATS: Install ATS on walls with disconnect operating handles not higher than 79 inches (2006 mm) above finished floor, and bottom of enclosure not less than 12 inches (305 mm) above finished floor unless otherwise indicated. Bolt units to wall or mount on lightweight structural-steel channels bolted to wall. For ATS not on walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."

B. Floor-Mounting ATS: Install ATS on concrete bases, using floor stands high enough so that the bottom of enclosure cabinet is not less than 12 inches (305 mm) above finished floor. Comply with requirements for concrete bases specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed

1. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.

2. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
3. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Seismic Bracing: Comply with requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."

D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

3.3 REMOTE ALARM PANEL INSTALLATION

A. Install panels on walls with tops not higher than 72 inches (1829 mm) above finished floor unless otherwise indicated. Bolt units to wall or mount on lightweight structural-steel channels bolted to wall. For ATS not on walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."

3.4 POWER WIRING INSTALLATION

A. Install power wiring between controllers and their services or sources, and between controllers and their drivers. Comply with requirements in NFPA 20, NFPA 70, and Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.5 CONTROL AND ALARM WIRING INSTALLATION

A. Install wiring between controllers and remote devices and facility's central monitoring system. Comply with requirements in NFPA 20, NFPA 70, and Section 260523 "Control-Voltage Electrical Power Cables."

B. Install wiring between remote alarm panels and controllers. Comply with requirements in NFPA 20, NFPA 70, and Section 260523 "Control-Voltage Electrical Power Cables."

C. Install wiring between controllers and the building's fire-alarm system. Comply with requirements specified in Section 284621.11 " Addressable Fire-Alarm Systems."

D. Bundle, train, and support wiring in enclosures.

E. Connect remote manual and automatic activation devices where applicable.

3.6 IDENTIFICATION

A. Comply with requirements in NFPA 20 for marking fire-pump controllers.

B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification in NFPA 20 and as specified in Section 260553 "Identification for Electrical Systems."

3.7 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

B. Acceptance Testing Preparation:

1. Inspect and Test Each Component:

   a. Inspect wiring, components, connections, and equipment installations. Test and adjust components and equipment.
   b. Test insulation resistance for each element, component, connecting supply, feeder, and control circuits.
   c. Test continuity of each circuit.

2. Verify and Test Each Electric-Drive Controller:

   a. Verify that voltages at controller locations are within plus 10 or minus 1 percent of motor nameplate rated voltages, with motors off. If outside this range for any motor, notify Architect, Construction Manager or Owner before starting the motor(s) as directed.
   b. Test each motor for proper phase rotation.

3. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Field Acceptance Tests:

1. Do not begin field acceptance testing until suction piping has been flushed and hydrostatically tested and the certificate for flushing and testing has been submitted to Architect, Construction Manager or Owner and authorities having jurisdiction as directed.
2. Prior to starting, notify authorities having jurisdiction of the time and place of the acceptance testing.
3. Engage manufacturer's factory-authorized service representative to be present during the testing.
4. Perform field acceptance tests as outlined in NFPA 20.

D. Controllers will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.8 STARTUP SERVICE

A. As directed, engage a factory-authorized service representative to perform or Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.9 ADJUSTING

A. Adjust controllers and battery charger systems to function smoothly and as recommended by manufacturer.

B. Set field-adjustable switches, auxiliary relays, time-delay relays, and timers.

C. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

D. Set field-adjustable pressure switches.

3.10 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain controllers and remote alarm panels.

END OF SECTION 262933

SECTION 263100 - PHOTOVOLTAIC COLLECTORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. PV systems description.
2. Manufactured PV units.
3. PV module framing.
4. PV array construction.
5. Inverters.
6. System overcurrent protection.
7. Mounting structures.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For PV modules.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies.
3. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Manufacturer's Special Warranty: Manufacturer agrees to repair or replace components of PV modules that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two or Five years from date of Substantial Completion.

B. Manufacturer's Special Minimum Power Output Warranty: Manufacturer agrees to repair or replace components of PV modules that fail to exhibit the minimum power output within

specified warranty period. Special warranty, applying to modules only, applies to materials only, on a prorated basis, for period specified.

1. Manufacturer's minimum power output warranties include, but are not limited to, the following warranty periods, from date of Substantial Completion:

    a. Specified minimum power output to 80 percent or more, for a period of 25 years.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

2.2 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled by a qualified testing agency and marked for intended location and application.

B. Seismic Qualification Certificates: For equipment as directed, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

2.3 PV CAPACITIES AND CHARACTERISTICS

A. Minimum Electrical Characteristics:

1. Rated Open-Circuit Voltage: As directed.
2. Maximum System Voltage: As directed.
3. Maximum Power at Voltage (Vpm): As directed.
4. Short-Circuit Temperature Coefficient: As directed.
5. Rated Short-Circuit Current (Isc): As directed.
6. Maximum System: As directed.
7. Rated Operation Current (Imp): As directed.
8. Maximum Power at STC (Pmax): As directed.

B. Additional Electrical Characteristics:

1. PTC Rating: As directed.
2. Peak Power per Unit Area: As directed.
3. Tolerance of Pmax: Percent as directed.
4. Minimum Peak Power: As directed.
5. Series Fuse Rating: As directed.
6. Module Efficiency: Percent as directed.

7. Temperature Cycling Range: As directed.
8. Humidity, Freeze, Damp Heat Condition: Percent RH as directed.
9. Wind Loading or Surface Pressure: As directed.
10. Maximum Distortion Angle: As directed.
11. Hailstone Impact Withstand: As directed.
12. Series Fuse Rating: As directed.

C. Normal Operating Temperature Characteristics (NOTC):

1. Temperature at Nominal Operating Cell Temperature: As directed.
2. Temperature Coefficient (NOTC Nominal Power): As directed.
3. Temperature Coefficient (NOTC Open-Circuit Voltage): As directed.
4. Temperature Coefficient (NOTC Short Circuit Current): As directed.
5. Temperature Coefficient (NOTC Maximum Power Voltage): As directed.
6. Temperature Coefficient (NOTC Maximum Power Current): As directed.

2.4 PV SYSTEMS DESCRIPTION

A. Interactive PV System: Collectors connected in parallel to the electrical utility; and capable of providing power for Project and supplying power to a distributed network.

1. A six-module array to generate a total nominal rated output of 1000 W.
2. System Components:

a. PV modules.
b. Array frame.
c. Utility-interactive inverter.
d. Overcurrent protection, disconnect, and rapid shutdown devices.
e. Mounting structure.
f. Utility meter.

2.5 MANUFACTURED PV UNITS

A. Cell Materials: Amorphous silicon (a-Si).

B. Cell Materials: Micromorphous silicon (a-Si+uc-Si).

C. Cell Materials: Copper indium (di)selenide (CIS).

D. Cell Materials: Copper indium gallium (di)selenide (CIGS).

E. Cell Materials: Cadmium telluride (CdTe).

F. Cell Materials: Cadmium sulfide.

G. Cell Materials: Polycrystalline or Monocrystalline as directed.

1. c-Si.
2. Gallium arsenide (GaAs).

H. Module Construction:

1. Nominal Size: 32 inches (800 mm) wide by 64 inches (1600 mm) long.
2. Weight: 42.8 lb (19.4 kg).

I. Encapsulant: Ethyl vinyl acetate.

J. Front Panel: Fully tempered glass.

K. Front Panel: 0.125-inch- (3.2-mm-) thick glass.

L. Backing Material: Tempered glass.

M. Backing Material: 0.125-inch- (3.2-mm-) thick glass; as directed.

N. Backing Material: Polyester film.
1. Layers: As directed.
2. Color: White.

O. Backing Material: PVC film.
1. Layers: As directed.
2. Color: White.

P. Junction Box:

1. Size: 1.56 by 3.96 by 0.52 inch (39.6 by 100.6 by 13.2 mm).
2. Fully potted, vandal resistant.
3. IP Code: As directed, IP65, IP66 or IP67.
4. Flammability Test: UL 1703.

Q. Output Cabling:

1. 0.158 inch (4 mm).
2. Quick, multiconnect, polarized connectors.
3. Two-Conductor Harness: No traditional return wire is needed from the end of a row back to the source combiner.

R. Series Fuse Rating: As directed.

2.6 PV MODULE FRAMING

A. PV laminates mounted in anodized extruded-aluminum frames.

1. Entire assembly UL listed for electrical and fire safety, Class A or Class C, according to UL 1703, and complying with IEC 61215.
2. Frame strength exceeding requirements of certifying agencies in subparagraph above.
3. Finish: Anodized aluminum.

a. Alloy and temper recommended by framing manufacturer for strength, corrosion resistance, and application of required finish.
b. Color: As indicated by manufacturer's designations.

4. Finish: High-performance organic finish.

    a. Fluoropolymer Two-Coat System: Manufacturer's standard two-coat, thermocured system consisting of specially formulated inhibitive primer and fluoropolymer color topcoat containing not less than 70 percent PVC resin by weight.
    b. Color: As indicated by manufacturer's designations.

5. Finish: Baked-enamel finish.

    a. Color: As indicated by manufacturer's designations.

2.7 PV ARRAY CONSTRUCTION

A. Framing:

1. Material: Extruded aluminum, Galvanized steel or Coated steel.
2. Maximum System Weight: Less than 4 lb/sq. ft. (19.53 kg/sq. m).
3. Minimum Distance to Connectors: As directed.
4. Raceway Cover Plates: Plastic, Aluminum or Galvanized steel as directed.

2.8 INVERTER

A. Inverter Type: Central or Microgrid as directed.

B. Control Type: Pulse-width-modulation control.

C. Control Type: Maximum power point tracker control.

D. Inverter Electrical Characteristics:

1. Maximum Recommended PV Input Power: As directed.
2. Maximum Open-Circuit Voltage: As directed.
3. PV Start Voltage: As directed.
4. MPPT Voltage Range: As directed.
5. Maximum Input Current: As directed.
6. Number of String Inputs: As directed.
7. Number of Independent MPPT Circuits: As directed.
8. Nominal Output Voltage: As directed.
9. CEC Rated Power: As directed.
10. Nominal Output Voltage: As directed.
11. Maximum Output Current: As directed.
12. Peak Efficiency: Percent as directed.
13. CEC Weighted Efficiency: Percent as directed.
14. CEC Night Tare Loss: Watts as directed.
15. DC/AC Terminal Range (AWG): Range of AWG values as directed.
16. Communications Interface: As directed, RS 485, RS 232, Ethernet or Zigbee.
17. Utility Interface: Utility-interactive inverter.

E. Operating Conditions:

1. Operating Ambient Temperatures: Minus 4 to plus 122 deg F (20 to plus 50 deg C).
2. Storage Temperature: Minus 40 to plus 122 deg F (minus 40 to plus 50 deg C).
3. Relative Humidity: Zero to 95 percent, noncondensing.

F. Charge controllers shall have the following:

1. Overcurrent protection.
2. Generator input breaker box.
3. Automatic transfer relay.
4. Digital display.
5. Transformer.
6. Disconnect switch.
7. Shunt controller.
8. Shunt regulator.
9. Surge overload protection.

G. Enclosure:

1. NEMA 250, Type 3R, Type 4X as directed.
2. Enclosure Material: As directed, Galvanized steel or Steel.
3. Cooling Methods:

    a. Fan convection cooling.
    b. Passive cooling.

4. Protective Functions:

    a. AC over/undervoltage.
    b. AC over/underfrequency.
    c. Ground overcurrent.
    d. Overtemperature.
    e. AC and dc overcurrent.
    f. DC overvoltage.

5. Standard LCD, four lines, 20 characters, with user display and on/off toggle switch.

H. Disconnects: Rated for system voltage and conductor.

I. Regulatory Approvals:

1. IEEE 1547.1.
2. IEEE 1547.3.
3. UL 1741.

J. Characteristics:

1. Inverter Dimensions: Inches (mm) as directed.
2. Inverter Weight: Lb (kg) as directed.

2.9 SYSTEM OVERCURRENT PROTECTION

A. Fuses: As directed.

B. Circuit Breakers: As directed.

2.10 MOUNTING STRUCTURES

A. Roof Mount: As directed, extruded aluminum, two or four rails, tilt legs, and roof standoffs.

B. Pole Mount: Top, Panel tops or Side as directed.

C. Tracking Mounts: One or Two axis as directed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Examine modules and array frame before installation. Reject modules and arrays that show shipping damage, are wet, are moisture damaged, or are mold damaged.

C. Coordinate layout and installation of PV panels with roof or support assembly and other construction.

D. Support PV panel assemblies independent of supports for other elements such as roof and support assemblies, enclosures, vents, pipes, and conduits. Support assembly to prevent twisting from eccentric loading.

E. Install PV inverters, energy storage, charge controller, rapid shutdown, and system control in locations indicated on Drawings.

F. Install weatherseal fittings and flanges where PV panel assemblies penetrate exterior elements such as walls or roofs. Seal around openings to make weathertight. See Section 079200 "Joint Sealants" for materials and application.

G. Seismic Restraints: Comply with requirements for seismic-restraint devices specified in Section 260548.16 "Seismic Controls for Electric Systems."

H. Wiring Method: Install cables in raceways.

I. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.2 CONNECTIONS

A. Coordinate installation of utility-interactive meter with utility.

B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

END OF SECTION 263100

SECTION 263213.13 - DIESEL EMERGENCY ENGINE GENERATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes packaged diesel engine generators for emergency use with the following features:

1. Diesel engine.
2. Diesel fuel-oil system.
3. Control and monitoring.
4. Generator overcurrent and fault protection.
5. Generator, exciter, and voltage regulator.
6. Vibration isolation devices.

B. Related Requirements:

1. Section 263600 "Transfer Switches" for transfer switches, including sensors and relays to initiate automatic-starting and -stopping signals for engine generators.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include plans and elevations for engine generator and other components specified. Indicate access requirements affected by height of subbase fuel tank.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Identify fluid drain ports and clearance requirements for proper fluid drain.
4. Design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and supported equipment. Include base weights.
6. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings for EPS equipment and functional relationship between all electrical components.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates for engine generator, accessories, and components, from manufacturer.

B. Source quality-control reports.

C. Certified test reports.

D. Field quality-control reports.

E. Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

B. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.6 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: As directed, Number of years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain packaged engine generators and auxiliary components from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Engine generator housing, day tank, engine generator, batteries, battery racks, silencers, sound attenuating equipment, accessories, and components shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Shake-table testing shall comply with ICC-ES AC156. Testing shall be performed with all fluids at worst-case normal levels. Water shall be substituted for diesel fuel in fuel tank during test.

3. Component Importance Factor: 1.5 or 1.0 as directed.

B. B11 Compliance: Comply with B11.19.

C. NFPA Compliance:

1. Comply with NFPA 37.
2. Comply with NFPA 70.
3. Comply with NFPA 99.
4. Comply with NFPA 110 requirements for Level 1 or 2 EPSS as directed.

D. UL Compliance: Comply with UL 2200.

E. Engine Exhaust Emissions: As directed, Comply with EPA Tier 2, 3 or 4 requirements and applicable state and local government requirements.

F. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by engine generator, including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

G. Environmental Conditions: Engine generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: 41 to 104 deg F (5 to 40 deg C) or 5 to 104 deg F (Minus 15 to plus 40 deg C) as directed.
2. Relative Humidity: Zero to 95 percent.
3. Altitude: Sea level to 1000 feet (300 m).

H. Unusual Service Conditions: Engine generator equipment and installation are required to operate under the following conditions:

1. High salt-dust content in the air due to sea-spray evaporation.

2.3 ENGINE GENERATOR ASSEMBLY DESCRIPTION

A. Factory-assembled and -tested, water-cooled engine, with brushless generator and accessories.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. EPSS Class: As directed, Engine generator shall be classified as a Class 2, Class 6, Class 48 or Class 96 according to NFPA 110.

D. Service Load: As directed, number kVA.

E. Power Factor: 0.8, lagging.

F. Frequency: 60 Hz.

G. Voltage: As directed, 208, 240, 480 or 600 V ac.

H. Phase: As directed, Three-phase, three or four-wire wye or delta.

I. Induction Method: As directed, Naturally aspirated or Turbocharged.

J. Governor: Adjustable isochronous, with speed sensing.

K. Mounting Frame: Structural steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.

1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and engine generator center of gravity.

L. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated at 0.8 power factor excluding power required for the continued and repeated operation of the unit and auxiliaries.
2. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.

M. Engine Generator Performance:

1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage, from no load to full load.
2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency, from no load to full load.
4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
7. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
8. Start Time: As directed, Comply with NFPA 110, Type U or Type 10 system requirements.

2.4 DIESEL ENGINE

A. Fuel: ASTM D975 diesel fuel oil, Grade 2-D S15.

B. Rated Engine Speed: 1800 rpm.

C. Lubrication System: Engine or skid mounted.

1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

D. Jacket Coolant Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity and with UL 499.

E. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine generator mounting frame and integral engine-driven coolant pump.

1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
2. Size of Radiator: Adequate to contain expansion of total system coolant, from cold start to 110 percent load condition.
3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant-system pressure for engine used. Equip with gage glass and petcock.
4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, UV-, and abrasion-resistant fabric.

    a. Rating: 50-psig (345-kPa) maximum working pressure with coolant at 180 deg F (82 deg C), and non-collapsible under vacuum.
    b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

F. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

1. Minimum sound attenuation of 25 dB at 500 Hz.
2. Sound level measured at a distance of 25 feet (8 m) from exhaust discharge after installation is complete shall be 78 dBA or less.

G. Muffler/Silencer: Semi-critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

1. Minimum sound attenuation of 18 dB at 500 Hz.
2. Sound level measured at a distance of 25 feet (8 m) from exhaust discharge after installation is complete shall be 85 dBA or less.

H. Muffler/Silencer: Commercial type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

1. Minimum sound attenuation of 12 dB at 500 Hz.
2. Sound level measured at a distance of 25 feet (8 m) from exhaust discharge after installation is complete shall be 90 dBA or less.

I. Air-Intake Filter: As directed, Standard or Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

J. Starting System: As directed, 12 or 24 V electric, with negative ground.

1. Components: Sized so they are not damaged during a full engine-cranking cycle, with ambient temperature at maximum specified in "Performance Requirements" Article.
2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
3. Cranking Cycle: As required by NFPA 110 for system level specified or 60 seconds.
4. Battery: As directed, Lead acid or Nickel cadmium, with capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least twice or three times without recharging.
5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 50 deg F (10 deg C) regardless of external ambient temperature within range specified in "Performance Requirements" Article. Include accessories required to support and fasten batteries in place. Provide ventilation to exhaust battery gases.
7. Battery Stand: Factory-fabricated, two-tier metal with acid-resistant finish designed to hold the quantity of battery cells required and to maintain the arrangement to minimize lengths of battery interconnections.
8. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
9. Battery Charger: Current-limiting, automatic-equalizing, and float-charging type designed for lead-acid or nickel-cadmium batteries as directed. Unit shall comply with UL 1236 and include the following features:

    a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
    b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg F (minus 40 deg C) to 140 deg F (plus 60 deg C) to prevent overcharging at high temperatures and undercharging at low temperatures.
    c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.

d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
f. Enclosure and Mounting: NEMA 250, Type 1 wall-mounted cabinet.

2.5 DIESEL FUEL-OIL SYSTEM

A. Comply with NFPA 30.

B. Piping: Fuel-oil piping shall be Schedule 40 black steel, complying with requirements in Section 231113 "Facility Fuel-Oil Piping." Cast iron, aluminum, copper, and galvanized steel shall not be used in the fuel-oil system.

C. Main Fuel Pump: Mounted on engine to provide primary fuel flow under starting and load conditions.

D. Fuel Filtering: Remove water and contaminants larger than 1 micron.

E. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.

F. Fuel-Oil Storage Tank: Comply with requirements in Section 231313 "Facility Underground Fuel-Oil Storage Tanks" or Section 231323 "Facility Aboveground Fuel-Oil Storage Tanks".

1. Fuel Tank Capacity: Minimum 133 percent of total fuel required for periodic maintenance operations between fuel refills plus fuel for the hours of continuous operation required for the indicated EPSS Class.
2. Duplex Fuel-Oil Transfer Pump: Comply with requirements in Section 231213 "Facility Fuel-Oil Pumps."

G. Day Tank: Comply with UL 142, freestanding, factory-fabricated fuel tank assembly, with integral, float-controlled transfer pump and the following features:

1. Containment: Integral rupture basin with a capacity of 150 percent of nominal capacity of day tank.

a. Leak Detector: Locate in rupture basin and connect to provide audible and visual alarm in the event of day-tank leak.

2. Tank Capacity: As recommended by engine manufacturer for an uninterrupted period of four hours' operation at 100 percent of rated power output of engine generator system without being refilled.
3. Pump Capacity: Exceeds maximum flow of fuel drawn by engine-mounted fuel-supply pump at 110 percent of rated capacity, including fuel returned from engine.
4. Low-Level Alarm Sensor: Liquid-level device operates alarm contacts at 25 percent of normal fuel level.

5. High-Level Alarm Sensor: Liquid-level device operates alarm and redundant fuel-shutoff contacts at midpoint between overflow level and 100 percent of normal fuel level.
6. Piping Connections: Factory-installed fuel-supply and return lines, from tank to engine; local fuel fill; vent line; overflow line; and tank drain line with shutoff valve.
7. Redundant High-Level Fuel Shutoff: Actuated by high-level alarm sensor in day tank to operate a separate motor control device that disconnects day-tank pump motor. Sensor shall signal solenoid valve, located in fuel suction line between fuel storage tank and day tank, to close. Both actions shall remain in shutoff state until manually reset. Shutoff action shall initiate an alarm signal to control panel but shall not shut down engine generator.

2.6 CONTROL AND MONITORING

A. Automatic-Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of engine generator. When mode-selector switch is switched to the on position, engine generator starts. The off position of same switch initiates engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.

B. Manual-Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts engine generator. The off position of same switch initiates engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.

C. Provide minimum run time control set for 15 or 30 minutes as directed, with override only by operation of a remote emergency-stop switch.

D. Comply with UL 508A.

E. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the engine generator. Mounting method shall isolate the control panel from engine generator vibration. Panel shall be powered from the engine generator battery.

F. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common wall-mounted control and monitoring panel. Panel shall be powered from the engine generator battery.

G. Control and Monitoring Panel:

1. Digital controller with integrated LCD display, controls, and microprocessor, capable of local and remote control, monitoring, and programming, with battery backup.
2. Analog control panel with dedicated gages and indicator lights for the instruments and alarms indicated below.
3. Instruments: Located on the control and monitoring panel and viewable during operation.

    a. Engine lubricating-oil pressure gage.

b. Engine-coolant temperature gage.
c. DC voltmeter (alternator battery charging).
d. Running-time meter.
e. AC voltmeter, for each phase or connected to a phase selector switch as directed.
f. AC ammeter, for each phase or connected to a phase selector switch as directed.
g. AC frequency meter.
h. Generator-voltage-adjusting rheostat.

4. Controls and Protective Devices: Controls, shutdown devices, and common visual alarm indication as required by NFPA 110 for Level 1 or 2 system as directed, including the following:

a. Cranking control equipment.
b. Run-Off-Auto switch.
c. Control switch not in automatic position alarm.
d. Overcrank alarm.
e. Overcrank shutdown device.
f. Low water temperature alarm.
g. High engine temperature pre-alarm.
h. High engine temperature.
i. High engine temperature shutdown device.
j. Overspeed alarm.
k. Overspeed shutdown device.
l. Low-fuel main tank.

1) Low-fuel-level alarm shall be initiated when the level falls below that required for operation for the duration required for the indicated EPSS class.

m. Coolant low-level alarm.
n. Coolant low-level shutdown device.
o. Coolant high-temperature pre-alarm.
p. Coolant high-temperature alarm.
q. Coolant low-temperature alarm.
r. Coolant high-temperature shutdown device.
s. EPS load indicator.
t. Battery high-voltage alarm.
u. Low-cranking voltage alarm.
v. Battery-charger malfunction alarm.
w. Battery low-voltage alarm.
x. Lamp test.
y. Contacts for local and remote common alarm.
z. Low-starting air pressure alarm.
aa. Low-starting hydraulic pressure alarm.
bb. Remote manual-stop shutdown device.
cc. Air shutdown damper alarm when used.
dd. Air shutdown damper shutdown device when used.
ee. Generator overcurrent-protective-device not-closed alarm.

H. Common Remote Panel with Common Audible Alarm: Comply with NFPA 110 requirements for Level 1 or 2 systems as directed. Include necessary contacts and terminals in control and monitoring panel. Remote panel shall be powered from the engine generator battery.

I. Remote Alarm Annunciator: Comply with NFPA 99. An LED indicator light labeled with proper alarm conditions shall identify each alarm event, and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.

1. Overcrank alarm.
2. Coolant low-temperature alarm.
3. High engine temperature pre-alarm.
4. High engine temperature alarm.
5. Low lube oil pressure alarm.
6. Overspeed alarm.
7. Low-fuel main tank alarm.
8. Low coolant level alarm.
9. Low-cranking voltage alarm.
10. Contacts for local and remote common alarm.
11. Audible-alarm silencing switch.
12. Air shutdown damper when used.
13. Run-Off-Auto switch.
14. Control switch not in automatic position alarm.
15. Fuel tank derangement alarm.
16. Fuel tank high-level shutdown of fuel-supply alarm.
17. Lamp test.
18. Low-cranking voltage alarm.
19. Generator overcurrent protective device not closed.

J. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator unless otherwise indicated.

K. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

2.7 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Overcurrent protective devices for the entire EPSS shall be coordinated to optimize selective tripping when a short circuit occurs. Coordination of protective devices shall consider both utility and EPSS as the voltage source.

1. Overcurrent protective devices for the EPSS shall be accessible only to authorized personnel.

B. Generator Circuit Breaker: Molded-case, thermal-magnetic type; 100 percent rated; complying with UL 489.

1. Tripping Characteristic: Designed specifically for generator protection.
2. Trip Rating: Matched to generator output rating.
3. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.

4. Mounting: Adjacent to or integrated with control and monitoring panel.

C. Generator Circuit Breaker: Molded-case, electronic-trip type; 100 percent rated; complying with UL 489.

1. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
2. Trip Settings: Selected to coordinate with generator thermal damage curve.
3. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
4. Mounting: Adjacent to or integrated with control and monitoring panel.

D. Generator Disconnect Switch: Molded-case type, 100 percent rated.

1. Trip Rating: Matched to generator output rating.
2. Shunt Trip: Connected to trip switch when signaled by generator protector or by other protective devices.

E. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other engine generator protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector performs the following functions:

1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other engine generator malfunction alarms. Contacts shall be available for load shed functions.
2. Under single- or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the engine generator.
4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

F. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground fault.

1. Indicate ground fault with other engine generator alarm indications.
2. Trip generator protective device on ground fault.

2.8 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. Electrical Insulation: Class H or Class F.

D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required. Provide six or 12-lead alternator as directed.

E. Range: As directed, provide limited, broad or extended range of output voltage by adjusting the excitation level as directed.

F. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.

G. Enclosure: Dripproof.

H. Instrument Transformers: Mounted within generator enclosure.

I. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified and as required by NFPA 110.

1. Adjusting Rheostat on Control and Monitoring Panel: Provide plus or minus 5 percent adjustment of output-voltage operating band.
2. Maintain voltage within 15, 20 or 30 percent on one step, full load as directed.
3. Provide anti-hunt provision to stabilize voltage.
4. Maintain frequency within 5, 10 or 15 percent and stabilize at rated frequency within two or five seconds as directed.

J. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

K. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

L. Subtransient Reactance: 12 percent, maximum.

2.9 VIBRATION ISOLATION DEVICES

A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.

1. Material: Standard neoprene, Natural rubber or Bridge-bearing neoprene, complying with AASHTO M 251 separated by steel shims.
2. Shore A Scale Durometer Rating: 30, 40, 45, 50, 60, 65 or 70 as directed.
3. Number of Layers: As directed, One, Two, Three or Four.
4. Minimum Deflection: 1 inch (25 mm).

B. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.

1. Housing: Steel with resilient, vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment-mounting and -leveling bolt that acts as blocking during installation.

2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Minimum Deflection: 1 inch (25 mm).

C. Comply with requirements in Section 232116 "Hydronic Piping Specialties" for vibration isolation and flexible connector materials for steel piping.

D. Comply with requirements in Section 233113 "Metal Ducts" for vibration isolation and flexible connector materials for exhaust shroud and ductwork.

E. Vibration isolation devices shall not be used to accommodate misalignments or to make bends.

2.10 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine generator using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

1. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify Architect, Construction Manager or Owner no fewer than two working days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Architect's, Construction Manager's or Owner's written permission as directed.

B. Comply with NECA 1 and NECA 404.

C. Comply with packaged engine generator manufacturers' written installation and alignment instructions and with NFPA 110.

D. Equipment Mounting:

1. Install packaged engine generators on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.

2. Coordinate size and location of concrete bases for packaged engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
3. As directed, install packaged engine generator with elastomeric isolator pads or restrained spring isolators having a minimum deflection of 1 inch (25 mm) on 4-inch- (100-mm-) high concrete base. Secure engine generator to anchor bolts installed in concrete bases. Concrete base construction is specified in Section 260548.16 "Seismic Controls for Electrical Systems."

E. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

F. Exhaust System: Install Schedule 40 black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet.

1. Piping materials and installation requirements are specified in Section 232113 "Hydronic Piping."
2. Install flexible connectors and steel piping materials according to requirements in Section 232116 "Hydronic Piping Specialties."
3. Insulate muffler/silencer and exhaust system components according to requirements in Section 230719 "HVAC Piping Insulation."
4. Install isolating thimbles where exhaust piping penetrates combustible surfaces with a minimum of 9 inches (225 mm) of clearance from combustibles.

G. Drain Piping: Install condensate drain piping to muffler drain outlet with a shutoff valve, stainless-steel flexible connector, and Schedule 40 black steel pipe with welded joints.

1. Piping materials and installation requirements are specified in Section 232113 "Hydronic Piping."
2. Drain piping valves, connectors, and installation requirements are specified in Section 232116 "Hydronic Piping Specialties."

H. Fuel Piping:

1. Diesel storage tanks, tank accessories, piping, valves, and specialties for fuel systems are specified in Section 231113 "Facility Fuel-Oil Piping."
2. Copper and galvanized steel shall not be used in the fuel-oil piping system.

I. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties.

B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow space for service and maintenance.

C. Connect cooling-system water piping to engine generator and heat exchanger with flexible connectors.

D. Connect engine exhaust pipe to engine with flexible connector.

E. Connect fuel piping to engines with a gate valve and union and flexible connector.

1. Additional requirements for diesel storage tanks, tank accessories, piping, valves, and specialties for fuel systems are specified in Section 231113 "Facility Fuel-Oil Piping."

F. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

G. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Provide a minimum of one 90-degree bend in flexible conduit routed to the engine generator from a stationary element.

H. Balance single-phase loads to obtain a maximum of 10 percent unbalance between any two phases.

3.3 IDENTIFICATION

A. Identify system components according to Section 230553 "Identification for HVAC Piping and Equipment" and Section 260553 "Identification for Electrical Systems."

B. Install a sign indicating the generator neutral is bonded to the main service neutral at the main service location.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Contractor will engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections with the assistance of a factory-authorized service representative.

E. Tests and Inspections:

1. Perform tests recommended by manufacturer and in "Visual and Mechanical Inspection" and "Electrical and Mechanical Tests" subparagraphs below, as specified in the NETA ATS. Certify compliance with test parameters.

a. Visual and Mechanical Inspection:

1) Compare equipment nameplate data with Drawings and the Specifications.
2) Inspect physical and mechanical condition.

3) Inspect anchorage, alignment, and grounding.
4) Verify that the unit is clean.

b. Electrical and Mechanical Tests:

1) Perform insulation-resistance tests according to IEEE 43.

a) Machines Larger Than 200 hp (150 kW): Test duration shall be 10 minutes. Calculate polarization index.
b) Machines 200 hp (150 kW) or Less: Test duration shall be one minute. Calculate the dielectric-absorption ratio.

2) Test protective relay devices.
3) Verify phase rotation, phasing, and synchronized operation as required by the application.
4) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
5) Perform vibration test for each main bearing cap.
6) Conduct performance test according to NFPA 110.
7) Verify correct functioning of the governor and regulator.

2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here, including, but not limited to, single-step full-load pickup test.
3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.

a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
c. Verify acceptance of charge for each element of the battery after discharge.
d. Verify that measurements are within manufacturer's specifications.

4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.
6. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg (120 kPa). Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.
7. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases and verify that performance is as specified.
8. Harmonic-Content Tests: Measure harmonic content of output voltage at 25 percent and 100 percent of rated linear load. Verify that harmonic content is within specified limits.

F. Coordinate tests with tests for transfer switches and run them concurrently.

G. Test instruments shall have been calibrated within the past 12 months, traceable to NIST Calibration Services, and adequate for making positive observation of test results. Make calibration records available for examination on request.

H. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.

I. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.

J. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

K. Remove and replace malfunctioning units and retest or reinspect as specified above.

L. Retest: Correct deficiencies identified by tests and observations, and retest until specified requirements are met.

M. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component, indicating satisfactory completion of tests.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.

END OF SECTION 263213.13

SECTION 263213.14 - DIESEL ENGINE GENERATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes packaged engine generators used to supply non-emergency power, with the following features:

1. Diesel engine.
2. Diesel fuel-oil system.
3. Control and monitoring.
4. Generator overcurrent and fault protection.
5. Generator, exciter, and voltage regulator.
6. Vibration isolation devices.
7. Finishes.

B. Related Requirements:

1. Section 263600 "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine generators.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include plans and elevations for engine generator and other components specified. Indicate access requirements affected by height of subbase fuel tank.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Identify fluid drain ports and clearance requirements for proper fluid drain.
4. Design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include base weights.
6. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings for engine generators and functional relationship between all electrical components.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer, manufacturer and testing agency as directed.

B. Seismic Qualification Data: Certificates, for engine generator, accessories, and components, from manufacturer.

C. Source quality-control reports.

D. Field quality-control reports.

E. Warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

B. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.6 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Years from date of Substantial Completion as directed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Engine generator housing, subbase fuel tank, day tank, engine generator, batteries, battery racks, silencers, load banks, sound attenuating equipment, accessories, and components shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Shake-table testing shall comply with ICC-ES AC156. Testing shall be performed with all fluids at worst-case normal levels. Water shall be substituted for diesel fuel in fuel tank during test.
3. Component Importance Factor: 1.5 or 1.0 as directed.

B. B11 Compliance: Comply with B11.19.

C. NFPA Compliance:

1. Comply with NFPA 37.
2. Comply with NFPA 70.

D. UL Compliance: Comply with UL 2200.

E. Engine Exhaust Emissions: Comply with EPA Tier 4 requirements and applicable state and local government requirements.

F. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by engine generator including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

G. Environmental Conditions: Engine generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: 5 to 104 deg F (Minus 15 to plus 40 deg C).
2. Relative Humidity: Zero to 95 percent.
3. Altitude: Sea level to 1000 feet (300 m).

H. Unusual Service Conditions: Engine generator equipment and installation are required to operate under the following conditions:

1. High salt-dust content in the air due to sea-spray evaporation.

2.3 ENGINE GENERATOR ASSEMBLY DESCRIPTION

A. Factory-assembled and -tested, water-cooled engine, with brushless generator and accessories.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

C. Power Rating: As directed, Prime or Industrial.

D. Overload Capacity: 110 percent of service load for 1 hour in 12 consecutive hours.

E. Service Load: Number kVA as directed.

F. Power Factor: 0.8, lagging.

G. Frequency: 60 Hz.

H. Voltage: As directed, 208, 240, 480, 600 or 4160-V ac.

I. Phase: Three-phase, three or four wire, wye or delta.

J. Induction Method: As directed, Naturally aspirated or Turbocharged.

K. Governor: Adjustable isochronous, with speed sensing.

L. Mounting Frame: Structural steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.

1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and engine generator center of gravity.

M. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated excluding power required for the continued and repeated operation of the unit and auxiliaries, with capacity as required to operate as a unit as evidenced by records of prototype testing.
2. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.

N. Engine Generator Performance:

1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.
2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
7. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
8. Start Time: 10 seconds.

2.4 DIESEL ENGINE

A. Fuel: ASTM D975, diesel fuel oil, Grade 2-D S15.

B. Rated Engine Speed: 1800 rpm.

C. Lubrication System: Engine or skid-mounted.

1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

D. Jacket Coolant Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with UL 499.

E. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine generator mounting frame and integral engine-driven coolant pump.

1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, UV-, and abrasion-resistant fabric.

    a. Rating: 50-psig (345-kPa) maximum working pressure with coolant at 180 deg F (82 deg C), and non-collapsible under vacuum.
    b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

F. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

1. Minimum sound attenuation of 25 dB at 500 Hz.
2. Sound level measured at a distance of 25 feet (8 m) from exhaust discharge after installation is complete shall be 78 dBA or less.

G. Muffler/Silencer: Semi-critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

1. Minimum sound attenuation of 18 dB at 500 Hz.
2. Sound level measured at a distance of 25 feet (8 m) from exhaust discharge after installation is complete shall be 85 dBA or less.

H. Muffler/Silencer: Commercial type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

1. Minimum sound attenuation of 12 dB at 500 Hz.
2. Sound level measured at a distance of 25 feet (8 m) from exhaust discharge after installation is complete shall be 90 dBA or less.

I. Air-Intake Filter: As directed, Standard or Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

J. Starting System: As directed, 12 or 24-V electric, with negative ground.

1. Components: Sized so they are not damaged during a full engine-cranking cycle with ambient temperature at maximum specified in "Performance Requirements" Article.
2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
3. Cranking Cycle: 60 seconds.
4. Battery: As directed, Lead acid or Nickel cadmium, with capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least twice or three times without recharging as directed.
5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 50 deg F (10 deg C) regardless of external ambient temperature within range specified in "Performance Requirements" Article. Include accessories required to support and fasten batteries in place. Provide ventilation to exhaust battery gases.
7. Battery Stand: Factory-fabricated, two-tier metal with acid-resistant finish designed to hold the quantity of battery cells required and to maintain the arrangement to minimize lengths of battery interconnections.
8. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
9. Battery Charger: Current-limiting, automatic-equalizing, and float-charging type designed for lead-acid or nickel-cadmium batteries as directed. Unit shall comply with UL 1236 and include the following features:

    a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
    b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 to 140 deg F (minus 40 to plus 60 deg C) to prevent overcharging at high temperatures and undercharging at low temperatures.
    c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.

d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.5 DIESEL FUEL-OIL SYSTEM

A. Comply with NFPA 30.

B. Piping: Fuel-oil piping shall be Schedule 40 black steel, complying with requirements in Section 231113 "Facility Fuel-Oil Piping." Cast iron, aluminum, copper, and galvanized steel shall not be used in the fuel-oil system.

C. Main Fuel Pump: Mounted on engine to provide primary fuel flow under starting and load conditions.

D. Fuel Filtering: Remove water and contaminants larger than 1 micron.

E. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.

F. Day Tank: Comply with UL 142, freestanding, factory-fabricated fuel tank assembly, with integral, float-controlled transfer pump and the following features:

1. Containment: Integral rupture basin with a capacity of 150 percent of nominal capacity of day tank.

    a. Leak Detector: Locate in rupture basin and connect to provide audible and visual alarm in the event of day-tank leak.

2. Tank Capacity: As recommended by engine manufacturer for an uninterrupted period of 4 hours' operation at 100 percent of rated power output of engine-generator system without being refilled.
3. Pump Capacity: Exceeds maximum flow of fuel drawn by engine-mounted fuel supply pump at 110 percent of rated capacity, including fuel returned from engine.
4. Low-Level Alarm Sensor: Liquid-level device operates alarm contacts at 25 percent of normal fuel level.
5. High-Level Alarm Sensor: Liquid-level device operates alarm and redundant fuel shutoff contacts at midpoint between overflow level and 100 percent of normal fuel level.
6. Piping Connections: Factory-installed fuel supply and return lines from tank to engine; local fuel fill, vent line, overflow line; and tank drain line with shutoff valve.
7. Redundant High-Level Fuel Shutoff: Actuated by high-level alarm sensor in day tank to operate a separate motor-control device that disconnects day-tank pump motor. Sensor shall signal solenoid valve, located in fuel suction line between fuel storage tank and day tank, to close. Both actions shall remain in shutoff state until manually reset. Shutoff

action shall initiate an alarm signal to control panel but shall not shut down engine generator.

2.6 CONTROL AND MONITORING

A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of engine generator. When mode-selector switch is switched to the on position, engine generator starts. The off position of same switch initiates engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.

B. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts engine generator. The off position of same switch initiates engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.

C. Provide minimum run time control set for 15 or 30 minutes with override only by operation of a remote emergency-stop switch as directed.

D. Comply with UL 508A.

E. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the engine generator. Mounting method shall isolate the control panel from engine generator vibration. Panel shall be powered from the engine generator battery.

F. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common wall-mounted control and monitoring panel. Panel shall be powered from the engine generator battery.

G. Control and Monitoring Panel:

1. Digital engine generator controller with integrated LCD display, controls, and microprocessor, capable of local and remote control, monitoring, and programming, with battery backup.
2. Analog control panel with dedicated gages and indicator lights for the instruments and alarms indicated below.
3. Instruments: Located on the control and monitoring panel and viewable during operation.

    a. Engine lubricating-oil pressure gage.
    b. Engine-coolant temperature gage.
    c. DC voltmeter (alternator battery charging).
    d. Running-time meter.
    e. AC voltmeter, for each phase or connected to a phase selector switch as directed.
    f. AC ammeter, for each phase or connected to a phase selector switch as directed.
    g. AC frequency meter.
    h. Generator-voltage adjusting rheostat.

4. Controls and Protective Devices: Controls, shutdown devices, and common alarm indication, including the following:

    a. Cranking control equipment.
    b. Run-Off-Auto switch.
    c. Control switch not in automatic position alarm.
    d. Overcrank alarm.
    e. Overcrank shutdown device.
    f. Low-water temperature alarm.
    g. High engine temperature pre-alarm.
    h. High engine temperature.
    i. High engine temperature shutdown device.
    j. Overspeed alarm.
    k. Overspeed shutdown device.
    l. Low fuel main tank.

        1) Low-fuel-level alarm shall be initiated when the level falls below that required for operation.

    m. Coolant low-level alarm.
    n. Coolant low-level shutdown device.
    o. Coolant high-temperature pre-alarm.
    p. Coolant high-temperature alarm.
    q. Coolant low-temperature alarm.
    r. Coolant high-temperature shutdown device.
    s. Battery high-voltage alarm.
    t. Low cranking voltage alarm.
    u. Battery-charger malfunction alarm.
    v. Battery low-voltage alarm.
    w. Lamp test.
    x. Contacts for local and remote common alarm.
    y. Low-starting air pressure alarm.
    z. Low-starting hydraulic pressure alarm.
    aa. Remote manual stop shutdown device.
    bb. Air shutdown damper alarm when used.
    cc. Air shutdown damper shutdown device when used.
    dd. Generator overcurrent-protective-device not-closed alarm.
    ee. Hours of operation.
    ff. Engine generator metering, including voltage, current, hertz, kilowatt, kilovolt ampere, and power factor.

H. Engine Generator Metering: Comply with Section 260913 "Electrical Power Monitoring and Control", Section 262713 "Electricity Metering", Section 260913 "Electrical Power Monitoring and Control" and Section 262713 "Electricity Metering" as directed

I. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator unless otherwise indicated.

2.7 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Overcurrent protective devices shall be coordinated to optimize selective tripping when a short circuit occurs.

B. Generator Circuit Breaker: Molded-case, thermal-magnetic type; 100 percent rated; complying with UL 489.

1. Tripping Characteristic: Designed specifically for generator protection.
2. Trip Rating: Matched to generator output rating.
3. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
4. Mounting: Adjacent to, or integrated with, control and monitoring panel.

C. Generator Circuit Breaker: Molded-case, electronic-trip type; 100 percent rated; complying with UL 489.

1. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
2. Trip Settings: Selected to coordinate with generator thermal damage curve.
3. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
4. Mounting: Adjacent to, or integrated with, control and monitoring panel.

D. Generator Disconnect Switch: Molded-case type; 100 percent rated.

1. Trip Rating: Matched to generator output rating.
2. Shunt Trip: Connected to trip switch when signaled by generator protector or by other protective devices.

E. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other engine generator protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector performs the following functions:

1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other engine generator malfunction alarms. Contacts shall be available for load shed functions.
2. Under single- or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the engine generator.
4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

2.8 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. Electrical Insulation: Class H or Class F as directed.

D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required. Provide six or 12-lead alternator as directed.

E. Range: As directed, provide limited, broad or extended range of output voltage by adjusting the excitation level.

F. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.

G. Enclosure: Dripproof.

H. Instrument Transformers: Mounted within generator enclosure.

I. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.

1. Adjusting Rheostat on Control and Monitoring Panel: Provide plus or minus 5 percent adjustment of output-voltage operating band.
2. As directed, Maintain voltage within 15, 20 or 30 percent on one step, full load.
3. Provide anti-hunt provision to stabilize voltage.
4. As directed, Maintain frequency within 5, 10 or 15 percent and stabilize at rated frequency within 2 or 5 seconds as directed.

J. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

K. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

L. Subtransient Reactance: 12 percent, maximum.

2.9 VIBRATION ISOLATION DEVICES

A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.

1. Material: As directed, Standard neoprene, Natural rubber or Bridge-bearing neoprene, complying with AASHTO M 251 separated by steel shims.
2. Shore A Scale Durometer Rating: As directed, 30, 40, 45, 50, 60, 65 or 70.
3. Number of Layers: As directed, One, Two, Three or Four as directed.
4. Minimum Deflection: 1 inch (25 mm).

B. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment-mounting and -leveling bolt that acts as blocking during installation.
2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Minimum Deflection: 1 inch (25 mm).

C. Comply with requirements in Section 232116 "Hydronic Piping Specialties" for vibration isolation and flexible connector materials for steel piping.

D. Comply with requirements in Section 233113 "Metal Ducts" for vibration isolation and flexible connector materials for exhaust shroud and ductwork.

E. Vibration isolation devices shall not be used to accommodate misalignments or to make bends.

2.10 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine generator using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

1. Tests: Comply with IEEE 115.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. As directed, Notify Architect, Construction Manager or Owner no fewer than two working days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Architect's, Construction Manager's or Owner's written permission as directed.

B. Comply with NECA 1 and NECA 404.

C. Comply with packaged engine generator manufacturers' written installation and alignment instructions.

D. Equipment Mounting:

1. Install packaged engine generators on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.
2. Coordinate size and location of concrete bases for packaged engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
3. As directed, install packaged engine generator with elastomeric isolator pads or restrained spring isolators having a minimum deflection of 1 inch (25 mm) on 4-inch- (100-mm-) high concrete base. Secure sets to anchor bolts installed in concrete bases. Concrete base construction is specified in Section 260548.16 "Seismic Controls for Electrical Systems."
4. Remote Radiators:

    a. As directed, install remote radiator with elastomeric isolator pads or restrained spring isolators on concrete base on grade or roof equipment supports on roof.
    b. Coordinate size and location of roof curbs, equipment supports, and roof penetrations for remote radiators. These items are specified in Section 077200 "Roof Accessories."

E. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

F. Exhaust System: Install Schedule 40 black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet.

1. Piping materials and installation requirements are specified in Section 232113 "Hydronic Piping."
2. Install flexible connectors and steel piping materials according to requirements in Section 232116 "Hydronic Piping Specialties."
3. Insulate muffler/silencer and exhaust system components according to requirements in Section 230719 "HVAC Piping Insulation."
4. Install isolating thimbles where exhaust piping penetrates combustible surfaces with a minimum of 9 inches (225 mm) of clearance from combustibles.

G. Drain Piping: Install condensate drain piping to muffler drain outlet with a shutoff valve, stainless-steel flexible connector, and Schedule 40 black steel pipe with welded joints.

1. Piping materials and installation requirements are specified in Section 232113 "Hydronic Piping."
2. Drain piping valves, connectors, and installation requirements are specified in Section 232116 "Hydronic Piping Specialties."

H. Fuel Piping:

1. Diesel storage tanks, tank accessories, piping, valves, and specialties for fuel systems are specified in Section 231113 "Facility Fuel-Oil Piping."
2. Copper and galvanized steel shall not be used in the fuel-oil piping system.

I. Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties.

B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow space for service and maintenance.

C. Connect cooling-system water piping to engine generator and heat exchanger with flexible connectors.

D. Connect engine exhaust pipe to engine with flexible connector.

E. Connect fuel piping to engines with a gate valve and union and flexible connector.

F. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

G. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Provide a minimum of one 90-degree bend in flexible conduit routed to the engine generator from a stationary element.

H. Balance single-phase loads to obtain a maximum of 10 percent unbalance between any two phases.

3.3 IDENTIFICATION

A. Identify system components according to Section 230553 "Identification for HVAC Piping and Equipment" and Section 260553 "Identification for Electrical Systems."

B. Install a sign indicating the generator neutral is bonded to the main service neutral at the main service location.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections with the assistance of a factory-authorized service representative.

E. Tests and Inspections:

1. Perform tests recommended by manufacturer and each visual and mechanical inspection and electrical and mechanical test listed in first two subparagraphs below, as specified in NETA ATS. Certify compliance with test parameters.

a. Visual and Mechanical Inspection:

1) Compare equipment nameplate data with Drawings and the Specifications.
2) Inspect physical and mechanical condition.
3) Inspect anchorage, alignment, and grounding.
4) Verify that the unit is clean.

b. Electrical and Mechanical Tests:

1) Perform insulation-resistance tests according to IEEE 43.

a) Machines Larger Than 200 hp (150 kW): Test duration shall be 10 minutes. Calculate polarization index.
b) Machines 200 hp (150 kW) or Less: Test duration shall be one minute. Calculate the dielectric-absorption ratio.

2) Test protective relay devices.
3) Verify phase rotation, phasing, and synchronized operation as required by the application.
4) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
5) Perform vibration test for each main bearing cap.
6) Verify correct functioning of the governor and regulator.

2. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.

a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
c. Verify acceptance of charge for each element of the battery after discharge.
d. Verify that measurements are within manufacturer's specifications.

3. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
4. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.
5. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg (120 kPa). Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.
6. Exhaust Emissions Test: Comply with applicable government test criteria.
7. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases and verify that performance is as specified.
8. Harmonic-Content Tests: Measure harmonic content of output voltage at 25 and 100 percent of rated linear load. Verify that harmonic content is within specified limits.

9. Noise Level Tests: Measure A-weighted level of noise emanating from engine generator installation, including engine exhaust and cooling-air intake and discharge, at four locations 25 feet (8 m) from edge of the generator enclosure or on the property line, and compare measured levels with required values as directed.

F. Coordinate tests with tests for transfer switches and run them concurrently.

G. Test instruments shall have been calibrated within the past 12 months, traceable to NIST Calibration Services, and adequate for making positive observation of test results. Make calibration records available for examination on request.

H. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.

I. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.

J. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

K. Remove and replace malfunctioning units and retest or reinspect as specified above.

L. Retest: Correct deficiencies identified by tests and observations, and retest until specified requirements are met.

M. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.

END OF SECTION 263213.14

SECTION 263213.16 - GASEOUS EMERGENCY ENGINE GENERATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes packaged engine generators for emergency use with the following features:

1. As directed, Natural gas, LP, Natural gas with LP backup or Dual fuel engine.
2. Gaseous fuel system.
3. Control and monitoring.
4. Generator overcurrent and fault protection.
5. Generator, exciter, and voltage regulator.
6. Vibration isolation devices.

B. Related Requirements:

1. Section 263600 "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine generators.

1.2 DEFINITIONS

A. EPS: Emergency power supply.

B. EPSS: Emergency power supply system.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include plans and elevations for engine generator and other components specified.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Identify fluid drain ports and clearance requirements for proper fluid drain.
4. Design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and supported equipment. Include base weights.
6. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings for EPS equipment and functional relationship between all electrical components.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: As directed, for Installer, manufacturer and testing agency.

B. Seismic Qualification Data: Certificates, for engine generator, accessories, and components, from manufacturer.

C. Source quality-control reports.

D. Field quality-control reports.

E. Warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

B. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.7 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Number of years from date of Substantial Completion as directed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Engine generator housing, engine generator, batteries, battery racks, silencers, sound attenuating equipment, accessories, and components shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Shake-table testing shall comply with ICC-ES AC156. Testing shall be performed with all fluids at worst-case normal levels.
3. Component Importance Factor: As directed, 1.5 or 1.0.

B. B11 Compliance: Comply with B11.19.

C. NFPA Compliance:

1. Comply with NFPA 37.
2. Comply with NFPA 70.
3. Comply with NFPA 99.
4. Comply with NFPA 110 requirements for Level 1 or 2 EPSS as directed.

D. UL Compliance: Comply with UL 2200.

E. Engine Exhaust Emissions: As directed, Comply with EPA Tier 2, 3 or 4 requirements and applicable state and local government requirements.

F. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by engine generator, including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

G. Environmental Conditions: Engine generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: As directed, 41 to 104 deg F (5 to 40 deg C) or 5 to 104 deg F (Minus 15 to plus 40 deg C).
2. Relative Humidity: Zero to 95 percent.
3. Altitude: Sea level to 1000 feet (300 m).

H. Unusual Service Conditions: Engine generator equipment and installation are required to operate under the following conditions:

1. High salt-dust content in the air due to sea-spray evaporation.

2.3 ENGINE GENERATOR ASSEMBLY DESCRIPTION

A. Factory-assembled and -tested, water-cooled engine, with brushless generator and accessories.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

C. EPSS Class: As directed, Engine generator shall be classified as Class 2, Class 6, Class 48 or Class 96 according to NFPA 110.

D. Service Load: Number of kVA as directed.

E. Power Factor: 0.8, lagging.

F. Frequency: 60 Hz.

G. Voltage: As directed, 208, 240, 480, 600 or 4160-V ac.

H. Phase: As directed, Three-phase, three or four-wire wye or delta.

I. Induction Method: As directed, Naturally aspirated or Turbocharged.

J. Governor: Adjustable isochronous, with speed sensing.

K. Mounting Frame: Structural-steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.

1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and engine generator center of gravity.

L. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated at 0.8 power factor excluding power required for the continued and repeated operation of the unit and auxiliaries, with capacity as required to operate as a unit as evidenced by records of prototype testing.
2. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.

M. Engine Generator Performance:

1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage, from no load to full load.
2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency, from no load to full load.
4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
7. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.

8. Start Time: As directed, Comply with NFPA 110, Type U or Type 10, system requirements.

2.4 ENGINE

A. Fuel: As directed, Natural gas, LP, Natural gas with LP backup or Dual fuel.

B. Rated Engine Speed: 1800 rpm.

C. Lubrication System: Engine or skid mounted.

1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

D. Jacket Coolant Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity and with UL 499.

E. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine generator mounting frame and integral engine-driven coolant pump.

1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
2. Size of Radiator: Adequate to contain expansion of total system coolant, from cold start to 110 percent load condition.
3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant-system pressure for engine used. Equip with gage glass and petcock.
4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, UV-, and abrasion-resistant fabric.

    a. Rating: 50-psig (345-kPa) maximum working pressure with coolant at 180 deg F (82 deg C), and non-collapsible under vacuum.
    b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

F. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

1. Minimum sound attenuation of 25 dB at 500 Hz.
2. Sound level measured at a distance of 25 feet (8 m) from exhaust discharge after installation is complete shall be 78 dBA or less.

G. Muffler/Silencer: Semicritical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

1. Minimum sound attenuation of 18 dB at 500 Hz.
2. Sound level measured at a distance of 25 feet (8 m) from exhaust discharge after installation is complete shall be 85 dBA or less.

H. Muffler/Silencer: Commercial type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

1. Minimum sound attenuation of 12 dB at 500 Hz.
2. Sound level measured at a distance of 25 feet (8 m) from exhaust discharge after installation is complete shall be 90 dBA or less.

I. Air-Intake Filter: As directed, Standard or Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

J. Starting System: As directed, 12 or 24-V electric, with negative ground.

1. Components: Sized so they are not damaged during a full engine-cranking cycle, with ambient temperature at maximum specified in "Performance Requirements" Article.
2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
3. Cranking Cycle: As required by NFPA 110 for system level specified or 60 seconds.
4. Battery: As directed, Lead acid or Nickel cadmium, with capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least twice or three times without recharging.
5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 50 deg F (10 deg C) regardless of external ambient temperature within range specified in "Performance Requirements" Article. Include accessories required to support and fasten batteries in place. Provide ventilation to exhaust battery gases.
7. Battery Stand: Factory-fabricated, two-tier metal with acid-resistant finish designed to hold the quantity of battery cells required and to maintain the arrangement to minimize lengths of battery interconnections.
8. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
9. Battery Charger: Current-limiting, automatic-equalizing and float-charging type designed for lead-acid or nickel-cadmium batteries as directed. Unit shall comply with UL 1236 and include the following features:

    a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
    b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 to 140 deg F (minus 40 to plus 60

deg C) to prevent overcharging at high temperatures and undercharging at low temperatures.

c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.

d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.

e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.

f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.5 GASEOUS FUEL SYSTEM

A. Natural Gas Piping: Comply with requirements in Section 231123 "Facility Natural Gas Piping."

B. LP Gas Piping: Comply with requirements in Section 231126 "Facility Liquefied-Petroleum Gas Piping."

C. Gas Train: Comply with NFPA 37.

D. Tanks: Comply with requirements for storage containers in Section 231126 "Facility Liquefied-Petroleum Gas Piping."

E. Engine Fuel System:

1. As directed, Natural Gas, LP Gas or Natural Gas with LP Gas Backup, Vapor-Withdrawal System:

   a. Carburetor.
   b. Secondary Gas Regulators: One for each fuel type, with atmospheric vents piped to building exterior.
   c. Fuel-Shutoff Solenoid Valves: NRTL-listed, normally closed, safety shutoff valves; one for each fuel source.

2. Fuel Filters: One for each fuel type.
3. Manual Fuel Shutoff Valves: One for each fuel type.
4. Flexible Fuel Connectors: Minimum one for each fuel connection.
5. LP gas flow adjusting valve.
6. Fuel change gas pressure switch.

2.6 CONTROL AND MONITORING

A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of engine generator. When mode-selector switch is switched to the on position, engine generator starts. The off position of

same switch initiates engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.

B. Manual Starting System Sequence of Operation: Switching On-Off switch on the generator control panel to the on position starts engine generator. The off position of same switch initiates engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.

C. Provide minimum run-time control set for 15 or 30 minutes as directed, with override only by operation of a remote emergency-stop switch.

D. Comply with UL 508A.

E. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the engine generator. Mounting method shall isolate the control panel from engine generator vibration. Panel shall be powered from the engine generator battery.

F. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common wall-mounted control and monitoring panel. Panel shall be powered from the engine generator battery.

G. Control and Monitoring Panel:

1. Digital controller with integrated LCD display, controls, and microprocessor, capable of local and remote control, monitoring, and programming, with battery backup.
2. Analog control panel with dedicated gages and indicator lights for the instruments and alarms indicated below.
3. Instruments: Located on the control and monitoring panel and viewable during operation.

    a. Engine lubricating-oil pressure gage.
    b. Engine-coolant temperature gage.
    c. DC voltmeter (alternator battery charging).
    d. Running-time meter.
    e. AC voltmeter, for each phase or connected to a phase selector switch as directed.
    f. AC ammeter, for each phase or connected to a phase selector switch as directed.
    g. AC frequency meter.
    h. Generator-voltage adjusting rheostat.

4. Controls and Protective Devices: Controls, shutdown devices, and common visual alarm indication as required by NFPA 110 for Level 1 or 2 system, including the following as directed:

    a. Cranking control equipment.
    b. Run-Off-Auto switch.
    c. Control switch not in automatic position alarm.
    d. Overcrank alarm.
    e. Overcrank shutdown device.
    f. Low water temperature alarm.
    g. High engine temperature pre-alarm.

h. High engine temperature.
i. High engine temperature shutdown device.
j. Overspeed alarm.
k. Overspeed shutdown device.
l. Low-fuel main tank.

1) Low-fuel-level alarm shall be initiated when the level falls below that required for operation for the duration required for the indicated EPSS class.

m. Coolant low-level alarm.
n. Coolant low-level shutdown device.
o. Coolant high-temperature pre-alarm.
p. Coolant high-temperature alarm.
q. Coolant low-temperature alarm.
r. Coolant high-temperature shutdown device.
s. EPS load indicator.
t. Battery high-voltage alarm.
u. Low-cranking voltage alarm.
v. Battery-charger malfunction alarm.
w. Battery low-voltage alarm.
x. Lamp test.
y. Contacts for local and remote common alarm.
z. Low-starting air pressure alarm.
aa. Low-starting hydraulic pressure alarm.
bb. Remote manual-stop shutdown device.
cc. Air shutdown damper alarm when used.
dd. Air shutdown damper shutdown device when used.
ee. Generator overcurrent-protective-device not-closed alarm.

H. Common Remote Panel with Common Audible Alarm: Comply with NFPA 110 requirements for Level 1 or 2 systems as directed. Include necessary contacts and terminals in control and monitoring panel. Remote panel shall be powered from the engine generator battery.

I. Remote Alarm Annunciator: Comply with NFPA 99. An LED indicator light labeled with proper alarm conditions shall identify each alarm event, and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.

1. Overcrank alarm.
2. Coolant low-temperature alarm.
3. High engine temperature pre-alarm.
4. High engine temperature alarm.
5. Low lube oil pressure alarm.
6. Overspeed alarm.
7. Low-fuel main tank alarm.
8. Low coolant level alarm.
9. Low-cranking voltage alarm.
10. Contacts for local and remote common alarm.
11. Audible-alarm silencing switch.

12. Air shutdown damper when used.
13. Run-Off-Auto switch.
14. Control switch not in automatic position alarm.
15. Fuel tank derangement alarm.
16. Fuel tank high-level shutdown of fuel supply alarm.
17. Lamp test.
18. Low-cranking voltage alarm.
19. Generator overcurrent-protective-device not-closed alarm.

J. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator unless otherwise indicated.

2.7 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Overcurrent protective devices for the entire EPSS shall be coordinated to optimize selective tripping when a short circuit occurs. Coordination of protective devices shall consider both utility and EPSS as the voltage source.

1. Overcurrent protective devices for the EPSS shall be accessible only to authorized personnel.

B. Generator Circuit Breaker: Molded-case, thermal-magnetic type; 100 percent rated; complying with UL 489.

1. Tripping Characteristic: Designed specifically for generator protection.
2. Trip Rating: Matched to generator output rating.
3. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
4. Mounting: Adjacent to, or integrated with, control and monitoring panel.

C. Generator Circuit Breaker: Molded-case, electronic-trip type; 100 percent rated; complying with UL 489.

1. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
2. Trip Settings: Selected to coordinate with generator thermal damage curve.
3. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
4. Mounting: Adjacent to or integrated with control and monitoring panel.

D. Generator Disconnect Switch: Molded-case type; 100 percent rated.

1. Trip Rating: Matched to generator output rating.
2. Shunt Trip: Connected to trip switch when signaled by generator protector or by other protective devices.

E. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other engine generator protective devices, a shunt-trip device in the generator disconnect switch shall open

the switch to disconnect the generator from load circuits. Protector performs the following functions:

1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other engine generator malfunction alarms. Contacts shall be available for load shed functions.
2. Under single- or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the engine generator.
4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

F. Ground-Fault Indication: Comply with NFPA 70 Article 700, "Emergency System" signals for ground fault.

1. Indicate ground fault with other engine generator alarm indications.
2. Trip generator protective device on ground fault.

2.8 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. Electrical Insulation: Class H or Class F.

D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required. Provide six or 12-lead alternator as directed.

E. Range: As directed, provide limited, broad or extended range of output voltage by adjusting the excitation level.

F. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.

G. Enclosure: Dripproof.

H. Instrument Transformers: Mounted within generator enclosure.

I. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified and as required by NFPA 110.

1. Adjusting Rheostat on Control and Monitoring Panel: Provide plus or minus 5 percent adjustment of output-voltage operating band.
2. As directed, Maintain voltage within 15, 20 or 30 percent on one step, full load.

3. Provide anti-hunt provision to stabilize voltage.
4. As directed, maintain frequency within 5, 10 or 15 percent and stabilize at rated frequency within two or five seconds.

J. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

K. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

L. Subtransient Reactance: 12 percent, maximum.

2.9 VIBRATION ISOLATION DEVICES

A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.

1. Material: As directed, Standard neoprene, Natural rubber or Bridge-bearing neoprene, complying with AASHTO M 251 separated by steel shims.
2. Shore A Scale Durometer Rating: As directed, 30, 40, 45, 50, 60, 65 or 70.
3. Number of Layers: As directed, One, Two, Three or Four.
4. Minimum Deflection: 1 inch (25 mm).

B. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment-mounting and -leveling bolt that acts as blocking during installation.
2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Minimum Deflection: 1 inch (25 mm).

C. Comply with requirements in Section 232116 "Hydronic Piping Specialties" for vibration isolation and flexible connector materials for steel piping.

D. Comply with requirements in Section 233113 "Metal Ducts" for vibration isolation and flexible connector materials for exhaust shroud and ductwork.

E. Vibration isolation devices shall not be used to accommodate misalignments or to make bends.

2.10 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine generator using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

1. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. As directed, Notify Architect, Construction Manager or Owner no fewer than two working days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Architect's, Construction Manager's or Owner's written permission as directed.

B. Comply with NECA 1 and NECA 404.

C. Comply with packaged engine generator manufacturers' written installation and alignment instructions and with NFPA 110.

D. Equipment Mounting:

1. Install packaged engine generators on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.
2. Coordinate size and location of concrete bases for packaged engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
3. As directed, install packaged engine generator with elastomeric isolator pads or restrained spring isolators having a minimum deflection of 1 inch (25 mm) on 4-inch- (100-mm-) high concrete base. As directed, Secure sets or enclosure to anchor bolts installed in concrete bases. Concrete base construction is specified in Section 260548.16 "Seismic Controls for Electrical Systems."

E. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

F. Cooling System: Install Schedule 40 black steel piping with welded joints for cooling water piping between engine generator and heat exchanger. Piping materials and installation requirements are specified in Section 232113 "Hydronic Piping."

1. Install isolating thimbles where exhaust piping penetrates combustible surfaces. Provide a minimum of 9 inches (225 mm) of clearance from combustibles.
2. Insulate cooling-system piping and components according to requirements in Section 230719 "HVAC Piping Insulation."

G. Exhaust System: Install Schedule 40 black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet.

1. Install flexible connectors and steel piping materials according to requirements in Section 232116 "Hydronic Piping Specialties."
2. Insulate muffler/silencer and exhaust system components according to requirements in Section 230719 "HVAC Piping Insulation."
3. Install isolating thimbles where exhaust piping penetrates combustible surfaces with a minimum of 9 inches (225 mm) of clearance from combustibles.

H. Drain Piping: Install condensate drain piping to muffler drain outlet with a shutoff valve, stainless-steel flexible connector, and Schedule 40 black steel pipe with welded joints.

I. Gaseous Fuel Piping:

1. Natural gas piping, valves, and specialties for gas distribution are specified in Section 231123 "Facility Natural Gas Piping."
2. LP gas piping, valves, and specialties for gas piping are specified in Section 231126 "Facility Liquefied-Petroleum Gas Piping."

J. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties.

B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.

C. Connect cooling-system water piping to engine generator and remote radiator or heat exchanger with flexible connectors as directed.

D. Connect engine exhaust pipe to engine with flexible connector.

E. Gaseous Fuel Connections:

1. Connect fuel piping to engines with a gate valve and union and flexible connector.
2. Install manual shutoff valve in a remote location to isolate gaseous fuel supply to the generator.
3. Vent gas pressure regulators outside building a minimum of 60 inches (1500 mm) from building openings.

F. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

G. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Provide a minimum of one 90-degree bend in flexible conduit routed to the engine generator from a stationary element.

H. Balance single-phase loads to obtain a maximum of 10 percent unbalance between any two phases.

3.3 IDENTIFICATION

A. Identify system components according to Section 230553 "Identification for HVAC Piping and Equipment" and Section 260553 "Identification for Electrical Systems."

B. Install a sign indicating the generator neutral is bonded to the main service neutral at the main service location.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections with the assistance of a factory-authorized service representative.

E. Tests and Inspections:

1. Perform tests recommended by manufacturer and each visual and mechanical inspection and electrical and mechanical test listed in first two subparagraphs below, as specified in NETA ATS. Certify compliance with test parameters.

    a. Visual and Mechanical Inspection:

        1) Compare equipment nameplate data with Drawings and the Specifications.
        2) Inspect physical and mechanical condition.
        3) Inspect anchorage, alignment, and grounding.
        4) Verify that the unit is clean.

    b. Electrical and Mechanical Tests:

        1) Perform insulation-resistance tests according to IEEE 43.

            a) Machines Larger Than 200 hp (150 kW): Test duration shall be 10 minutes. Calculate polarization index.
            b) Machines 200 hp (150 kW) or Less: Test duration shall be one minute. Calculate the dielectric-absorption ratio.

2) Test protective relay devices.
3) Verify phase rotation, phasing, and synchronized operation as required by the application.
4) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
5) Perform vibration test for each main bearing cap.
6) Conduct performance test according to NFPA 110.
7) Verify correct functioning of the governor and regulator.

2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.
3. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
4. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.
5. Exhaust Emissions Test: Comply with applicable government test criteria.
6. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases and verify that performance is as specified.
7. Harmonic-Content Tests: Measure harmonic content of output voltage at 25 and 100 percent of rated linear load. Verify that harmonic content is within specified limits.
8. Noise Level Tests: Measure A-weighted level of noise emanating from engine generator installation, including engine exhaust and cooling-air intake and discharge, at four locations 25 feet (8 m) from edge of the generator enclosure or on the property line as directed, and compare measured levels with required values.

F. Coordinate tests with tests for transfer switches and run them concurrently.

G. Test instruments shall have been calibrated within the past 12 months, traceable to NIST Calibration Services, and adequate for making positive observation of test results. Make calibration records available for examination on request.

H. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.

I. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.

J. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

K. Remove and replace malfunctioning units and retest or reinspect as specified above as directed.

L. Retest: Correct deficiencies identified by tests and observations, and retest until specified requirements are met.

M. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.

END OF SECTION 263213.16

SECTION 263213.17 - GASEOUS ENGINE GENERATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes packaged engine generators for non-emergency use with the following features:

1. As directed, Natural gas and LP gas or Natural gas with LP gas backup engine.
2. Gaseous fuel system.
3. Control and monitoring.
4. Generator overcurrent and fault protection.
5. Generator, exciter, and voltage regulator.
6. Vibration isolation devices.

B. Related Requirements:

1. Section 263600 "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine generators.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include plans and elevations for engine generator and other components specified.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Identify fluid drain ports and clearance requirements for proper fluid drain.
4. Design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include base weights.
6. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings for EPS equipment and functional relationship between all electrical components.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: As directed, For Installer, manufacturer or and testing agency.

B. Seismic Qualification Data: Certificates, for engine generator, accessories, and components, from manufacturer.

C. Source quality-control reports.

D. Field quality-control reports.

E. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

B. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.6 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Number of years from date of Substantial Completion as directed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain packaged engine generators and auxiliary components through one source from a single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Engine generator housing, engine generator, batteries, battery racks, silencers, load banks, and sound attenuating equipment, accessories, and components shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Shake-table testing shall comply with ICC-ES AC156. Testing shall be performed with all fluids at worst-case normal levels.
3. Component Importance Factor: As directed, 1.5 or 1.0.

B. B11 Compliance: Comply with B11.19.

C. NFPA Compliance:

1. Comply with NFPA 37.
2. Comply with NFPA 70.

D. UL Compliance: Comply with UL 2200.

E. Engine Exhaust Emissions: Comply with EPA Tier 4 requirements and applicable state and local government requirements.

F. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by engine generator including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

G. Environmental Conditions: Engine generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: 5 to 104 deg F (Minus 15 to plus 40 deg C).
2. Relative Humidity: Zero to 95 percent.
3. Altitude: Sea level to 1000 feet (300 m).

H. Unusual Service Conditions: Engine generator equipment and installation are required to operate under the following conditions:

1. High salt-dust content in the air due to sea-spray evaporation.

2.3 ENGINE GENERATOR ASSEMBLY DESCRIPTION

A. Factory-assembled and -tested, water-cooled engine, with brushless generator and accessories.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended location and use.

C. Power Rating: As directed, Prime or Industrial.

D. Overload Capacity: 110 percent of service load for 1 hour in 12 consecutive hours.

E. Service Load: kVA as directed.

F. Power Factor: 0.8, lagging.

G. Frequency: 60 Hz

H. Voltage: As directed, 208, 240, 480, 600 or 4160 V ac.

I. Phase: AS directed, Three-phase, three, four wire, wye or delta.

J. Induction Method: As directed, Naturally aspirated or Turbocharged.

K. Governor: Adjustable isochronous, with speed sensing.

L. Mounting Frame: Structural steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.

1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.

M. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated at 0.8 power factor excluding power required for the continued and repeated operation of the unit and auxiliaries, with capacity as required to operate as a unit as evidenced by records of prototype testing.
2. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.

N. Engine Generator Performance:

1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.
2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
7. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
8. Start Time: 10 seconds.

2.4 GASEOUS ENGINE

A. Fuel: As directed, Natural gas and LP gas or Natural gas with LP gas backup.

B. Rated Engine Speed: 1800 rpm.

C. Lubrication System: Engine or skid-mounted.

1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

D. Jacket Coolant Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with UL 499.

E. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine generator mounting frame and integral engine-driven coolant pump.

1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.

    a. Rating: 50-psig (345-kPa) maximum working pressure with coolant at 180 deg F (82 deg C), and non-collapsible under vacuum.
    b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

F. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

1. Minimum sound attenuation of 25 dB at 500 Hz.
2. Sound level measured at a distance of 25 feet (8 m) from exhaust discharge after installation is complete shall be 78 dBA or less.

G. Muffler/Silencer: Semi-critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

1. Minimum sound attenuation of 18 dB at 500 Hz.
2. Sound level measured at a distance of 25 feet (8 m) from exhaust discharge after installation is complete shall be 85 dBA or less.

H. Muffler/Silencer: Commercial type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

1. Minimum sound attenuation of 12 dB at 500 Hz.
2. Sound level measured at a distance of 25 feet (8 m) from exhaust discharge after installation is complete shall be 90 dBA or less.

I. Air-Intake Filter: As directed, Standard or Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

J. Starting System: As directed, 12 or 24-V electric, with negative ground.

1. Components: Sized so they are not damaged during a full engine-cranking cycle with ambient temperature at maximum specified in "Performance Requirements" Article.
2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
3. Cranking Cycle: 60 seconds.
4. Battery: As directed, Lead acid or Nickel cadmium, with capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least twice or three times without recharging.
5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 50 deg F (10 deg C) regardless of external ambient temperature within range specified in "Performance Requirements" Article. Include accessories required to support and fasten batteries in place. Provide ventilation to exhaust battery gases.
7. Battery Stand: Factory-fabricated, two-tier metal with acid-resistant finish designed to hold the quantity of battery cells required and to maintain the arrangement to minimize lengths of battery interconnections.
8. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35 A minimum continuous rating.
9. Battery Charger: Current-limiting, automatic-equalizing and float-charging type designed for lead-acid or nickel cadmium batteries as directed. Unit shall comply with UL 1236 and include the following features:

    a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
    b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg F (minus 40 deg C) to 140 deg F (plus 60 deg C) to prevent overcharging at high temperatures and undercharging at low temperatures.
    c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
    d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
    e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense

high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.

f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.5 GASEOUS FUEL SYSTEM

A. Natural Gas Piping: Comply with requirements in Section 231123 "Facility Natural Gas Piping."

B. LP Gas Piping: Comply with requirements in Section 231126 "Facility Liquefied-Petroleum Gas Piping."

C. Gas Train: Comply with NFPA 37.

D. Engine Fuel System:

E. As directed, Natural Gas and LP Gas or Natural Gas with LP Gas Backup, Vapor-Withdrawal System:

1. Carburetor.
2. Secondary Gas Regulators: One for each fuel type, with atmospheric vents piped to building exterior.
3. Fuel-Shutoff Solenoid Valves: NRTL-listed, normally closed, safety shutoff valves; one for each fuel source.
4. Fuel Filters: One for each fuel type.
5. Manual Fuel Shutoff Valves: One for each fuel type.
6. Flexible Fuel Connectors: Minimum one for each fuel connection.
7. LP gas flow adjusting valve.
8. Fuel change gas pressure switch.

2.6 CONTROL AND MONITORING

A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of engine generator. When mode-selector switch is switched to the on position, engine generator starts. The off position of same switch initiates generator-set shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.

B. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts engine generator. The off position of same switch initiates generator-set shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.

C. As directed, provide minimum run time control set for 15 or 30 minutes with override only by operation of a remote emergency-stop switch.

D. Comply with UL 508A.

E. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the engine generator. Mounting method shall isolate the control panel from generator-set vibration. Panel shall be powered from the engine generator battery.

F. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common wall-mounted control and monitoring panel. Panel shall be powered from the engine generator battery.

G. Control and Monitoring Panel:

1. Digital controller with integrated LCD, controls, and microprocessor, capable of local and remote control, monitoring, and programming, with battery backup.
2. Analog control panel with dedicated gages and indicator lights for the instruments and alarms indicated below.
3. Instruments: Located on the control and monitoring panel and viewable during operation.

    a. Engine lubricating-oil pressure gage.
    b. Engine-coolant temperature gage.
    c. DC voltmeter (alternator battery charging).
    d. Running-time meter.
    e. AC voltmeter, for each phase or connected to a phase selector switch as directed.
    f. AC ammeter, for each phase or connected to a phase selector switch as directed.
    g. AC frequency meter.
    h. Generator-voltage adjusting rheostat.

4. Controls and Protective Devices: Controls, shutdown devices, and common visual alarm indication, including the following:

    a. Cranking control equipment.
    b. Run-Off-Auto switch.
    c. Control switch not in automatic position alarm.
    d. Overcrank alarm.
    e. Overcrank shutdown device.
    f. Low water temperature alarm.
    g. High engine temperature pre-alarm.
    h. High engine temperature.
    i. High engine temperature shutdown device.
    j. Overspeed alarm.
    k. Overspeed shutdown device.
    l. Low fuel main tank.
    m. Coolant low-level alarm.
    n. Coolant low-level shutdown device.
    o. Coolant high-temperature pre-alarm.
    p. Coolant high-temperature alarm.
    q. Coolant low-temperature alarm.
    r. Coolant high-temperature shutdown device.
    s. EPS supplying load indicator.
    t. Battery high-voltage alarm.

u. Low cranking voltage alarm.
v. Battery-charger malfunction alarm.
w. Battery low-voltage alarm.
x. Lamp test.
y. Contacts for local and remote common alarm.
z. Low-starting air pressure alarm.
aa. Low-starting hydraulic pressure alarm.
bb. Remote manual stop shutdown device.
cc. Air shutdown damper alarm when used.
dd. Air shutdown damper shutdown device when used.
ee. Hours of operation.
ff. Engine generator metering, including voltage, current, Hz, kW, kVA, and power factor.
gg. Generator overcurrent protective device not closed alarm.

H. Engine Generator Metering: Comply with Section 260913 "Electrical Power Monitoring and Control", Section 262713 "Electricity Metering" or Section 260913 "Electrical Power Monitoring and Control" and Section 262713 "Electricity Metering" as directed.

I. Common Remote Panel with Common Audible Alarm: Include necessary contacts and terminals in control and monitoring panel. Remote panel shall be powered from the engine generator battery.

J. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.

2.7 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Generator Circuit Breaker: Molded-case, thermal-magnetic type; 100 percent rated; complying with UL 489.

1. Tripping Characteristic: Designed specifically for generator protection.
2. Trip Rating: Matched to generator output rating.
3. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
4. Mounting: Adjacent to or integrated with control and monitoring panel.

B. Generator Circuit Breaker: Molded-case, electronic-trip type; 100 percent rated; complying with UL 489.

1. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
2. Trip Settings: Selected to coordinate with generator thermal damage curve.
3. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
4. Mounting: Adjacent to or integrated with control and monitoring panel.

C. Generator Disconnect Switch: Molded-case type, 100 percent rated.

1. Trip Rating: Matched to generator output rating.

2. Shunt Trip: Connected to trip switch when signaled by generator protector or by other protective devices.

D. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other generator-set protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector performs the following functions:

1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other generator-set malfunction alarms. Contacts shall be available for load shed functions.
2. Under single or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the engine generator.
4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

2.8 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. Electrical Insulation: As directed, Class H or Class F.

D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required. As directed, Provide six or 12 lead alternator.

E. Range: As directed, provide limited, broad or extended range of output voltage by adjusting the excitation level.

F. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.

G. Enclosure: Dripproof.

H. Instrument Transformers: Mounted within generator enclosure.

I. Voltage Regulator: Solid-state type, separate from exciter.

1. Adjusting Rheostat on Control and Monitoring Panel: Provide plus or minus 5 percent adjustment of output-voltage operating band.
2. As directed, Maintain voltage within 15, 20 or 30 percent on one step, full load.

3. Provide anti-hunt provision to stabilize voltage.
4. As directed, maintain frequency within 5, 10 or 15 percent and stabilize at rated frequency within 2 or 5 seconds.

J. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

K. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

L. Subtransient Reactance: 12 percent, maximum.

2.9 VIBRATION ISOLATION DEVICES

A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.

1. Material: As directed, Standard neoprene, Natural rubber or Bridge-bearing neoprene, complying with AASHTO M 251 separated by steel shims.
2. Shore "A" Scale Durometer Rating: As directed, 30, 40, 45, 50, 60, 65 or 70.
3. Number of Layers: As directed, One, Two, Three or Four.
4. Minimum Deflection: 1 inch (25 mm).

B. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Minimum Deflection: 1 inch (25 mm).

C. Comply with requirements in Section 232116 "Hydronic Piping Specialties" for vibration isolation and flexible connector materials for steel piping.

D. Comply with requirements in Section 233113 "Metal Ducts" for vibration isolation and flexible connector materials for exhaust shroud and ductwork.

E. Vibration isolation devices shall not be used to accommodate misalignments or to make bends.

2.10 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine generator using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

1. Tests: Comply with IEEE 115.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. As directed, Notify Architect, Construction Manager or Owner no fewer than two working days in advance of proposed interruption of electrical service.
2. As directed, do not proceed with interruption of electrical service without Architect's, Construction Manager's or Owner's written permission.

B. Comply with NECA 1 and NECA 404.

C. Comply with packaged engine generator manufacturers' written installation.

D. Equipment Mounting:

1. Install packaged engine generators on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed
2. Coordinate size and location of concrete bases for packaged engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
3. Install packaged engine generator with elastomeric isolator pads or restrained spring isolators having a minimum deflection of 1 inch (25 mm) on 4-inch- (100-mm-) high concrete base. Secure engine generator to anchor bolts installed in concrete bases. Concrete base construction is specified in Section 260548.16 "Seismic Controls for Electrical Systems."

E. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

F. Exhaust System: Install Schedule 40, black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet.

1. Install flexible connectors and steel piping materials according to requirements in Section 232116 "Hydronic Piping Specialties."

2. Insulate muffler/silencer and exhaust system components according to requirements in Section 230719 "HVAC Piping Insulation."
3. Install isolating thimbles where exhaust piping penetrates combustible surfaces with a minimum of 9 inches (225 mm) clearance from combustibles.

G. Drain Piping: Install condensate drain piping to muffler drain outlet with a shutoff valve, stainless-steel flexible connector, and Schedule 40, black steel pipe, the full size of the drain connection, with welded joints.

H. Gaseous Fuel Piping:

1. Natural gas piping, valves, and specialties for gas distribution are specified in Section 231123 "Facility Natural Gas Piping."
2. LP gas piping, valves, and specialties for gas piping are specified in Section 231126 "Facility Liquefied-Petroleum Gas Piping."

I. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties.

B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.

C. Connect cooling-system water piping to engine generator and heat exchanger with flexible connectors.

D. Connect engine exhaust pipe to engine with flexible connector.

E. Gaseous Fuel Connections:

1. Connect fuel piping to engines with a gate valve and union and flexible connector.
2. Install manual shutoff valve in a remote location to isolate gaseous fuel supply to the generator.
3. Vent gas pressure regulators outside building a minimum of 60 inches (1500 mm) from building openings.

F. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

G. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Provide a minimum of one 90-degree bend in flexible conduit routed to the engine generator from a stationary element.

H. Balance single-phase loads to obtain a maximum of 10 percent unbalance between any two phases.

3.3 IDENTIFICATION

A. Identify system components according to Section 230553 "Identification for HVAC Piping and Equipment" and Section 260553 "Identification for Electrical Systems."

B. Install a sign indicating the generator neutral is bonded to the main service neutral at the main service location.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections with the assistance of a factory-authorized service representative.

E. Tests and Inspections:

1. Perform tests recommended by manufacturer and each visual and mechanical inspection and electrical and mechanical test listed in the first two subparagraphs below as specified in the NETA ATS. Certify compliance with test parameters.

    a. Visual and Mechanical Inspection

        1) Compare equipment nameplate data with drawings and specifications.
        2) Inspect physical and mechanical condition.
        3) Inspect anchorage, alignment, and grounding.
        4) Verify the unit is clean.

    b. Electrical and Mechanical Tests

        1) Perform insulation-resistance tests in accordance with IEEE 43.

            a) Machines larger than 200 hp (150 kW). Test duration shall be 10 minutes. Calculate polarization index.
            b) Machines 200 hp (150 kW) or less. Test duration shall be one minute. Calculate the dielectric-absorption ratio.

        2) Test protective relay devices.
        3) Verify phase rotation, phasing, and synchronized operation as required by the application.
        4) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
        5) Perform vibration test for each main bearing cap.
        6) Verify correct functioning of the governor and regulator.

2. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.

a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
c. Verify acceptance of charge for each element of the battery after discharge.
d. Verify that measurements are within manufacturer's specifications.

3. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
4. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.
5. Exhaust Emissions Test: Comply with applicable government test criteria.
6. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases and verify that performance is as specified.
7. Harmonic-Content Tests: Measure harmonic content of output voltage at 25 percent and 100 percent of rated linear load. Verify that harmonic content is within specified limits.
8. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at four locations 25 feet (8 m) from edge of the generator enclosure or on the property line, and compare measured levels with required values.

F. Coordinate tests with tests for transfer switches and run them concurrently.

G. Test instruments shall have been calibrated within the past 12 months, traceable to NIST Calibration Services, and adequate for making positive observation of test results. Make calibration records available for examination on request.

H. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.

I. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.

J. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

K. As directed, remove and replace malfunctioning units and retest or reinspect as specified above.

L. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

M. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.

END OF SECTION 263213.17

SECTION 263213.19 - BI-FUEL EMERGENCY ENGINE GENERATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes packaged bi-fuel engine generators for emergency use with the following features:

1. Bi-fuel engine.
2. Diesel fuel-oil system.
3. Gaseous fuel system.
4. Control and monitoring.
5. Generator overcurrent and fault protection.
6. Generator, exciter, and voltage regulator.
7. Vibration isolation devices.

B. Related Requirements:

1. Section 263600 "Transfer Switches" for transfer switches, including sensors and relays to initiate automatic-starting and -stopping signals for engine generators.

1.2 DEFINITIONS

A. Bi-Fuel: An engine generator that starts using diesel fuel, and upon assumption of the electrical load, transitions to a diesel-fuel and natural gas mix.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include plans and elevations for engine generator and other components specified. Indicate access requirements affected by height of subbase fuel tank.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Identify fluid drain ports and clearance requirements for proper fluid drain.
4. Design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and supported equipment. Include base weights.
6. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings for EPS equipment and functional relationship between all electrical components.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for engine generator, accessories, and components, from manufacturer.

B. Source quality-control reports.

C. Field quality-control reports.

D. Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

B. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.7 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Number of years from date of Substantial Completion as directed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain engine generators and auxiliary components through single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Engine generator housing, day tank, engine generator, batteries, battery racks, silencers, sound attenuating equipment, accessories, and components shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Shake-table testing shall comply with ICC-ES AC156. Testing shall be performed with all fluids at worst-case normal levels. Water shall be substituted for diesel fuel in fuel tank during test.
3. Component Importance Factor: As directed, 1.5 or 1.0.

B. B11 Compliance: Comply with B11.19.

C. NFPA Compliance:

1. Comply with NFPA 37.
2. Comply with NFPA 70.
3. Comply with NFPA 99.
4. As directed, Comply with NFPA 110 requirements for Level 1 or 2 EPSS.

D. UL Compliance: Comply with UL 2200.

E. Engine Exhaust Emissions: As directed, Comply with EPA Tier 2, 3 or 4 requirements and applicable state and local government requirements.

F. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by engine generator, including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

G. Environmental Conditions: Engine generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: As directed, 41 to 104 deg F (5 to 40 deg C) or 5 to 104 deg F (Minus 15 to plus 40 deg C).
2. Relative Humidity: Zero to 95 percent.
3. Altitude: Sea level to 1000 feet (300 m).

H. Unusual Service Conditions: Engine generator equipment and installation are required to operate under the following conditions:

1. High salt-dust content in the air due to sea-spray evaporation.

2.3 ENGINE GENERATOR ASSEMBLY DESCRIPTION

A. Factory-assembled and -tested, water-cooled engine, with brushless generator and accessories.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

C. EPSS Class: As directed, Engine generators shall be classified as a Class 2, Class 6, Class 48 or Class 96 according to NFPA 110.

D. Service load: Number kVA as directed.

E. Power Factor: 0.8, lagging.

F. Frequency: 60 Hz

G. Voltage: As directed, 208, 240, 480 or 600 V ac.

H. Phase: As directed, Three-phase, three or four-wire wye or delta.

I. Induction Method: As directed, Naturally aspirated or Turbocharged.

J. Governor: Adjustable isochronous, with speed sensing.

K. Mounting Frame: Structural-steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.

1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and engine generator center of gravity.

L. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated at 0.8 power factor excluding power required for the continued and repeated operation of the unit and auxiliaries.
2. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.

M. Engine Generator Performance:

1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage, from no load to full load.
2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency, from no load to full load.
4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
6. Output Waveform: At no load, harmonic content, measured line to line or line to neutral, shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
7. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.

8. Start Time: As directed, Comply with NFPA 110, Type U or Type 10, system requirements.

2.4 BI-FUEL ENGINE

A. Fuel: ASTM D975 diesel fuel oil, Grade 2-D S15, and natural gas.

B. Rated Engine Speed: 1800 rpm.

C. Lubrication System: Engine or skid mounted.

1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

D. Jacket Coolant Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity and with UL 499.

E. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine generator mounting frame and integral engine-driven coolant pump.

1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
2. Size of Radiator: Adequate to contain expansion of total system coolant, from cold start to 110 percent load condition.
3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant-system pressure for engine used. Equip with gage glass and petcock.
4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, UV-, and abrasion-resistant fabric.

    a. Rating: 50-psig (345-kPa) maximum working pressure with coolant at 180 deg F (82 deg C), and non-collapsible under vacuum.
    b. End Fittings: Flanges or steel pipe nipples, with clamps to suit piping and equipment connections.

F. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

1. Minimum sound attenuation of 25 dB at 500 Hz.
2. Sound level measured at a distance of 25 feet (8 m) from exhaust discharge after installation is complete shall be 78 dBA or less.

G. Muffler/Silencer: Semi-critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

1. Minimum sound attenuation of 18 dB at 500 Hz.
2. Sound level measured at a distance of 25 feet (8 m) from exhaust discharge after installation is complete shall be 85 dBA or less.

H. Muffler/Silencer: Commercial type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

1. Minimum sound attenuation of 12 dB at 500 Hz.
2. Sound level measured at a distance of 25 feet (8 m) from exhaust discharge after installation is complete shall be 90 dBA or less.

I. Air-Intake Filter: As directed, Standard or Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

J. Starting System: As directed, 12 or 24-V electric, with negative ground.

1. Components: Sized so they are not damaged during a full engine-cranking cycle, with ambient temperature at maximum specified in "Performance Requirements" Article.
2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
3. Cranking Cycle: As required by NFPA 110 for system level specified or 60 seconds.
4. Battery: As directed, Lead acid or Nickel cadmium, with capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least twice or three times without recharging.
5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 50 deg F (10 deg C) regardless of external ambient temperature within range specified in "Performance Requirements" Article. Include accessories required to support and fasten batteries in place. Provide ventilation to exhaust battery gases.
7. Battery Stand: Factory-fabricated, two-tier metal with acid-resistant finish designed to hold the quantity of battery cells required and to maintain the arrangement to minimize lengths of battery interconnections.
8. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
9. Battery Charger: Current-limiting, automatic-equalizing and float-charging type designed for lead-acid or nickel-cadmium batteries as directed. Unit shall comply with UL 1236 and include the following features:

    a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
    b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg F (minus 40 deg C) to 140

deg F (plus 60 deg C) to prevent overcharging at high temperatures and undercharging at low temperatures.

c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.

d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.

e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.

f. Enclosure and Mounting: NEMA 250, Type 1 wall-mounted cabinet.

2.5 DIESEL FUEL-OIL SYSTEM

A. Comply with NFPA 30.

B. Piping: Fuel-oil piping shall be Schedule 40 black steel, complying with requirements in Section 231113 "Facility Fuel-Oil Piping." Cast iron, aluminum, copper, and galvanized steel shall not be used in the fuel-oil system.

C. Main Fuel Pump: Mounted on engine to provide primary fuel flow under starting and load conditions.

D. Fuel Filtering: Remove water and contaminants larger than 1 micron.

E. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.

F. Fuel-Oil Storage Tank: Comply with requirements in Section 231313 "Facility Underground Fuel-Oil Storage Tanks" or Section 231323 "Facility Aboveground Fuel-Oil Storage Tanks" as directed

1. Fuel Tank Capacity: Minimum 133 percent of total fuel required for periodic maintenance operations between fuel refills plus fuel for the hours of continuous operation required for the indicated EPSS Class.
2. Duplex Fuel-Oil Transfer Pump: Comply with requirements in Section 231213 "Facility Fuel-Oil Pumps."

G. Day Tank: Comply with UL 142, freestanding, factory-fabricated fuel tank assembly, with integral, float-controlled transfer pump and the following features:

1. Containment: Integral rupture basin with a capacity of 150 percent of nominal capacity of day tank.

a. Leak Detector: Locate in rupture basin and connect to provide audible and visual alarm in the event of day-tank leak.

2. Tank Capacity: As recommended by engine manufacturer for an uninterrupted period of four hours' operation at 100 percent of rated power output of engine generator system without being refilled.
3. Pump Capacity: Exceeds maximum flow of fuel drawn by engine-mounted fuel-supply pump at 110 percent of rated capacity, including fuel returned from engine.
4. Low-Level Alarm Sensor: Liquid-level device operates alarm contacts at 25 percent of normal fuel level.
5. High-Level Alarm Sensor: Liquid-level device operates alarm and redundant fuel-shutoff contacts at midpoint between overflow level and 100 percent of normal fuel level.
6. Piping Connections: Factory-installed fuel-supply and return lines, from tank to engine; local fuel fill; vent line; overflow line; and tank drain line with shutoff valve.
7. Redundant High-Level Fuel Shutoff: Actuated by high-level alarm sensor in day tank to operate a separate motor control device that disconnects day-tank pump motor. Sensor shall signal solenoid valve, located in fuel suction line between fuel storage tank and day tank, to close. Both actions shall remain in shutoff state until manually reset. Shutoff action shall initiate an alarm signal to control panel but shall not shut down engine generator.

2.6 GASEOUS FUEL SYSTEM

A. Natural Gas Piping: Comply with requirements in Section 231123 "Facility Natural-Gas Piping."

B. Gas Train: Comply with NFPA 37.

C. Engine Fuel System:

1. Natural Gas, Vapor-Withdrawal System:

   a. Carburetor.
   b. Fuel-Shutoff Solenoid Valves: NRTL-listed, normally closed, safety shutoff valves; one for each fuel source.

2. Fuel Filters: One for each fuel type.
3. Manual Fuel Shutoff Valves: One for each fuel type.
4. Flexible Fuel Connectors: Minimum one for each fuel connection.

2.7 CONTROL AND MONITORING

A. Automatic-Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of engine generator. When mode-selector switch is switched to the on position, engine generator starts. The off position of same switch initiates engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.

B. Manual-Starting System Sequence of Operation: Switching On-Off switch on the generator control panel to the on position starts engine generator. The off position of same switch initiates

engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.

C. Provide minimum run time control set for 15 or 30 minutes as directed, with override only by operation of a remote emergency-stop switch.

D. Comply with UL 508A.

E. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the engine generator. Mounting method shall isolate the control panel from engine generator vibration. Panel shall be powered from the engine generator battery.

F. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common wall-mounted control and monitoring panel. Panel shall be powered from the engine generator battery.

G. Control and Monitoring Panel:

1. Digital controller with integrated LCD, controls, and microprocessor, capable of local and remote control, monitoring, and programming, with battery backup.
2. Analog control panel with dedicated gages and indicator lights for the instruments and alarms indicated below.
3. Instruments: Located on the control and monitoring panel and viewable during operation.

    a. Engine lubricating-oil pressure gage.
    b. Engine-coolant temperature gage.
    c. DC voltmeter (alternator battery charging).
    d. Running-time meter.
    e. As directed, AC voltmeter, for each phase or connected to a phase selector switch.
    f. As directed, AC ammeter, for each phase or connected to a phase selector switch.
    g. AC frequency meter.
    h. Generator-voltage-adjusting rheostat.

4. Controls and Protective Devices: As directed, Controls, shutdown devices, and common visual alarm indication as required by NFPA 110 for Level 1 or 2 system, including the following:

    a. Cranking control equipment.
    b. Run-Off-Auto switch.
    c. Control switch not in automatic position alarm.
    d. Overcrank alarm.
    e. Overcrank shutdown device.
    f. Low water temperature alarm.
    g. High engine temperature pre-alarm.
    h. High engine temperature.
    i. High engine temperature shutdown device.
    j. Overspeed alarm.
    k. Overspeed shutdown device.
    l. Low-fuel main tank.

1) Low-fuel-level alarm shall be initiated when the level falls below that required for operation for the duration required for the indicated EPSS class.

m. Coolant low-level alarm.
n. Coolant low-level shutdown device.
o. Coolant high-temperature prealarm.
p. Coolant high-temperature alarm.
q. Coolant low-temperature alarm.
r. Coolant high-temperature shutdown device.
s. EPS load indicator.
t. Battery high-voltage alarm.
u. Low-cranking voltage alarm.
v. Battery-charger malfunction alarm.
w. Battery low-voltage alarm.
x. Lamp test.
y. Contacts for local and remote common alarm.
z. Low-starting air pressure alarm.
aa. Low-starting hydraulic pressure alarm.
bb. Remote manual-stop shutdown device.
cc. Air shutdown damper alarm when used.
dd. Air shutdown damper shutdown device when used.
ee. Generator overcurrent-protective-device not-closed alarm.

H. Common Remote Panel with Common Audible Alarm: As directed, Comply with NFPA 110 requirements for Level 1 or 2 systems. Include necessary contacts and terminals in control and monitoring panel. Remote panel shall be powered from the engine generator battery.

I. Remote Alarm Annunciator: Comply with NFPA 99. An LED indicator light labeled with proper alarm conditions shall identify each alarm event, and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.

1. Overcrank alarm.
2. Coolant low-temperature alarm.
3. High engine temperature pre-alarm.
4. High engine temperature alarm.
5. Low lube oil pressure alarm.
6. Overspeed alarm.
7. Low-fuel main tank alarm.
8. Low coolant level alarm.
9. Low-cranking voltage alarm.
10. Contacts for local and remote common alarm.
11. Audible-alarm silencing switch.
12. Air shutdown damper when used.
13. Run-Off-Auto switch.
14. Control switch not in automatic position alarm.
15. Fuel tank derangement alarm.
16. Fuel tank high-level shutdown of fuel-supply alarm.

17. Lamp test.
18. Low-cranking voltage alarm.
19. Generator overcurrent protective device not closed.

J. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

K. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator unless otherwise indicated.

2.8 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Overcurrent protective devices for the entire EPSS shall be coordinated to optimize selective tripping when a short circuit occurs. Coordination of protective devices shall consider both utility and EPSS as the voltage source.

1. Overcurrent protective devices for the EPSS shall be accessible only to authorized personnel.

B. Generator Circuit Breaker: Molded-case, thermal-magnetic type; 100 percent rated; complying with UL 489.

1. Tripping Characteristic: Designed specifically for generator protection.
2. Trip Rating: Matched to generator output rating.
3. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
4. Mounting: Adjacent to or integrated with control and monitoring panel.

C. Generator Circuit Breaker: Molded-case, electronic-trip type; 100 percent rated; complying with UL 489.

1. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
2. Trip Settings: Selected to coordinate with generator thermal damage curve.
3. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
4. Mounting: Adjacent to or integrated with control and monitoring panel.

D. Generator Disconnect Switch: Molded-case type, 100 percent rated.

1. Trip Rating: Matched to generator output rating.
2. Shunt Trip: Connected to trip switch when signaled by generator protector or by other protective devices.

E. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other engine generator protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector performs the following functions:

1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other engine generator malfunction alarms. Contacts shall be available for load shed functions.
2. Under single- or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the engine generator.
4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

F. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground fault.

1. Indicate ground fault with other engine generator alarm indications.
2. Trip generator protective device on ground fault.

2.9 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. Electrical Insulation: Class H or Class F.

D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required. As directed, Provide six or 12-lead alternator.

E. Range: As directed, provide limited, broad or extended range of output voltage by adjusting the excitation level.

F. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.

G. Enclosure: Dripproof.

H. Instrument Transformers: Mounted within generator enclosure.

I. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified and as required by NFPA 110.

1. Adjusting Rheostat on Control and Monitoring Panel: Provide plus or minus 5 percent adjustment of output-voltage operating band.
2. As directed, maintain voltage within 15, 20 or 30 percent on one step, full load.
3. Provide anti-hunt provision to stabilize voltage.
4. As directed, maintain frequency within 5, 10 or 15 percent and stabilize at rated frequency within two or five seconds.

J. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

K. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

L. Subtransient Reactance: 12 percent, maximum.

2.10 VIBRATION ISOLATION DEVICES

A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.

1. Material: As directed, Standard neoprene, Natural rubber or Bridge-bearing neoprene, complying with AASHTO M 251 separated by steel shims.
2. Shore A Scale Durometer Rating: As directed, 30, 40, 45, 50, 60, 65 or 70.
3. Number of Layers: As directed, One, Two, Three or Four.
4. Minimum Deflection: 1 inch (25 mm).

B. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.

1. Housing: Steel with resilient, vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment-mounting and -leveling bolt that acts as blocking during installation.
2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Minimum Deflection: 1 inch (25 mm).

C. Comply with requirements in Section 232116 "Hydronic Piping Specialties" for vibration isolation and flexible connector materials for steel piping.

D. Comply with requirements in Section 233113 "Metal Ducts" for vibration isolation and flexible connector materials for exhaust shroud and ductwork.

E. Vibration isolation devices shall not be used to accommodate misalignments or to make bends.

2.11 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine generator using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

1. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. As directed, notify Architect, Construction Manager or Owner no fewer than two working days in advance of proposed interruption of electrical service.
2. As directed, do not proceed with interruption of electrical service without Architect's, Construction Manager's or Owner's written permission.

3.2 INSTALLATION

A. Comply with NECA 1 and NECA 404.

B. Comply with packaged engine generator manufacturers' written installation and alignment instructions and with NFPA 110.

C. Equipment Mounting:

1. Install packaged engine generators on cast-in-place concrete equipment bases. As directed, comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete".
2. Coordinate size and location of concrete bases for packaged engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
3. Install packaged engine generator with elastomeric isolator pads or restrained spring isolators having a minimum deflection of 1 inch (25 mm) on 4-inch- (100-mm-) high concrete base. Secure engine generator to anchor bolts installed in concrete bases. Concrete base construction is specified in Section 260548.16 "Seismic Controls for Electrical Systems."

D. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

E. Cooling System: Install Schedule 40 black steel piping with welded joints for cooling water piping between engine generator and heat exchanger. Piping materials and installation requirements are specified in Section 232113 "Hydronic Piping."

1. Install isolating thimbles where exhaust piping penetrates combustible surfaces. Provide a minimum of 9 inches (225 mm) of clearance from combustibles.
2. Insulate cooling-system piping and components according to requirements in Section 230719 "HVAC Piping Insulation."

F. Exhaust System: Install Schedule 40 black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet.

1. Install flexible connectors and steel piping materials according to requirements in Section 232116 "Hydronic Piping Specialties."
2. Insulate muffler/silencer and exhaust system components according to requirements in Section 230719 "HVAC Piping Insulation."
3. Install isolating thimbles where exhaust piping penetrates combustible surfaces with a minimum of 9 inches (225 mm) of clearance from combustibles.

G. Drain Piping: Install condensate drain piping to muffler drain outlet with a shutoff valve, stainless-steel flexible connector, and Schedule 40 black steel pipe, the full size of the drain connection, with welded joints.

H. Fuel Piping:

1. Diesel storage tanks, tank accessories, piping, valves, and specialties for fuel systems are specified in Section 231113 "Facility Fuel-Oil Piping."
2. Natural gas piping, valves, and specialties for gas distribution are specified in Section 231123 "Facility Natural Gas Piping."
3. Copper and galvanized steel shall not be used in the diesel fuel-oil piping system.

I. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties.

B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.

C. Connect cooling-system water piping to engine generator and heat exchanger with flexible connectors.

D. Connect engine exhaust pipe to engine with flexible connector.

E. Fuel Connections:

1. Connect fuel piping to engines with a gate valve and union and flexible connector.
2. Install manual shutoff valve in a remote location to isolate gas supply to the generator.
3. Vent gas pressure regulators outside building a minimum of 60 inches (1500 mm) from building openings.

F. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

G. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Provide a minimum of one 90-degree bend in flexible conduit routed to the engine generator from a stationary element.

H. Balance single-phase loads to obtain a maximum of 10 percent unbalance between any two phases.

3.4 IDENTIFICATION

A. Identify system components according to Section 230553 "Identification for HVAC Piping and Equipment" and Section 260553 "Identification for Electrical Systems."

B. Install a sign indicating the generator neutral is bonded to the main service neutral at the main service location.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Contractor will engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections with the assistance of a factory-authorized service representative.

E. Tests and Inspections:

1. Perform tests recommended by manufacturer and in "Visual and Mechanical Inspection" and "Electrical and Mechanical Tests" subparagraphs below, as specified in NETA ATS. Certify compliance with test parameters.

    a. Visual and Mechanical Inspection

        1) Compare equipment nameplate data with Drawings and specifications.
        2) Inspect physical and mechanical condition.
        3) Inspect anchorage, alignment, and grounding.
        4) Verify the unit is clean.

    b. Electrical and Mechanical Tests

        1) Perform insulation-resistance tests according to IEEE 43.

            a) Machines Larger Than 200 hp (150 kW): Test duration shall be 10 minutes. Calculate polarization index.
            b) Machines 200 hp (150 kW) or Less: Test duration shall be one minute. Calculate the dielectric-absorption ratio.

        2) Test protective relay devices.
        3) Verify phase rotation, phasing, and synchronized operation as required by the application.
        4) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.

5) Perform vibration test for each main bearing cap.
6) Conduct performance test according to NFPA 110.
7) Verify correct functioning of the governor and regulator.

2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here, including, but not limited to, single-step full-load pickup test.
3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.

    a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
    b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
    c. Verify acceptance of charge for each element of the battery after discharge.
    d. Verify that measurements are within manufacturer's specifications.

4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.
6. Exhaust Emissions Test: Comply with applicable government test criteria.
7. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases and verify that performance is as specified.
8. Harmonic-Content Tests: Measure harmonic content of output voltage at 25 percent and 100 percent of rated linear load. Verify that harmonic content is within specified limits.

F. Coordinate tests with tests for transfer switches and run them concurrently.

G. Test instruments shall have been calibrated within the past 12 months, traceable to NIST Calibration Services, and adequate for making positive observation of test results. Make calibration records available for examination on request.

H. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.

I. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.

J. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

K. As directed, remove and replace malfunctioning units and retest or reinspect as specified above.

L. Retest: Correct deficiencies identified by tests and observations, and retest until specified requirements are met.

M. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component, indicating satisfactory completion of tests.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.

END OF SECTION 263213.19

SECTION 263213.20 - BI-FUEL ENGINE GENERATORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes packaged bi-fuel engine generators with the following features:

1. Bi-fuel engine.
2. Diesel fuel-oil system.
3. Gaseous fuel system.
4. Control and monitoring.
5. Generator overcurrent and fault protection.
6. Generator, exciter, and voltage regulator.
7. Vibration isolation devices.

B. Related Requirements:

1. Section 263600 "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine generators.

1.2 DEFINITIONS

A. Bi-Fuel: An engine generator that starts using diesel fuel, and upon assumption of the electrical load, transitions to a diesel fuel and natural gas mix.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include plans and elevations for engine generator and other components specified. Indicate access requirements affected by height of subbase fuel tank.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Identify fluid drain ports and clearance requirements for proper fluid drain.
4. Design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include base weights.

6. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings for EPS equipment and functional relationship between all electrical components.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for engine generator, accessories, and components, from manufacturer.

B. Source quality-control reports.

C. Field quality-control reports.

D. Warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

B. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.7 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Number of years from date of Substantial Completion as directed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Engine generator housing, day tank, engine generator, batteries, battery racks, silencers, and sound-attenuating equipment, accessories, and components shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Shake-table testing shall comply with ICC-ES AC156. Testing shall be performed with all fluids at worst case normal levels. Water shall be substituted for diesel fuel in fuel tank during test.
3. Component Importance Factor: As directed, 1.5 or 1.0.

B. B11 Compliance: Comply with B11.19.

C. NFPA Compliance:

1. Comply with NFPA 37.
2. Comply with NFPA 70.

D. UL Compliance: Comply with UL 2200.

E. Engine Exhaust Emissions: As directed, Comply with EPA Tier 2, 3 or 4 requirements and applicable state and local government requirements.

F. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by engine generator including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

G. Environmental Conditions: Engine generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: As directed, 41 to 104 deg F (5 to 40 deg C) or 5 to 104 deg F (Minus 15 to plus 40 deg C).
2. Relative Humidity: Zero to 95 percent.
3. Altitude: Sea level to 1000 feet (300 m).

H. Unusual Service Conditions: Engine generator equipment and installation are required to operate under the following conditions:

1. High salt-dust content in the air due to sea-spray evaporation.

2.3 ENGINE GENERATOR ASSEMBLY DESCRIPTION

A. Factory-assembled and -tested, water-cooled engine, with brushless generator and accessories.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended location and use.

C. Power Rating: As directed, Prime or Industrial.

D. Overload Capacity: 110 percent of service load for 1 hour in 12 consecutive hours.

E. Service Load: Number of kVA as directed.

F. Power Factor: 0.8, lagging.

G. Frequency: 60 Hz.

H. Voltage: As directed, 208, 240, 480, 600 or 4160-V ac.

I. Phase: As directed, Three-phase, three or four-wire, wye or delta.

J. Induction Method: As directed, Naturally aspirated or Turbocharged.

K. Governor: Adjustable isochronous, with speed sensing.

L. Mounting Frame: Structural steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.

1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and engine generator center of gravity.

M. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated excluding power required for the continued and repeated operation of the unit and auxiliaries, with capacity as required to operate as a unit as evidenced by records of prototype testing.
2. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.

N. Engine Generator Performance:

1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.
2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.

4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
7. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
8. Start Time: 10 seconds.

2.4 BI-FUEL ENGINE

A. Fuel: ASTM D975, diesel fuel oil, Grade 2-D S15 and natural gas.

B. Rated Engine Speed: 1800 rpm.

C. Lubrication System: Engine or skid mounted.

1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

D. Jacket Coolant Heater: Electric-immersion type, factory installed in coolant jacket system.

E. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine generator mounting frame and integral engine-driven coolant pump.

1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, UV-, and abrasion-resistant fabric.

    a. Rating: 50-psig (345-kPa) maximum working pressure with coolant at 180 deg F (82 deg C), and non-collapsible under vacuum.

b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

F. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

1. Minimum sound attenuation of 25 dB at 500 Hz.
2. Sound level measured at a distance of 25 feet (8 m) from exhaust discharge after installation is complete shall be 78 dBA or less.

G. Muffler/Silencer: Semi-critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

1. Minimum sound attenuation of 18 dB at 500 Hz.
2. Sound level measured at a distance of 25 feet (8 m) from exhaust discharge after installation is complete shall be 85 dBA or less.

H. Muffler/Silencer: Commercial type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

1. Minimum sound attenuation of 12 dB at 500 Hz.
2. Sound level measured at a distance of 25 feet (8 m) from exhaust discharge after installation is complete shall be 90 dBA or less.

I. Air-Intake Filter: As directed, Standard or Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

J. Starting System: As directed, 12 or 24-V electric, with negative ground.

1. Components: Sized so they are not damaged during a full engine-cranking cycle with ambient temperature at maximum specified in "Performance Requirements" Article.
2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
3. Cranking Cycle: 60 seconds.
4. Battery: As directed, Lead acid or Nickel cadmium, with capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least twice or three times without recharging as directed.
5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 50 deg F ()10 deg C) regardless of external ambient temperature within range specified in "Performance Requirements" Article. Include accessories required to support and fasten batteries in place. Provide ventilation to exhaust battery gases.
7. Battery Stand: Factory-fabricated, two-tier metal with acid-resistant finish designed to hold the quantity of battery cells required and to maintain the arrangement to minimize lengths of battery interconnections.

8. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
9. Battery Charger: As directed, Current-limiting, automatic-equalizing and float-charging type designed for lead-acid or nickel-cadmium batteries. Unit shall comply with UL 1236 and include the following features:

    a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
    b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 to 140 deg F (minus 40 to plus 60 deg C) to prevent overcharging at high temperatures and undercharging at low temperatures.
    c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
    d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
    e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
    f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.5 DIESEL FUEL-OIL SYSTEM

A. Comply with NFPA 30.

B. Piping: Fuel-oil piping shall be Schedule 40 black steel complying with requirements in Section 231113 "Facility Fuel-Oil Piping." Cast iron, aluminum, copper, and galvanized steel shall not be used in the fuel-oil system.

C. Main Fuel Pump: Mounted on engine to provide primary fuel flow under starting and load conditions.

D. Fuel Filtering: Remove water and contaminants larger than 1 micron.

E. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.

F. Fuel-Oil Storage Tank: As directed, Comply with requirements in Section 231313 "Facility Underground Fuel-Oil Storage Tanks" or Section 231323 "Facility Aboveground Fuel-Oil Storage Tanks."

    1. Fuel Tank Capacity: Minimum 133 percent of total fuel required for periodic maintenance operations between fuel refills plus fuel for the hours of continuous operation required for the indicated EPSS Class.

2. Duplex Fuel-Oil Transfer Pump: Comply with requirements in Section 231213 "Facility Fuel-Oil Pumps."

G. Day Tank: Comply with UL 142, freestanding, factory-fabricated fuel tank assembly, with integral, float-controlled transfer pump and the following features:

1. Containment: Integral rupture basin with a capacity of 150 percent of nominal capacity of day tank.

a. Leak Detector: Locate in rupture basin and connect to provide audible and visual alarm in the event of day-tank leak.

2. Tank Capacity: As recommended by engine manufacturer for an uninterrupted period of 4 hours' operation at 100 percent of rated power output of engine generator system without being refilled.
3. Pump Capacity: Exceeds maximum flow of fuel drawn by engine-mounted fuel supply pump at 110 percent of rated capacity, including fuel returned from engine.
4. Low-Level Alarm Sensor: Liquid-level device operates alarm contacts at 25 percent of normal fuel level.

2.6 GASEOUS FUEL SYSTEM

A. Natural Gas Piping: Comply with requirements in Section 231123 "Facility Natural Gas Piping."

B. Gas Train: Comply with NFPA 37.

C. Engine Fuel System:

1. Natural Gas, Vapor-Withdrawal System:

a. Carburetor.
b. Secondary Gas Regulators: One for each fuel type, with atmospheric vents piped to building exterior.
c. Fuel-Shutoff Solenoid Valves: NRTL-listed, normally closed, safety shutoff valves; one for each fuel source.
d. Fuel Filters: One for each fuel type.
e. Manual Fuel Shutoff Valves: One for each fuel type.
f. Flexible Fuel Connectors: Minimum one for each fuel connection.

2.7 CONTROL AND MONITORING

A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of engine generator. When mode-selector switch is switched to the on position, engine generator starts. The off position of same switch initiates engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.

B. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts engine generator. The off position of same switch initiates engine generator shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.

C. As directed, provide minimum run-time control set for 15 or 30 minutes with override only by operating a remote emergency-stop switch.

D. Comply with UL 508A.

E. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the engine generator. Mounting method shall isolate the control panel from engine generator vibration. Panel shall be powered from the engine generator battery.

F. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common wall-mounted control and monitoring panel. Panel shall be powered from the engine generator battery.

G. Control and Monitoring Panel:

1. Digital controller with integrated LCD display, controls, and microprocessor, capable of local and remote control, monitoring, and programming, with battery backup.
2. Analog control panel with dedicated gages and indicator lights for the instruments and alarms indicated below.
3. Instruments: Located on the control and monitoring panel and viewable during operation.

    a. Engine lubricating-oil pressure gage.
    b. Engine-coolant temperature gage.
    c. DC voltmeter (alternator battery charging).
    d. Running-time meter.
    e. As directed, AC voltmeter, for each phase or connected to a phase selector switch.
    f. As directed, AC ammeter, for each phase or connected to a phase selector switch.
    g. AC frequency meter.
    h. Generator-voltage adjusting rheostat.

4. Controls and Protective Devices: Controls, shutdown devices and common visual alarm indication including the following:

    a. Cranking control equipment.
    b. Run-Off-Auto switch.
    c. Control switch not in automatic position alarm.
    d. Overcrank alarm.
    e. Overcrank shutdown device.
    f. Low water temperature alarm.
    g. High engine temperature pre-alarm.
    h. High engine temperature.
    i. High engine temperature shutdown device.
    j. Overspeed alarm.
    k. Overspeed shutdown device.

l. Low fuel main tank.

1) Low fuel level alarm shall be initiated when the level falls below that required for operation for the duration required in "Fuel Tank Capacity" Subparagraph in "Diesel Fuel-Oil System" Article.

m. Coolant low-level alarm.
n. Coolant low-level shutdown device.
o. Coolant high-temperature pre-alarm.
p. Coolant high-temperature alarm.
q. Coolant low-temperature alarm.
r. Coolant high-temperature shutdown device.
s. EPS supplying load indicator.
t. Battery high-voltage alarm.
u. Low cranking voltage alarm.
v. Battery-charger malfunction alarm.
w. Battery low-voltage alarm.
x. Lamp test.
y. Contacts for local and remote common alarm.
z. Low-starting air pressure alarm.
aa. Low-starting hydraulic pressure alarm.
bb. Remote manual stop shutdown device.
cc. Air shutdown damper alarm when used.
dd. Air shutdown damper shutdown device when used.
ee. Generator overcurrent-protective-device not-closed alarm.

H. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.

2.8 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Overcurrent protective devices for the entire EPSS shall be coordinated to optimize selective tripping when a short circuit occurs. Coordination of protective devices shall consider both utility and EPSS as the voltage source.

1. Overcurrent protective devices for the EPSS shall be accessible only to authorized personnel.

B. Generator Circuit Breaker: Molded-case, thermal-magnetic type; 100 percent rated; complying with UL 489.

1. Tripping Characteristic: Designed specifically for generator protection.
2. Trip Rating: Matched to generator output rating.
3. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
4. Mounting: Adjacent to, or integrated with, control and monitoring panel.

C. Generator Circuit Breaker: Molded-case, electronic-trip type; 100 percent rated; complying with UL 489.

1. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
2. Trip Settings: Selected to coordinate with generator thermal damage curve.
3. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
4. Mounting: Adjacent to or integrated with control and monitoring panel.

D. Generator Disconnect Switch: Molded-case type; 100 percent rated.

1. Trip Rating: Matched to generator output rating.
2. Shunt Trip: Connected to trip switch when signaled by generator protector or by other protective devices.

E. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other engine generator protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector performs the following functions:

1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other engine generator malfunction alarms. Contacts shall be available for load shed functions.
2. Under single- or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the engine generator.
4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

F. Ground-Fault Indication: Comply with NFPA 70 Article 700, "Emergency System" signals for ground fault.

1. Trip generator protective device on ground fault.

2.9 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. Electrical Insulation: Class H or Class F.

D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required. As directed, Provide six or 12-lead alternator.

E. Range: As directed, provide limited, broad or extended range of output voltage by adjusting the excitation level.

F. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.

G. Enclosure: Dripproof.

H. Instrument Transformers: Mounted within generator enclosure.

I. Voltage Regulator: Solid-state type, separate from exciter.

1. Adjusting Rheostat on Control and Monitoring Panel: Provide plus or minus 5 percent adjustment of output-voltage operating band.
2. As directed, maintain voltage within 15, 20 or 30 percent on one step, full load.
3. Provide anti-hunt provision to stabilize voltage.
4. As directed, maintain frequency within 5, 10 or 15 percent and stabilize at rated frequency within 2 or 5 seconds.

J. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

K. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

L. Subtransient Reactance: 12 percent, maximum.

2.10 VIBRATION ISOLATION DEVICES

A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.

1. Material: As directed, Standard neoprene, Natural rubber or Bridge-bearing neoprene, complying with AASHTO M 251 separated by steel shims.
2. Shore A Scale Durometer Rating: As directed, 30, 40, 45, 50, 60, 65 or 70.
3. Number of Layers: As directed, One, Two, Three or Four.
4. Minimum Deflection: 1 inch (25 mm).

B. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Minimum Deflection: 1 inch (25 mm).

C. Comply with requirements in Section 232116 "Hydronic Piping Specialties" for vibration isolation and flexible connectors materials for steel piping.

D. Comply with requirements in Section 233113 "Metal Ducts" for vibration isolation and flexible connector materials for exhaust shroud and ductwork.

E. Vibration isolation devices shall not be used to accommodate misalignments or to make bends.

2.11 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine generator using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. As directed, notify Architect, Construction Manager or Owner no fewer than two working days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Architect's, Construction Manager's or Owner's written permission.

B. Comply with NECA 1 and NECA 404.

C. Comply with packaged engine generator manufacturers' written installation and alignment instructions.

D. Equipment Mounting:

1. Install packaged engine generators on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed
2. Coordinate size and location of concrete bases for packaged engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
3. As directed, install packaged engine generator with elastomeric isolator pads or restrained spring isolators having a minimum deflection of 1 inch (25 mm) on 4-inch- (100-mm-) high concrete base. As directed, Secure sets or enclosure to anchor bolts installed in concrete bases. Concrete base construction is specified in Section 260548.16 "Seismic Controls for Electrical Systems."

E. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

F. Cooling System: Install Schedule 40 black steel piping with welded joints for cooling water piping between engine generator and heat exchanger. Piping materials and installation requirements are specified in Section 232113 "Hydronic Piping."

1. Install isolating thimbles where exhaust piping penetrates combustible surfaces. Provide a minimum of 9 inches (225 mm) of clearance from combustibles.
2. Insulate cooling system piping and components according to requirements in Section 230719 "HVAC Piping Insulation."

G. Exhaust System: Install Schedule 40 black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet.

1. Install flexible connectors and steel piping materials according to requirements in Section 232116 "Hydronic Piping Specialties."
2. Insulate muffler/silencer and exhaust system components according to requirements in Section 230719 "HVAC Piping Insulation."
3. Install isolating thimbles where exhaust piping penetrates combustible surfaces with a minimum of 9 inches (225 mm) of clearance from combustibles.

H. Drain Piping: Install condensate drain piping to muffler drain outlet with a shutoff valve, stainless-steel flexible connector, and Schedule 40 black steel pipe with welded joints.

I. Fuel Piping:

1. Diesel storage tanks, tank accessories, piping, valves, and specialties for fuel systems are specified in Section 231113 "Facility Fuel-Oil Piping."
2. Natural gas piping, valves, and specialties for gas distribution are specified in Section 231123 "Facility Natural Gas Piping."
3. Copper and galvanized steel shall not be used in the diesel fuel-oil piping system.

J. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties.

B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.

C. Connect cooling-system water piping to engine generator and heat exchanger with flexible connectors.

D. Connect engine exhaust pipe to engine with flexible connector.

E. Fuel Connections:

1. Connect fuel piping to engines with a gate valve and union and flexible connector.
2. Install manual shutoff valve in a remote location to isolate gas supply to the generator.
3. Vent gas pressure regulators outside building a minimum of 60 inches (1500 mm) from building openings.

F. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

G. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Provide a minimum of one 90-degree bend in flexible conduit routed to the generator set from a stationary element.

H. Balance single-phase loads to obtain a maximum of 10 percent unbalance between any two phases.

3.3 IDENTIFICATION

A. Identify system components according to Section 230553 "Identification for HVAC Piping and Equipment" and Section 260553 "Identification for Electrical Systems."

B. Install a sign indicating the generator neutral is bonded to the main service neutral at the main service location.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections with the assistance of a factory-authorized service representative.

E. Tests and Inspections:

1. Perform tests recommended by manufacturer and each visual and mechanical inspection and electrical and mechanical test listed in first two subparagraphs, as specified in NETA ATS. Certify compliance with test parameters.

    a. Visual and Mechanical Inspection:

        1) Compare equipment nameplate data with Drawings and the Specifications.
        2) Inspect physical and mechanical condition.
        3) Inspect anchorage, alignment, and grounding.
        4) Verify that the unit is clean.

    b. Electrical and Mechanical Tests:

1) Perform insulation-resistance tests according to IEEE 43.

a) Machines Larger Than 200 hp (150 kW): Test duration shall be 10 minutes. Calculate polarization index.
b) Machines 200 hp (150 kW) or Less: Test duration shall be one minute. Calculate the dielectric-absorption ratio.

2) Test protective relay devices.
3) Verify phase rotation, phasing, and synchronized operation as required by the application.
4) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
5) Perform vibration test for each main bearing cap.
6) Verify correct functioning of the governor and regulator.

2. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.
3. Exhaust Emissions Test: Comply with applicable government test criteria.
4. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases and verify that performance is as specified.
5. Harmonic-Content Tests: Measure harmonic content of output voltage at 25 and 100 percent of rated linear load. Verify that harmonic content is within specified limits.
6. Noise Level Tests: Measure A-weighted level of noise emanating from engine generator installation, including engine exhaust and cooling-air intake and discharge, at four locations 25 feet (8 m) from edge of the generator enclosure or on the property line as directed, and compare measured levels with required values.

F. Coordinate tests with tests for transfer switches and run them concurrently.

G. Test instruments shall have been calibrated within the last 12 months, traceable to NIST Calibration Services, and adequate for making positive observation of test results. Make calibration records available for examination on request.

H. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.

I. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.

J. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

K. Remove and replace malfunctioning units and retest or reinspect as specified above as directed.

L. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

M. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.

END OF SECTION 263213.20

SECTION 263223.13 - HORIZONTAL-AXIS WIND TURBINES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes small-scale, horizontal-axis wind turbines.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For wind-energy equipment.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions (including rotor sweep area), weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of equipment.
4. Include diagrams for power, signal, and control wiring.
5. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated-Design Submittal:

1. For horizontal wind turbine structural loads.
2. For horizontal wind turbine mounting.
3. For vibration isolation mounts.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Erection and interconnection drawings and other details, drawn to scale, using input from installers of the items involved.

B. Seismic Qualification Data: For horizontal wind turbines, accessories, and components, from manufacturer.

C. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of wind-energy equipment that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 STRUCTURAL ANALYSIS CRITERIA FOR POLE SELECTION

A. Dynamic Loads: Use the following dynamic load factors for load calculations according to IEC 61400-2:

1. Number of blades.
2. Rotor diameter.
3. Rotor radius.
4. Rotor center to yaw axis (tower center) distance.
5. Rotor center to first bearing distance.
6. Mass of blade.
7. Mass of rotor.
8. Moment of inertia of blade.
9. Rated power.
10. Wind speed at rated power.
11. Rotor speed at rated power.
12. Tip speed (angular velocity) of rotor at rated power.
13. Tip speed (linear velocity) at rated power.
14. TSR at rated power.
15. Rotor torque rated power.
16. IEC average wind speed at hub height.
17. IEC "Reference" wind speed.
18. IEC 50-year TSR.
19. Maximum rotor speed with load.
20. Maximum rotor speed with no load.
21. IEC maximum yaw rate.
22. Rotor center to blade center of gravity distance.
23. Drag coefficient of blade.
24. Drag coefficient of generator.
25. Drag coefficient of tail assembly.
26. Acceleration due to gravity.
27. Air density at sea level and 25 deg C.

2.3 PERFORMANCE REQUIREMENTS

A. Support-Structure, Wind-Load Strength: Poles and other support structures, brackets, arms, appurtenances, bases, anchorages, and foundations shall comply with IEC 61400-2 (or local codes and ordinances) and shall be certified by manufacturers to withstand winds up to 100 mph (160 km/h) without permanent deflection or whipping.

B. Support-Structure Seismic Strength: Poles or other support structures, brackets, arms, appurtenances, bases, anchorages, and foundations shall be designed to prevent separation of components or fracture of poles, luminaire supports, or pole foundations during a seismic event.

C. Mountings, Fasteners, and Appurtenances:

1. Corrosion resistant, compatible with support components, and which shall not cause galvanic action at contact points.

    a. Steel Components: Hot-dip galvanized after fabrication, complying with ASTM A123/A123M.
    b. Mounting Hardware Fasteners: Hot-dip galvanized, complying with ASTM A153/A153M, or minimum 18-8 grade stainless steel.

2. Accommodate attachments and wiring of other indicated systems.

D. Concrete for Tower Foundations: 3000-psi (20.7-MPa), 28-day minimum compressive strength. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."

E. Direct-buried steel structures or poles shall not be used.

2.4 GENERATORS

A. Rotors:

1. Swept Area: 52.8 (4.91) sq. ft. (sq. m).
2. Rotor Diameter: 8.2 (2.7) sq. ft. (sq. m).
3. Number of Blades: Three.
4. RPM at Rated Output: 450.
5. TSR: 5.8.
6. Cut-in Wind Speed: 5.6 (9.01) mph (km/h).
7. Predicted Energy Output: As directed.
8. Maximum Design Wind Speed: 120 (193.05) mph (km/h).
9. Blade Type: As directed, Injection molded plastic, Pultruded fiberglass, Fiber composite or Polypropylene.
10. Wind Governing Control:

    a. As directed, Blade-pitch or Furling control.

11. Generator:

    a. Rated Power: 1000 W.

b. Voltage: As directed, 24, 48 or 96-V dc.
c. Peak Output (Pmax): 1500 W.
d. Fixed Magnet: As directed, Ferrite or Rare earth.

12. Nacelle Body Material: As directed, Aluminum or Fiber composite.
13. Governing System: As directed, Blade-pitching governor, Blade-tip-pitching governor, Side-furling governor, Dynamic-brake, side-furling governor, Stall-regulated airfoil governor or Electrically stalled, blade-pitching governor.
14. Gearbox Type: As directed, Furling winch, Regulator or Transformer.
15. Shutdown Mechanism: As directed, Dynamic brake, Disc brake, Crank-out tail or Motor yaw, disc brake.
16. Turbine Lateral Thrust: 200 lb (90.7 kg).
17. Tower Top Weight: 75 (34.02) lb (kg).

2.5 LIGHTNING PROTECTION

A. Protect metal tower structures according to Section 260526 "Grounding and Bonding for Electrical Systems."

1. Install grounding electrode for each tower unless otherwise indicated.
2. Install grounding conductor pigtail in the base for connecting turbine to grounding system.

B. Ground nonmetallic poles and support structures according to Section 260526 "Grounding and Bonding for Electrical Systems."

1. Install grounding electrode for each tower.
2. Install grounding conductor and conductor protector.
3. Ground metallic components of tower accessories and foundations.

C. Lightning Arrestor:

1. Install lightning arrestor at the main breaker panel.
2. Install surge capacitor protection at the main breaker panel.

2.6 MOUNTING CONFIGURATION

A. Roof Mounting: As directed, Steel or Aluminum, guyed tower.

B. Roof Mounting: As directed, Steel or Aluminum, mono-pole tower.

C. Roof Mounting: As directed, Steel or Aluminum, metal tube tower.

D. Tower Mounting: As directed, Steel or Aluminum, guyed tower.

E. Tower Mounting: As directed, Steel or Aluminum, mono-pole tower.

F. Tower Mounting: As directed, Steel or Aluminum, metal tube tower.

G. Winch Mechanism: As directed, Furling or Tilt up.

H. Guyed Wire Gage: As directed.

I. Guyed Wire Anchorage: As directed, Direct-soil-embedded, screw type, Direct-soil-embedded, arrow type or Concrete-embedded anchor.

2.7 CHARGE CONTROLLER

A. Charge Controller Electrical Characteristics:

1. Output Current Rating: As directed, A.
2. Nominal Battery Voltage: Value-V dc as directed.

2.8 INVERTER

A. Inverter Type:

1. Modified sinewave, non-grid tie.
2. Modified sinewave, grid tie.
3. True sinewave, non-grid tie.
4. True sinewave, grid tie.

B. Control Type: MPPT control.

1. Maximum Recommended Input Power: As directed.
2. Maximum Current: Value-V dc as directed.
3. Start Voltage: Value-V dc as directed.
4. Maximum Voltage: Value-V dc as directed.
5. Maximum Input Current: As directed.
6. Number of Independent MPPT Circuits: As directed.
7. Nominal Output Voltage: Value-V ac as directed.
8. Maximum Output Current: As directed.
9. Peak Efficiency: As directed.
10. CEC Rated Power: As directed.
11. CEC Weighted Efficiency: As directed.
12. Maximum AC Overcurrent Protective Device Rating: As directed.
13. NEMA Enclosure Rating: As directed.
14. Weight: As directed, lb (kg).

C. Disconnects:

1. Low-voltage disconnects.
2. Low-voltage reconnects.
3. High-temperature disconnects.
4. High-temperature reconnects.

D. Inverter Regulatory Approvals:

1. IEEE 1547.
2. UL 1741.

2.9 DIVERSION LOAD SYSTEM

A. Electric Resistance Coil: Activated at 15-V dc.

B. Water-Submersible Resistance Element: Activated at 15-V dc.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Equipment Installation: Comply with requirements for seismic-restraint devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."

C. For power wiring, comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. For digital data transmission and low-voltage (operating at less than 50 V) remote control and signaling cables, comply with Section 260523 "Control-Voltage Electrical Power Cables."

E. Field-Installed Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and non-power-limited conductors according to conductor manufacturer's written instructions.

F. Provide for erection loads and for sufficient temporary bracing to maintain indicated alignment until completion of erection and installation of permanent attachments.

G. Separate dissimilar metals and use gasketed fasteners, isolation shim, or isolation tape to eliminate possibility of corrosive or electrolytic action between metals.

H. Install flashing boots at base supports as required to provide a watertight connection. Install as recommended by roofing materials manufacturer.

I. Remove protective masking from material immediately after installation.

J. Adjust rotors, mounting, and controls to function smoothly, and lubricate as recommended by manufacturer.

END OF SECTION 263223.13

SECTION 263223.16 - VERTICAL-AXIS WIND TURBINES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes small-scale, vertical-axis wind turbines.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For wind-energy equipment.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions (including rotor sweep area), weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of equipment.
4. Include diagrams for power, signal, and control wiring.
5. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated-Design Submittal:

1. For vertical-axis wind turbine structural loads.
2. For vertical-axis wind turbine mounting.
3. For vibration isolation mounts.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Erection and interconnection drawings and other details, drawn to scale, using input from installers of the items involved.

B. Seismic Qualification Data: For vertical-axis wind turbines, accessories, and components, from manufacturer.

C. Field quality-control reports.

D. Design data.

E. Sample warranty.

F. Oversize construction certificate.

G. Wiring diagrams.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of wind-energy equipment that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 STRUCTURAL ANALYSIS CRITERIA FOR POLE SELECTION

A. Dynamic Loads: Use the following dynamic load factors for load calculations according to IEC 61400-2:

1. Number of blades.
2. Rotor diameter.
3. Rotor radius.
4. Rotor center to first bearing distance.
5. Mass of blade.
6. Mass of rotor.
7. Moment of inertia of blade.
8. Rated power.
9. Wind speed at rated power.
10. Rotor speed at rated power.
11. Tip speed (angular velocity) of rotor at rated power.
12. Tip speed (linear velocity) at rated power.
13. TSR at rated power.
14. Rotor torque rated power.
15. IEC average wind speed at hub height.
16. IEC "Reference" wind speed.
17. IEC 50-year TSR.
18. Maximum rotor speed with load.
19. Maximum rotor speed no load.
20. IEC maximum yaw rate.
21. Rotor center to blade center of gravity distance.
22. Drag coefficient of blade.
23. Drag coefficient of generator.
24. Drag coefficient of tail assembly.
25. Acceleration due to gravity.
26. Air density at sea level and 25 deg C.

2.3 PERFORMANCE REQUIREMENTS

A. Support-Structure, Wind-Load Strength: Poles and other support structures, brackets, arms, appurtenances, bases, anchorages, and foundations shall comply with IEC 61400-2 (or local codes or ordinances) and shall be certified by manufacturers to withstand winds up to 100 mph (160 km/h) without permanent deflection or whipping.

B. Support-Structure Seismic Strength: Poles or other support structures, brackets, arms, appurtenances, bases, anchorages, and foundations shall be designed to prevent separation of components or fracture of poles, luminaire supports, or pole foundations during a seismic event.

C. Mountings, Fasteners, and Appurtenances:

1. Corrosion resistant, compatible with support components, and which shall not cause galvanic action at contact points.

    a. Steel Components: Hot-dip galvanized after fabrication, complying with ASTM A123/A123M.
    b. Mounting Hardware Fasteners: Hot-dip galvanized, complying with ASTM A153/A153M, or minimum 18-8 grade stainless steel.

2. Accommodate attachments and wiring of other indicated systems.

D. Concrete for Tower Foundations: 3000-psi (20.7-MPa), 28-day minimum compressive strength. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."

E. Direct-buried steel structures or poles shall not be used.

F. Operating Conditions:

1. Ambient Temperature: Minus 4 to plus 122 deg F (Minus 20 to plus 50 deg C).
2. Relative Humidity: Zero to 95 percent, noncondensing.
3. Altitude: Sea level to 1000 (300) feet (m).

2.4 GENERATORS

A. Rotors:

1. Swept Area: 80 (7.43) sq. ft. (sq. m).
2. Rotor Diameter: 4.1 (1.2) feet (m).
3. Rotor Height: 20 (6.1) feet (m).
4. Number of Blades: Three.
5. RPM at Rated Output: 450.
6. TSR: 2.3.
7. Cut-in Wind Speed: 8.5 (13.68) mph (km/h).
8. Maximum Design Wind Speed: 105 (168.9) mph (km/h).
9. Blade Type: As directed, Aluminum, aircraft grade, Injection molded plastic, Pultruded fiberglass or Carbon fiber composite.
10. Generator:

a. Rated Power: 1200 W.
b. Voltage: As directed, 12, 24, 48 or 96-V dc.
c. Peak Output (Pmax): 1500 W.
d. Fixed Magnet: As directed, Ferrite or Rare earth.

11. Generator Cover Material: As directed, Aluminum or Galvanized steel.
12. Governing System: Dynamic brake, electric.
13. Shutdown Mechanism: As directed, Dynamic or Disc brake.
14. Tower Top Weight: 175 (79.38) lb (kg).

2.5 LIGHTNING PROTECTION

A. Protect metal tower structures according to Section 260526 "Grounding and Bonding for Electrical Systems."

1. Install grounding electrode for each tower unless otherwise indicated.
2. Install grounding conductor pigtail in the base for connecting turbine to grounding system.

B. Ground nonmetallic poles and support structures according to Section 260526 "Grounding and Bonding for Electrical Systems."

1. Install grounding electrode for each tower.
2. Install grounding conductor and conductor protector.
3. Ground metallic components of tower accessories and foundations.

C. Lightning Arrestor:

1. Install lightning arrestor at the main breaker panel.
2. Install surge capacitor protection at the main breaker panel.

2.6 MOUNTING CONFIGURATION

A. Roof Mounting: As directed, Steel or Aluminum, guyed tower.

B. Roof Mounting: As directed, Steel or Aluminum, mono-pole tower.

C. Roof Mounting: As directed, Steel or Aluminum, metal tube tower.

D. Tower Mounting: As directed, Steel or Aluminum, guyed tower.

E. Tower Mounting: As directed, Steel or Aluminum, mono-pole tower.

F. Tower Mounting: As directed, Steel or Aluminum, metal tube tower.

G. Winch Mechanism: As directed, Furling or Tilt up.

H. Guyed Wire Gage: As directed.

I. Guyed Wire Anchorage: As directed, Direct-soil-embedded, screw type, Direct-soil-embedded, arrow type or Concrete-embedded anchor.

2.7 CHARGE CONTROLLER

A. Charge Controller Electrical Characteristics:

1. Output Current Rating: As directed, A.
2. Nominal Battery Voltage: As directed-V dc.

2.8 INVERTER

A. Inverter Type:

1. Modified sinewave, non-grid tie.
2. Modified sinewave, grid tie.
3. True sinewave, non-grid tie.
4. True sinewave, grid tie.

B. Control Type: MPPT control.

1. Maximum Recommended Input Power: As directed, kW.
2. Maximum Current: As directed -V dc.
3. Start Voltage: As directed -V dc.
4. Maximum Voltage: As directed -V dc.
5. Maximum Input Current: As directed, A.
6. Number of Independent MPPT Circuits: As directed.
7. Nominal Output Voltage: As directed -V ac.
8. Maximum Output Current: As directed, A.
9. Peak Efficiency: As directed, percent.
10. CEC Rated Power: As directed, kW.
11. CEC Weighted Efficiency: As directed, percent.
12. Maximum AC Overcurrent Protective Device Rating: As directed, A.
13. Weight: As directed, lb (kg).

C. Disconnects:

1. Low-voltage disconnects.
2. Low-voltage reconnects.
3. High-temperature disconnects.
4. High-temperature reconnects.

D. Inverter Regulatory Approvals:

1. IEEE 1547.
2. UL 1741.

2.9 DIVERSION LOAD SYSTEM

A. Electric Resistance Coil: Activated at 15-V dc.

B. Water-Submersible Resistance Element: Activated at 15-V dc.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Equipment Installation: Comply with requirements for seismic-restraint devices specified in Section 260548.48 "Seismic Controls for Electrical Systems."

C. For power wiring, comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. For digital data transmission and low-voltage (operating at less than 50 V) remote control and signaling cables, comply with Section 260523 "Control-Voltage Electrical Power Cables."

E. Field-Installed Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and non-power-limited conductors according to conductor manufacturer's written instructions.

F. Provide for erection loads and for sufficient temporary bracing to maintain indicated alignment until completion of erection and installation of permanent attachments.

G. Separate dissimilar metals and use gasketed fasteners, isolation shim, or isolation tape to eliminate possibility of corrosive or electrolytic action between metals.

H. Install flashing boots at base supports as required to provide a watertight connection. Install as recommended by roofing materials manufacturer.

I. Remove protective masking from material immediately after installation.

J. Adjust rotors, mounting, and controls to function smoothly, and lubricate as recommended by manufacturer.

END OF SECTION 263223.16

SECTION 263323.11 - CENTRAL BATTERY EQUIPMENT FOR EMERGENCY LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes interruptible (fast-transfer) central battery equipment rated 600 V and less for emergency lighting:

1.2 DEFINITIONS

A. Interruptible: As used in the Section Text, an off-line, passive-standby or line-interactive, inverter-only unit, with an intentional interruption of power to the load until an internal transfer switch picks up and transfers the load to the unit's inverter and internal battery source on loss of the "normal" source, and then retransfers to the "normal" source when it is restored. Transfer time can be "slow" (up to approximately 1 second) or "fast" (2-4 ms or 40-50 ms, depending on manufacturer).

B. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.3 ACTION SUBMITTALS

A. Product Data: For each type and rating of central battery equipment unit.

B. Shop Drawings: For each type and rating of central battery equipment unit.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, ventilation requirements, method of field assembly, components, and location and size of each field connection.
3. Include system one-line diagram, internal and interconnecting wiring; and diagrams for power, signal, and control wiring.
4. Include elevation, details, and legends of control and indication displays.
5. Include -circuit current (withstand) rating of unit.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around central battery equipment.

B. Qualification Data: For testing agency.

C. Seismic Qualification Data: For central battery equipment, accessories, and components, from manufacturer.

D. Field quality-control reports.

E. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL acceptable to authorities having jurisdiction.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace central battery equipment that fails in materials or workmanship within specified warranty period. Special warranty, applying to batteries only, applies to materials only, on a prorated basis, for period specified.

1. Warranty Period: Include the following warranty periods, from date of Substantial Completion:

a. Central Battery Equipment (excluding Batteries): One or Two year(s) as directed.
b. Standard VRLA Batteries:

1) Full Warranty: One year(s).
2) Pro Rata: Nine years.

c. Premium VRLA Batteries:

1) Full Warranty: One year(s).
2) Pro Rata: 19 years.

d. NiCd, Wet-Cell Batteries:

1) Full Warranty: Five years.
2) Pro Rata: 15 years.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Central battery equipment shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. The designated central battery equipment shall be tested and certified by an NRTL as meeting ICC-ES AC 156 test procedure requirements.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.2 INTERRUPTIBLE (FAST-TRANSFER) CENTRAL BATTERY EQUIPMENT

A. General Requirements for Interruptible (Fast-Transfer) Central Battery Equipment:

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. NRTL Compliance: Fabricate and label central battery equipment to comply with UL 924 and UL 1778.
3. Comply with the IBC, NFPA 70, and NFPA 101.
4. Comply with NEMA PE 1.

B. Performance Requirements:

1. Fast-Transfer Central Battery Equipment: As directed, Passive standby (off-line) or Line-interactive (on-line) system. Automatically sense loss of normal ac supply and use a solid-state static switch to transfer load. As directed, Transfer in 2-4 or 40-50 ms or less from normal supply to battery-inverter supply.
2. Automatic Operation:

    a. Normal Conditions: Supply the load with ac power flowing from normal ac power input terminals, bypassing inverter, with battery connected in parallel via rectifier/charger output.
    b. Abnormal Supply Conditions: If normal ac supply deviates from specified voltage, transfer switch operates and battery supplies constant, regulated ac power through the inverter to the load, with a momentary loss of power to the load.
    c. If normal power fails, transfer switch operates and battery supplies constant, regulated ac power through the inverter to the load, with a momentary loss of power to the load.
    d. If a fault occurs in system when being supplied by inverter and current flows in excess of the overload rating of inverter, inverter automatically protects itself against damage from overloads and short circuits by shutting down.
    e. When normal ac power is restored at input supply terminals of unit, controls automatically retransfer the load back to the normal ac supply, with a momentary loss of power to the load. Rectifier/charger then recharges battery.
    f. If normal power failure is prolonged (more than 90 minutes), integral low-voltage battery protective circuit disconnects battery and prevents battery from damage due to deep discharge.
    g. If battery becomes discharged, and when normal ac supply is again available, rectifier/charger recharges battery. When battery is fully charged, rectifier/charger automatically shifts to float-charge mode.
    h. If battery is disconnected, and normal ac power is available, central battery equipment continues to supply power to the load with no degradation of its regulation of voltage and frequency of output bus.

C. Unit Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus 15 percent of central battery equipment input voltage rating.
2. Input Frequency Tolerance: As directed, Plus or minus 3 or 5 percent of central battery equipment frequency rating.
3. Synchronizing Slew Rate: 1 Hz per second, maximum.
4. Minimum Off-Line Efficiency: As directed, 95 or 99 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 96 or 98 percent under any load or operating condition.
6. Ambient Temperature Rating (Other Than Batteries): Not less than 68 deg F (20 deg C) and not exceeding 86 deg F (30 deg C).
7. Ambient Storage Temperature Rating (Other Than Batteries): Not less than minus 4 deg F (minus 20 deg C) and not exceeding 158 deg F ((70 deg C).)
8. Ambient Temperature Rating (Batteries): Not less than 32 deg F (0 deg C) and not exceeding 104 deg F (40 deg C).
9. Ambient Storage Temperature Rating (Batteries): Not less than 0 deg F (minus 18 deg C) and not exceeding 104 deg F ((40 deg C).)
10. Humidity Rating: Less than 95 percent (noncondensing).
11. Altitude Rating: Not exceeding 3300 feet (1005 m).
12. Off-Line Overload Capability: As directed, 1.1 or 1.5 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.

D. Inverter and Controls Logic: Microprocessor based, isolated from all power circuits; provides complete self-diagnostics, periodic automatic testing and reporting; with alarms.

E. Controls and Indication:

1. Status Indication: Door-mounted, labeled LED indicators or digital screen displaying the following conditions:

    a. Normal power available.
    b. Status of system.
    c. Battery charging status.
    d. On battery power.
    e. System fault.
    f. External fault.

2. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

    a. Keypad: In addition to required programming and control keys, include the following:

        1) Keys for METER, CONTROL, PROGRAM, and CLEAR modes.
        2) Security Access: Provide electronic security access to controls through identification and password with at least two levels of access: View only; and view, operate, and service.
        3) Control Authority: Supports at least three conditions: Off, local manual control at unit and local automatic control at unit.

b. Digital Display: Plain-English language messages on a digital display; provide the following historical logging information and displays:

1) Real-time clock with current time and date.
2) Tests and Events Logs: Record and store up to 25 or 50 tests and events.

a) Dates.
b) Times.
c) Durations.
d) Output voltage and currents.

3) Alarm Logs: Record and store up to 25 or 50 alarms as directed.

a) Dates.
b) Times.
c) Alarm type.

4) Metering Functions: Display central battery equipment metering parameters including, but not limited to, the following:

a) Input and output voltage (V ac) and output current (A ac).
b) Battery voltage (V dc) and current (A ac).
c) Fault or alarming status (code).
d) Power output (VA).
e) Inverter load (W).
f) Ambient temperature (deg F).
g) System run time (cumulative days).
h) Inverter run time (cumulative minutes).

5) Alarm Functions: Digital display mounted flush in unit door and connected to display central battery equipment parameters including, but not limited to, the following:

a) High/low battery charge voltage.
b) High/low input voltage.
c) Battery nearing low-voltage condition.
d) Battery low voltage.
e) High ambient temperature.
f) Inverter fault.
g) Output fault.
h) Output overload.

3. Remote Signal Interfaces:

a. Remote Indication Interface: A minimum of one programmable (Form C) dry-circuit relay output(s) (120-V ac, 2 A) for remote indication of the following:

1) Fault or status indication.
2) On bypass.
3) Low battery.

b. Communications Interface: Factory-installed hardware and software to enable a remote PC to program central battery equipment and monitor and display status and alarms using RS-232 or RS-485 port as directed.

F. Self-Protection and Reliability Features:

1. Input surge protection by means of SPDs to provide protection against damage from supply voltage surges as defined in IEEE C62.45, Category B and C.
2. Integral, programmable, self-diagnostic and self-test circuitry; with alarms and logging.
3. Battery deep-discharge and self-discharge protection; with alarms.
4. Battery self-test circuitry; with alarms and logging.

G. Integral Input Disconnecting Means and OCPD: Thermal-magnetic circuit breaker, complying with UL 489 or None as directed.

1. Integrated Equipment Minimum Short-Circuit Current (Withstand) Rating: As directed, 5, 10, 22 or 65 kA.

H. Inverter:

1. Description: Solid-state, high-frequency, PWM type, with the following operational features:

a. Automatically regulate output voltage to within plus or minus 3 or 5 percent as directed, for all load ranges and for maximum 25 percent step-load changes; regulation may increase to 8 percent for 100 percent step-load changes.
b. Automatically regulate output frequency to within plus or minus 1 Hz, from no load to full load, at unity power factor, over the operating range of battery voltage.
c. Output Voltage Waveform: As directed, Sine wave with maximum 3 or 5 percent TDD throughout battery operating-voltage range, for 100 percent linear load.
d. Inverter Overload Capability: 115 percent for 10 minutes; 150 percent surge for 10 seconds.
e. Load Power Factor: 0.5 lead to 0.5 lag.

I. Rectifier/Battery Charger:

1. Description: Solid state, variable rate, temperature compensated; automatically maintains batteries in fully charged condition when normal power is available.
2. Maximum Battery Recharge Time from Fully Discharged State: 24 hours.
3. Low-voltage disconnect circuit reduces battery discharge during extended power outages, monitors battery voltage, and disconnects inverter when battery voltage drops to no less than 85.7 percent of nominal voltage.

J. Batteries:

1. Description: Standard VRLA, Premium VRLA or NiCd, wet-cell batteries as directed.

a. Capable of sustaining full-capacity output of inverter unit for minimum of 90 minutes.

2. Battery Disconnect and OCPD: Manufacturer's standard.

K. Maintenance Bypass Systems:

1. Maintenance Bypass Mode: Internal; manual operation only; bypasses central battery equipment power circuits (inverter and static transfer switch); requires local operator selection at central battery equipment. As directed, Transfer and retransfer shall be make-before-break, without disrupting power to the load or causing system instabilities or break-before-make, with temporary disrupting power to the load.
2. Maintenance Bypass Mode: External; manual operation only; bypasses central battery equipment completely; requires local operator selection at external switch enclosure remote from central battery equipment. As directed, Transfer and retransfer shall be make-before-break, without disrupting power to the load or causing system instabilities or break-before-make, with disrupting power to the load.
3. Bypass Overload Capability: 1.5 times the base load current.

L. Integral Output Disconnecting Means and OCPD:

1. Single-Output OCPD: As scheduled on Drawings, Fuses or Thermal-magnetic circuit breaker, complying with UL 489 as directed; manufacturer's standard ratings based on unit output ratings.
2. Multiple-Output OCPDs: Thermal-magnetic circuit breakers, complying with UL 489; voltage rating matching unit output voltage rating; 20 A, single pole.

    a. Normally Closed: 2; with trip alarm; with time delay.
    b. Normally Open: 2; with trip alarm.

2.3 OPTIONAL AND ACCESSORY FEATURES

A. Factory-Installed Options and Accessories:

1. Auto-dialer.
2. Audible alarm with silencer switch.
3. Remote Summary Alarm Panel: Labeled LEDs on panel faceplate shall indicate five basic status conditions. Audible signal indicates alarm conditions; silencing switch in face of panel silences signal without altering visual indication.

    a. Cabinet and Faceplate: Surface or flush mounted to suit mounting conditions indicated.
    b. Maximum Distance from Main Unit: 1000 feet (304 m).

PART 3 - EXECUTION

3.1 INSTALLATION

A. Coordinate layout and installation of central battery equipment with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Wall-Mounted Central Battery Equipment: Install central battery equipment on walls with tops at uniform height and with disconnect operating handles not higher than 79 inches (2000 mm) above finished floor unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For units not on walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."

C. Suspended-Mounted Central Battery Equipment: Suspend central battery equipment from structural ceiling components using hangers, clamps, and associated fittings, designed for types and sizes of units to be supported. Provide support devices complying with Section 260529 "Hangers and Supports for Electrical Systems."

D. Floor-Mounted Central Battery Equipment: Install central battery equipment on 4-inch (100-mm) nominal-thickness concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

E. Seismic Bracing: Comply with requirements specified in Section 260548 "Vibration and Seismic Controls for Electrical Systems."

F. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

G. Comply with NECA 1.

H. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used for low-voltage control and alarm wiring. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for cable trays specified in Section 260536 "Cable Trays for Electrical Systems."
3. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

I. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

J. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

K. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

1. Separately Derived Systems: Make grounding connections to grounding electrodes and bonding connections to metallic piping systems as indicated; comply with NFPA 70.

L. Install control wiring between central battery equipment and remote devices and facility's central-control system. Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."

M. Identify central battery equipment, components, and control wiring. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.2 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Inspect central battery equipment, wiring, components, connections, and equipment installation. Test and adjust components and equipment.
2. Test insulation resistance for all external branch circuit, feeder, control, and alarm wiring connected to central battery equipment element and component.
3. Test continuity of each circuit.
4. Perform each visual and mechanical inspection and electrical test stated in manufacturer's written instructions and in NETA Acceptance Testing Specification, including specifically those for batteries, battery chargers, and UPS, regardless of the type of central battery equipment provided. Certify compliance with test parameters.
5. Perform a load-duration test at rated voltage and rated output current to verify the correct functional operation of the unit under full-load stable operating conditions for the minimum time limits required by UL 924. Monitor and record ambient temperature and temperatures within the unit.
6. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
7. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. Central battery equipment will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies central battery equipment and describes all test results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.3 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain central battery equipment, and to use and reprogram microprocessor-based control, monitoring, and display functions.

END OF SECTION 263323.11

SECTION 263343 - BATTERY CHARGERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes battery chargers for emergency engine generators.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of battery charger.

B. Shop Drawings: For battery chargers to include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for battery changers, accessories, and components, from manufacturer.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of battery chargers that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Number of years from date of Substantial Completion as directed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. UL Compliance: Comply with UL 1236 for Category BBHH. OEM-supplied, open-frame chargers may be UL recognized to Category BBHH provided they are housed in a listed enclosure.

C. NFPA Compliance: Comply with NFPA 110.

D. Environmental Conditions: Battery charger shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: Minus 40 to plus 158 deg F (minus 40 to plus 70 deg C) with full charger output available up to 104 deg F (40 deg C).
2. Relative Humidity: 5 to 95 percent.
3. Altitude: Meets full performance from sea level to 5000 feet (1600 m). Chargers installed at higher altitudes may automatically derate output power to prevent overheating of internal components but shall remain operable.
4. Electromagnetic Immunity: Charger power terminals shall be immune to conducted and radiated electromagnetic energy to IEC 61000-4-12.
5. Vibration Resistance: Charger enclosure rated to IEC 60068-2-6 vibration test; 4-g force from 18 to 500 Hz on 3 axes; and 0.01 power spectral density value from 20 to 500 Hz.

E. Seismic Performance: Battery chargers shall withstand the effects of earthquake motions determined according to IBC 2006, IBC 2009, IBC 2012, IBC 2015, the latest edition of the IBC or ASCE/SEI 7 as directed.

1. Shake-Table Testing: Comply with ICC-ES AC156.
2. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
3. Component Importance Factor: 1.5 or 1.0 as directed.
4. Equipment seismic application, spectral response acceleration, short period (Sds) for Project is indicated on Drawings.

F. Battery-Charger Power Conversion Energy Efficiency:

1. Certified to California Code of Regulations, Title 20, "Appliance Efficiency Regulations"; https://cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx.
2. Comply with Oregon Department of Energy standards for appliance energy efficiency.

2.2 BATTERY CHARGERS FOR EMERGENCY ENGINE GENERATORS

A. Battery-Charger Operation: Current-limited, constant voltage, boost-and-float-type charger designed for lead-acid or nickel-cadmium batteries as directed, with the following features:

1. Output Voltage Regulation: Charger regulates output to within plus or minus 0.5 percent of manufacturer-provided voltage settings despite variations of input voltage, input frequency, and output current.
2. Battery Thermal Compensation: Battery temperature compensation with adjustable slope, factory set at minus 0.18 percent per degree C, and equipped for sensing battery temperature.
3. Automatic Dead Battery Recharge: Charger automatically recharges a battery discharged to 0 V at full-rated output current, without the need for user intervention.
4. AC Input: Charger operates from any 47- to 63-Hz ac source with voltage ranging from 90- to 265-V rms.

5. Lead-Acid Battery Longevity and Safety Mode: Charger emulates vehicle duty for which starting batteries are designed to maximize battery life, minimize battery explosion risk, and minimize electrolyte loss in lead-acid batteries.
6. Charger Enclosure: As directed, NEMA 250, Type 1 (IP20) or Type 3R (IP22), wall mounted and rated for generator duty with charger enclosure vibration resistance. Housing materials: aluminum or stainless steel.
7. Battery-Charger Status Indication: Output voltage and current meters on front panel.

2.3 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect assembled battery chargers to manufacturer's written instructions. Verify NFPA 110 recharge performance by validating that battery charger is listed to UL 1236 Category BBHH on the UL certification database.

B. Battery charger will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 BATTERY-CHARGER INSTALLATION

A. Examine areas, mounting locations, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting battery-charger performance.

B. Follow manufacturer's written instructions to prevent damage from static electricity. Provide clearances for service and ventilation.

C. Identify system components according to Section 260553 "Identification for Electrical Systems."

3.2 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Provide branch-circuit overcurrent protection.

C. Comply with requirements for branch-circuit protection and service disconnects in Section 262816 "Enclosed Switches and Circuit Breakers."

3.3 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. As directed, perform the following tests and inspections with authorities having jurisdiction or with the assistance of a factory-authorized service representative:

1. Verify that certification labels are properly installed. Verify NFPA 110 compliance by validating that battery charger is listed to UL 1236 Category BBHH on the UL certification database.
2. Verify that connections are secure and in the proper locations. Ensure wiring is correctly connected between charger and battery.
3. Operational Test: After electrical circuitry has been energized, apply input voltage to confirm proper unit operation.
4. Test and adjust alarms, display indicators, controls, and safeties.

D. Battery charger will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.4 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain battery chargers and related equipment.

END OF SECTION 263343

SECTION 263353 - STATIC UNINTERRUPTIBLE POWER SUPPLY

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Three-phase, on-line, double-conversion, static-type, UPS units with the following features:

    a. Surge suppression.
    b. Rectifier-charger.
    c. Inverter.
    d. Controls and indications.
    e. Static bypass transfer switch.
    f. Output distribution section.
    g. Battery and battery disconnect device.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of UPS.

B. Shop Drawings: For UPS.

1. Include plans, elevations, sections, and mounting or attachment details as directed.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Show access, workspace, and clearance requirements; details of control panels; and battery arrangement.
4. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For UPS equipment, from manufacturer.

B. Product Certificates: For each product, from manufacturer.

C. Factory test reports.

D. Product test reports.

E. Field quality-control reports.

F. Sample warranties.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Power Quality Specialist Qualifications: A registered professional electrical engineer or engineering technician, currently certified by the National Institute for Certification in Engineering Technologies, NICET Level 4, minimum, experienced in performance testing UPS installations and in performing power quality surveys similar to that required in "Performance Testing" Article.

B. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.6 WARRANTY

A. Special Battery Warranties: Manufacturer and Installer agree to repair or replace UPS system storage batteries that fail in materials or workmanship within specified warranty period.

B. Special UPS Warranties: Specified form in which manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within special warranty period.

1. Special Warranty Period: As directed, Two or Three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 OPERATIONAL REQUIREMENTS

A. Automatic operation includes the following:

1. Double Conversion, Standard Efficiency:

a. Normal Conditions: Load is supplied with power flowing from the normal power input terminals, through the rectifier-charger and inverter, with the battery connected in parallel with the rectifier-charger output.
b. Abnormal Supply Conditions: If normal supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, the battery supplies energy to maintain constant, regulated inverter power output to the load without switching or disturbance.
c. Power Failure: If normal power fails, energy supplied by the battery through the inverter continues supply-regulated power to the load without switching or disturbance.

2. Double Conversion, Line Interactive:

a. Normal Conditions: Load is supplied with power flowing from the normal power input terminals, with the rectifier-charger and inverter turned off and the battery disconnected.
b. Abnormal Supply Conditions: If normal supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, the rectifier-charger and inverter turn on and the battery supplies energy to provide constant, regulated inverter power output to the load with minimum of 98 percent UPS system efficiency.
c. Power Failure: If normal power fails, there is a maximum 4-microsecond delay while the rectifier-charger and inverter turn on and the battery supplies energy to re-establish constant, regulated power output to the load.

3. Double Conversion, IGBT:

a. Normal Conditions: Load is supplied with power flowing from the normal power input terminals, through the rectifier-charger and inverter, with the battery connected in parallel with the rectifier-charger output. High-efficiency carrier stored trench IGBT, in both rectifier-charger and inverter circuits, provides a minimum of 97 percent efficiency for the UPS system at full load and a minimum of 94 percent efficiency at 50 percent load.
b. Abnormal Supply Conditions: If normal supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, the battery supplies energy to provide constant, regulated inverter power output to the load.
c. Power Failure: If normal power fails, the rectifier-charger and inverter use energy from the battery to supply constant, regulated power output to the load without switching or disturbance.

4. When power is restored at the normal supply terminals of the system, controls shall automatically synchronize the inverter with the external source before transferring the load. The rectifier-charger shall supply power to the load through the inverter and simultaneously recharge the battery.
5. If the battery becomes discharged and normal supply is available, the rectifier-charger shall charge the battery. The rectifier-charger shall automatically shift to float-charge mode on reaching full charge.
6. If any element of the UPS system fails and power is available at the normal supply terminals of the system, the static bypass transfer switch shall switch the load to the normal ac supply circuit without disturbance or interruption.
7. The output power converters shall produce up to 300 percent of rated full-load current for short-circuit clearing. The inverter shall sustain steady-state overload conditions of up to 200 percent of rated full-load current for 60 seconds in normal operation.
8. The inverter shall be capable of sustaining 150 percent of system capacity for 30 seconds while powered from the battery.
9. Should overloads persist past the time limitations, the automatic static transfer switch shall switch the load to the bypass output of the UPS. When the fault has cleared, the static bypass transfer switch shall return the load to the UPS system.
10. If the battery is disconnected, the UPS shall supply power to the load from the normal supply with no degradation of its regulation of voltage and frequency of the output bus.

B. Manual operation includes the following:

1. Turning the inverter off causes the static bypass transfer switch to transfer the load directly to the normal ac supply circuit without disturbance or interruption.
2. Turning the inverter on causes the static bypass transfer switch to transfer the load to the inverter.

C. Maintenance Bypass/Isolation Switch Operation: Switch is interlocked so it cannot be operated unless the static bypass transfer switch is in the bypass mode. Device provides manual selection among the three conditions described below without interrupting supply to the load during switching:

1. Full Isolation: Load is supplied, bypassing the UPS. Normal UPS ac input circuit, static bypass transfer switch, and UPS load terminals are completely disconnected from external circuits.
2. Maintenance Bypass: Load is supplied, bypassing the UPS. UPS ac supply terminals are energized to permit operational checking, but system load terminals are isolated from the load.
3. Normal: Normal UPS ac supply terminals are energized and the load is supplied through the static bypass transfer switch and the UPS rectifier-charger and inverter, or the battery and the inverter.

D. Environmental Conditions: The UPS shall be capable of operating continuously in the following environmental conditions without mechanical or electrical damage or degradation of operating capability, except battery performance:

1. Ambient Temperature for Electronic Components: 32 to 104 deg F (0 to 40 deg C).
2. Ambient Temperature for Battery: 41 to 95 deg F (5 to 35 deg C).
3. Relative Humidity: Zero to 95 percent, noncondensing.
4. Altitude: Sea level to 4000 feet (1220 m).

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: UPS shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

B. UL Compliance: Listed and labeled by an NRTL to comply with UL 1778.

C. NFPA Compliance: UPS components shall be listed and labeled by an NRTL as suitable for installation in computer rooms according to NFPA 75.

D. The UPS shall perform as specified in this article while supplying rated full-load current, composed of any combination of linear and nonlinear load, up to 100 percent nonlinear load with a maximum load crest factor of 3.0, under the following conditions or combinations of the following conditions:

1. Inverter is switched to battery source.

2. Steady-state ac input voltage deviates up to plus or minus 10 or 15 percent from nominal voltage as directed.
3. Steady-state input frequency deviates up to plus or minus 5 percent from nominal frequency.
4. THD of input voltage is 15 percent or more with a minimum crest factor of 3.0, and the largest single harmonic component is a minimum of 5 percent of the fundamental value.
5. As directed, Load is 30, 50 or 100 percent unbalanced continuously.

E. Minimum Duration of Supply: If battery is sole energy source supplying rated full-load UPS current at 80 percent power factor, duration of supply is five, 10 or 15 minutes as directed.

F. Input Voltage Tolerance: System steady-state and transient output performance remains within specified tolerances when steady-state ac input voltage varies plus 10 percent and minus 15, 20 or 30 percent from nominal voltage as directed.

G. Overall UPS Efficiency: As directed, equal to or greater than 94 or 95 percent at 100 percent load, 94 or 95 percent at 75 percent load, and 93 or 94 percent at 25 percent load.

H. Maximum Acoustical Noise: Value as directed, "A" weighting, emanating from any UPS component under any condition of normal operation, measured distance as directed, from nearest surface of component enclosure.

I. Maximum Energizing Inrush Current: Six times the full-load current, Eight times the full-load current or Soft start linear input current rise to 100 percent over a 1- to 40-second period, factory set at 10 seconds as directed.

J. AC Output-Voltage Regulation for Loads 100 Percent Unbalanced: Maximum of plus or minus 2 percent over the full range of battery voltage.

K. AC Output-Voltage Regulation for Loads 100 Percent Balanced: Maximum of plus or minus 1 percent over the full range of battery voltage.

L. Output Frequency: 60 Hz, plus or minus 0.1 percent over the full range of input voltage, load, and battery voltage.

M. Limitation of harmonic distortion of input current to the UPS shall be as follows:

1. Description: Rectifier-charger circuits shall limit THD to 5 percent, maximum, at rated full-load UPS current, for power sources with X/R ratio between 2 and 30. Provide tuned harmonic filter if required to meet harmonic distortion limit.
2. Description: THD is limited to a maximum of 32 percent, at rated full-load UPS current, for power sources with X/R ratio between 2 and 30.

N. Maximum Harmonic Content of Output-Voltage Waveform: 5 percent rms total and 3 percent rms for any single harmonic, for rated full load with THD up to 50 percent, with a load crest factor of 3.0.

O. Minimum Overload Capacity of UPS at Rated Voltage: 125 percent of rated full load for 10 minutes, 200 percent for 60 seconds in normal operation, and 150 percent for 30 seconds in battery operating mode.

P. Maximum Output-Voltage Transient Excursions from Rated Value: For the following instantaneous load changes, stated as percentages of rated full UPS load, voltage shall remain within stated percentages of rated value and recover to, and remain within, plus or minus 2 percent of that value within 50 ms:

1. 50 Percent: Plus or minus 3 percent.
2. 100 Percent: Plus or minus 5 percent.
3. Loss of AC Input Power: Plus or minus 1 percent.
4. Restoration of AC Input Power: Plus or minus 1 percent.

Q. Input Power Factor: As directed, A minimum of 0.90 or 0.95 lagging when supply voltage and current are at nominal rated values and the UPS is supplying rated full-load current without additional filters.

R. Output Power Factor Rating: Loads with power factor of 0.9 leading to 0.8 lagging shall not require derating of the UPS. For loads with power factors outside this range, derate the UPS output as follows:

1. Derate the UPS a maximum of 5 percent for 0.7 PF lagging.
2. Derate the UPS a maximum of 10 percent for 0.6 PF lagging.
3. Derate the UPS a maximum of 15 percent for 0.5 PF lagging.
4. Derate the UPS a maximum of 20 percent for a range of 0.4 to 0.1 PF lagging.

S. EMI Emissions: Comply with FCC rules and regulations and with 47 CFR 15 for Class A equipment.

2.3 UPS SYSTEMS

A. Description: Self-contained, battery backup device and accessories that provides three-phase electrical power in the event of failure or sag in the normal power system.

B. Electronic Equipment: Solid-state devices using hermetically sealed, semiconductor elements. Devices include rectifier-charger, inverter, static bypass transfer switch, and system controls.

C. Enclosures: Comply with NEMA 250, Type 1, unless otherwise indicated.

D. Configuration: As directed, Single-cabinet, Multi-cabinet or Field-assembled, multi-cabinet modular style units.

E. Control Assemblies: Mount on modular plug-ins, readily accessible for maintenance.

F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Seismic-Restraint Design: UPS assemblies, subassemblies, and components (and fastenings and supports, mounting, and anchorage devices for them) shall be designed and fabricated to withstand static and seismic forces.

H. Output Circuit Neutral Bus, Conductor, and Terminal Ampacity: Rated phase current times a multiple of 1.73, minimum.

2.4 SURGE SUPPRESSION

A. Protect internal UPS components from surges that enter at each ac power input connection including main disconnect switch, static bypass transfer switch, and maintenance bypass/isolation switch. Protect rectifier-charger, inverter, controls, and output components.

1. Use factory-installed surge suppressors tested according to IEEE C62.41.1 and IEEE C62.41.2, Category B or Category C as directed.
2. Additional Surge Protection: Protect internal UPS components from low-frequency, high-energy voltage surges described in IEEE C62.41.1 and IEEE C62.41.2. Design the circuits connecting with external power sources and select circuit elements, conductors, conventional surge suppressors, and rectifier components and controls so input assemblies will have adequate mechanical strength and thermal and current-carrying capacity to withstand stresses imposed by 400-Hz, 180 percent voltage surges described in IEEE C62.41.1 and IEEE C62.41.2.

2.5 RECTIFIER-CHARGER

A. Description: As directed, Voltage source converter, six or 12-pulse IGBT or GTO rectifier.

B. Capacity: Adequate to supply the inverter during rated full output load conditions and simultaneously recharge the battery from fully discharged condition to 95 percent of full charge within 10 times the rated discharge time for duration of supply under battery power at full load.

C. Output Ripple: Limited by output filtration to less than 0.5 percent of rated current, peak to peak.

D. Control Circuits: Immune to frequency variations within rated frequency ranges of normal and emergency power sources.

1. Response Time: Field adjustable for maximum compatibility with local generator-set power source.

E. Battery Float-Charging Conditions: Comply with battery manufacturer's written instructions for battery terminal voltage and charging current required for maximum battery life. The battery charger shall be matched to the battery type supplied.

F. NiCd Battery Charger: Sense full charge by measuring the rate of temperature increase. Battery charging shall be terminated when the rate of temperature rise reaches 1.8 deg F (1 deg C)per minute. If the battery reaches 140 deg F (60 deg C) prior to reaching this rate of temperature rise, charging shall terminate. Chargers that determine full charge by voltage measurement to sense a 10-mV drop per cell when reaching full charge are also acceptable.

2.6 INVERTER

A. Description: As directed, Pulse-width modulated, carrier stored trench IGBT or IGBT with sinusoidal output.

B. Description: As directed, Pulse-width modulated, carrier stored trench IGBT or IGBT with sinusoidal output. Include a bypass phase synchronization window adjustment to optimize compatibility with local engine-generator-set power source.

2.7 CONTROLS AND INDICATIONS

A. Description: Group displays, indications, and basic system controls on a common control panel on front of UPS enclosure.

B. Minimum displays, indicating devices, and controls include those in lists below. Provide sensors, transducers, terminals, relays, and wiring required to support listed items. Alarms include audible signals and visual displays.

C. Indications: As directed, Labeled LED or Plain-language messages on a digital LCD.

1. Quantitative indications shall include the following:

    a. Input voltage, each phase, line to line.
    b. Input current, each phase, line to line.
    c. Bypass input voltage, each phase, line to line.
    d. Bypass input frequency.
    e. System output voltage, each phase, line to line.
    f. System output current, each phase.
    g. System output frequency.
    h. DC bus voltage.
    i. Battery current and direction (charge/discharge).
    j. Elapsed time discharging battery.

2. Basic status condition indications shall include the following:

    a. Normal operation.
    b. Load-on bypass.
    c. Load-on battery.
    d. Inverter off.
    e. Alarm condition.

3. Alarm indications shall include the following:

    a. Bypass ac input overvoltage or undervoltage.
    b. Bypass ac input over frequency or underfrequency.
    c. Bypass ac input and inverter out of synchronization.
    d. Bypass ac input wrong-phase rotation.
    e. Bypass ac input single-phase condition.
    f. Bypass ac input filter fuse blown.
    g. Internal frequency standard in use.
    h. Battery system alarm.
    i. Control power failure.
    j. Fan failure.
    k. UPS overload.
    l. Battery-charging control faulty.

m. Input overvoltage or undervoltage.
n. Input transformer overtemperature.
o. Input circuit breaker tripped.
p. Input wrong-phase rotation.
q. Input single-phase condition.
r. Approaching end of battery operation.
s. Battery undervoltage shutdown.
t. Maximum battery voltage.
u. Inverter fuse blown.
v. Inverter transformer overtemperature.
w. Inverter overtemperature.
x. Static bypass transfer switch overtemperature.
y. Inverter power supply fault.
z. Inverter transistors out of saturation.
aa. Identification of faulty inverter section/leg.
bb. Inverter output overvoltage or undervoltage.
cc. UPS overload shutdown.
dd. Inverter current sensor fault.
ee. Inverter output contactor open.
ff. Inverter current limit.

4. Controls shall include the following:

a. Inverter on-off.
b. UPS start.
c. Battery test.
d. Alarm silence/reset.
e. Output-voltage adjustment.

D. Dry-form "C" contacts shall be available for remote indication of the following conditions:

1. UPS on battery.
2. UPS on-line.
3. UPS load-on bypass.
4. UPS in alarm condition.
5. UPS off (maintenance bypass closed).

E. Emergency Power off Switch: Capable of local operation and operation by means of activation by external dry contacts.

2.8 STATIC BYPASS TRANSFER SWITCH

A. Description: Solid-state switching device providing uninterrupted transfer with a contactor or electrically operated circuit breaker to automatically provide electrical isolation for the switch.

B. Switch Rating: Continuous duty at the rated full-load UPS current, minimum.

C. Input SPD: As directed, 80 or 160 kA.

2.9 BATTERY

A. Description: Valve-regulated, recombinant, lead-calcium units, factory assembled in an isolated compartment of UPS cabinet, complete with battery disconnect switch.

1. Arrange for drawout removal of battery assembly from cabinet for testing and inspecting.

B. Description: Flooded, lead-calcium, heavy-duty industrial units in styrene acrylonitrile containers. As directed, Mount on two-tier, three-tier, acid-resistant, painted steel racks. Assembly includes battery disconnect switch, intercell connectors, hydrometer syringe, and thermometer with specific gravity-correction scales.

C. Description: Flooded cell, heavy-duty, industrial, NiCd units in polypropylene containers. As directed, mount on two-tier, three-tier, acid-resistant, painted steel racks, complete with battery disconnect switch and intercell connectors.

D. Description: Valve-regulated, heavy-duty, industrial, recombinant, pocket plate design, NiCd units in polypropylene containers, complete with battery disconnect switch and intercell connectors.

1. Factory assembled in an isolated compartment of UPS cabinet.
2. As directed, Mount on two-tier, three-tier, acid-resistant, painted steel racks.
3. Arrange for drawout removal of battery assembly from cabinet for testing and inspecting.

E. Seismic-Restraint Design: Battery racks, cabinets, assemblies, subassemblies, and components (and fastenings and supports, mounting, and anchorage devices for them) shall be designed and fabricated to withstand static and seismic forces.

2.10 BASIC BATTERY MONITORING

A. Description: Continuous, real-time capture of battery performance data.

B. Battery Ground-Fault Detector: Initiates alarm when resistance to ground of positive or negative bus of battery is less than 5000 ohms.

C. Battery compartment high-temperature detector initiates an alarm when smoke or a temperature greater than 167 deg F (75 deg C) occurs within the compartment.

D. Battery compartment smoke/high-temperature detector initiates an alarm when smoke or a temperature greater than 167 deg F (75 deg C) occurs within the compartment.

E. Annunciation of Alarms: At UPS control panel and remotely.

2.11 BATTERY-CYCLE WARRANTY MONITORING

A. Description: Electronic device, acceptable to battery manufacturer as a basis for warranty action, for monitoring of charge-discharge cycle history of batteries covered by cycle-life warranties.

B. Performance: Automatically measure and record each discharge event, classify it according to duration category and total discharges according to warranty criteria, and display remaining warranted battery life on front panel display.

C. Additional monitoring functions and features shall include the following:

1. Measuring and Recording: Total voltage at battery terminal. Initiate an alarm for excursions outside the proper float-voltage level.
2. Monitoring: Ambient temperature at battery; initiate an alarm if temperature deviates from normally acceptable range.
3. Keypad on Device Front Panel: Provide access to monitored data using front panel display.
4. Alarm Contacts: As directed, arrange to initiate local or remote alarm for battery discharge events, abnormal temperature or abnormal battery voltage or temperature.
5. Memory: Store recorded data in nonvolatile electronic memory.
6. Ethernet Port: Permits downloading of data to a PC.

2.12 SOURCE QUALITY CONTROL

A. Factory test complete UPS system before shipment. Include the following:

1. Test and demonstration of all functions, controls, indicators, sensors, and protective devices.
2. Full-load test.
3. Transient-load response test.
4. Overload test.
5. Power failure test.

B. Report test results. Include the following data:

1. Description of input source and output loads used. Describe actions required to simulate source load variation and various operating conditions and malfunctions.
2. List of indications, parameter values, and system responses considered satisfactory for each test action. Include tabulation of actual observations during test.
3. List of instruments and equipment used in factory tests.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for conditions affecting performance of the UPS.

B. Comply with NECA 1.

C. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions

where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for cable trays specified in Section 260536 "Cable Trays for Electrical Systems."
3. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

D. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

E. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

F. Equipment Mounting: Install UPS on concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base 6 inches (150 mm) from the outer edge of the base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

G. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

H. Connections: Interconnect system components. Make connections to supply and load circuits according to manufacturer's wiring diagrams unless otherwise indicated. Apply oxide inhibitor on battery terminals.

I. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Identify each battery cell individually.

3.2 GROUNDING

A. Separately Derived Systems: If not part of a listed power supply for a data-processing room, comply with NFPA 70 requirements for connecting to grounding electrodes and for bonding to metallic piping near isolation transformer. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

B. Separately Derived Systems: If part of a listed power supply for a data-processing room, comply with manufacturer's written instructions that include grounding requirements in excess

of NFPA 70 requirements for connecting to grounding electrodes and for bonding to metallic piping near isolation transformer. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.3 BATTERY EQUALIZATION

A. Equalize charging of battery cells according to manufacturer's written instructions. Record individual-cell voltages.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

D. Tests and Inspections:

1. Inspect interiors of enclosures, including the following:

    a. Inspect anchorage, alignment, grounding, and required clearances.
    b. Component type and labeling verification.
    c. Ratings of installed components.

2. Test electrical and mechanical interlock systems for correct operation and sequencing.
3. Inspect bolted electrical connections for high resistance using one or more of the following methods:

    a. Use of low-resistance ohmmeter according to Section 7.22.2.2 of NETA ATS.
    b. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or Table 100.12 of NETA ATS.
    c. Perform thermographic survey according to Section 9 of NETA ATS.

4. Test static transfer from inverter to bypass and back. Use normal load, if possible.
5. Test dc undervoltage trip level on inverter input breaker. Set according to manufacturer's published data.
6. Verify synchronizing indicators for static switch and bypass switches.
7. Test insulated-case and molded-case breakers.

    a. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with the circuit breaker closed, and across each open pole. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 of NETA ATS.
    b. Perform insulation-resistance tests on all control wiring for ground. Applied potential shall be 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable. Test duration shall be one minute. For units with solid-state components, follow manufacturer's recommendation.

c. Use primary current injection to determine long time and short time, ground fault, and instantaneous pickup, Use secondary current injection to test trip functions.
d. Perform minimum pickup voltage tests on shunt trip and close coils according to manufacturer's published data.
e. Verify operation of charging mechanism.
f. Verify correct operation of auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, antipump function, and trip unit battery condition. Reset all trip logs and indicators.

8. Test automatic transfer switches.

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter, if applicable, according to Section 7.22.3.1 of NETA ATS.
b. Perform insulation-resistance tests on all control wiring for ground. Applied potential shall be 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable. Test duration shall be one minute. For units with solid-state components or for control devices that cannot tolerate the applied voltage, follow manufacturer's recommendation.
c. Perform a contact/pole-resistance test.
d. Verify settings and operation of control devices.
e. Calibrate and set all relays and timers according to Section 7.9 of NETA ATS.
f. Verify phase rotation, phasing, and synchronized operation as required by the application.
g. Perform automatic transfer tests.

1) Simulate loss of normal power.
2) Return to normal power.
3) Simulate loss of emergency power.
4) Simulate all forms of single-phase conditions.

h. Verify correct operation and timing of the following functions:

1) Normal source voltage-sensing and frequency-sensing relays.
2) Time delay on transfer.
3) Alternative source voltage-sensing and frequency-sensing relays.
4) Automatic transfer operation.
5) Interlocks and limit switch function.
6) Time delay and retransfer on normal power restoration.

9. Test direct current system's batteries.

a. Verify adequacy of battery support racks, mounting, anchorage, alignment, grounding, and clearances.
b. Verify electrolyte level. Measure electrolyte level, specific gravity, and temperature.
c. Inspect spill containment installation. Measure charger float and equalizing voltage levels. Adjust to battery manufacturer's recommended settings.
d. Verify all charger functions and alarms.
e. Measure each cell voltage and total battery voltage with charger energized and in float mode of operation.

f. Perform a load test according to manufacturer's published data or IEEE 450.
g. Measure charger float and equalizing voltage levels. Adjust to battery manufacturer's recommended settings.
h. Test values.

1) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
2) Charger float and equalize voltage levels shall be according to battery manufacturer's published data.
3) The results of charger functions and alarms shall be according to manufacturer's published data.
4) Cell voltages shall be within 0.05 V of each other or according to manufacturer's published data.
5) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
6) Cell internal ohmic values (resistance, impedance, or conductance) shall not vary by more than 25 percent between identical cells that are in a fully charged state.
7) Results of load tests shall be according to manufacturer's published data or IEEE 450.

10. Test communication of status and alarms to remote monitoring equipment.
11. Load the system using a variable-load bank to simulate kilovolt amperes, kilowatts, and power factor of loads for unit's rating. Use instruments calibrated within the previous six months according to NIST standards.

a. Simulate malfunctions to verify protective device operation.
b. Test duration of supply on emergency, low-battery voltage shutdown, and transfers and restoration due to normal source failure.
c. Test harmonic content of input and output current at 25, 50, and 100 percent of rated loads.
d. Test output voltage under specified transient-load conditions.
e. Test efficiency at 50, 75, and 100 percent of rated loads.
f. Test remote status and alarm panel functions.
g. Test battery-monitoring system functions.

E. Seismic-restraint tests and inspections shall include the following:

1. Inspect type, size, quantity, arrangement, and proper installation of mounting or anchorage devices.
2. Test mounting and anchorage devices according to requirements in Section 260548.16 "Seismic Controls for Electrical Systems."

F. The UPS system will be considered defective if it does not pass tests and inspections.

G. Record of Tests and Inspections: Maintain and submit documentation of tests and inspections, including references to manufacturers' written instructions and other test and inspection criteria. Include results of tests, inspections, and retests.

H. Prepare test and inspection reports.

3.5 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain the UPS.

END OF SECTION 263353

SECTION 263533 - POWER FACTOR CORRECTION EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes power or automatic power factor correction equipment rated 600 V and less as directed.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For automatic power factor correction units.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Wire Termination Diagrams and Schedules: Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features. Differentiate between manufacturer- and field-installed wiring.
5. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices used. Describe characteristics of network and other data communication lines.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Submit evidence that power factor correction equipment is compatible with connected monitoring and control devices and systems.

B. Seismic Qualification Data: Certificates, for power capacitor banks, accessories, and components, from manufacturer.

C. Product Test Reports: Factory production test reports.

D. Evaluation Reports: Energy loss statement for each type of power capacitor.

E. Field quality-control reports.

F. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace power capacitors and power capacitor bank components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with IEEE 18.

1. The measured capacitance of a unit shall not vary more than minus zero percent to plus 10 percent of the nominal value.

C. Comply with NFPA 70.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Power factor correction equipment shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.3 POWER CAPACITOR

A. Comply with UL 810.

B. Capacitor Element: Dry metallized-dielectric, self-healing type. Each cell shall be encapsulated in thermosetting resin inside a plastic container.

C. Rupture Protection: Pressure-sensitive circuit interrupter for each cell.

D. Losses: Maximum dielectric losses of 0.25 W/kVAr, and a total loss of 0.5 W/kVAr.

2.4 FIXED CAPACITOR BANK

A. Description: Factory-assembled unit, consisting of non-automatic power capacitor bank, disconnect, fuses, and accessories, factory installed in independent enclosures or motor-control center, with a connection to motor-control center bus as directed. Comply with UL 810.

B. Description: Non-automatic power capacitor bank, disconnect, fuses, and accessories installed in independent enclosures. Comply with UL 810.

C. Disconnect and Overcurrent Protective Device: Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers." Operable from outside the enclosure to disconnect the unit, the cover may be opened only when the disconnect switch is open.

1. Molded-Case Circuit Breaker: Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Type HD fusible or non-fusible switch.

D. Fuses for Protection of Power Capacitor Bank: Current limiting; complying with UL 248-12 for Class R and Class RK fuses, or UL 248-15 for Class T fuses, as recommended by manufacturer; providing an interrupting capacity of 100,000 or 200,000 symmetrical A as directed. Provide blown fuse indicator light and "push-to-test" for each fuse on the bank cover.

1. Spare-Fuse Cabinet: Compartmented steel box or Cabinet with hinged lockable door as directed.

a. Comply with equipment identification requirements in Section 260553 "Identification for Electrical Systems."

E. Discharge Device: Factory installed and wired.

F. Enclosure: As directed, NEMA 250, Type 1, Type 3R, Type 4 or Type 12, steel or aluminum, with hinged door and hand-operated catch. Door shall be interlocked with controls or main circuit breaker to de-energize power capacitors when door is opened.

1. Factory Finish: Manufacturer's standard enamel over corrosion-resistant treatment or primer coat.
2. Comply with equipment identification requirements in Section 260553 "Identification for Electrical Systems."

2.5 AUTOMATIC POWER CAPACITOR BANK

A. Description: Factory-assembled unit, consisting of power capacitors, inductors, contactors, controls, and accessories, factory installed in independent enclosures or motor-control center, with a connection to motor-control center bus as directed. Comply with UL 508A.

B. Performance Requirements: Controls permit selection of a target power factor, adjustable to any value between unity and 0.80 lagging. Controls continuously sense the power factor on circuits being corrected and, when the power factor differs from the target setting for more than 10 seconds, operate a contractor to switch a power capacitor bank into or out of the circuit. Contactors are opened or closed as required to bring the corrected circuit power factor closest to the high (unity) end of target setting. Provide number of switching steps indicated in the Three-Phase Power Capacitor Bank Schedule or on Drawings.

C. Disconnect and Overcurrent Protective Device: Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers." Operable from outside the enclosure to disconnect the unit, the cover may be opened only when the disconnect switch is open.

1. Molded-Case Circuit Breaker: Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Type HD fusible or non-fusible switch.

D. Fuses for Protection of Power Capacitor Bank: Current limiting; listed and labeled as defined in NFPA 70, by a qualified testing agency as complying with UL 248-12 for Class R and Class RK fuses, or UL 249-15 for Class T fuses, as recommended by manufacturer; providing an interrupting capacity of 100 or 200 kA as directed. Provide blown fuse indicator light and "push-to-test" for each fuse on the bank cover.

1. Spare-Fuse Cabinet: As directed, Compartmented steel box or Cabinet with hinged lockable door as directed.

a. Comply with equipment identification requirements in Section 260553 "Identification for Electrical Systems."

E. Controls: Solid-state, microprocessor-based controls; control power shall be from the low-voltage power conductors associated with the bank. Include the following:

1. Reactive Current Control: Field programmable:

a. Target power factor selector switch, with setting range from 70 to 95 percent lagging as directed.
b. Time delay between steps with setting range from 5 seconds to 20 minutes to reduce hunting and allow for voltage decay.

2. Current Transformers: Type, configuration, and ratio recommended by manufacturer to suit sensing and mounting conditions.
3. Undervoltage Relay: Interrupts switching of power capacitors and disconnects the power capacitors for power-supply interruptions longer than 15 minutes.
4. "Advance" and "Retard" push buttons on the control panel to permit manually controlled power capacitor bank switching.

F. Contactors: Three pole; rated for the repetitive high-inrush-switching duty in the power capacitor application. Comply with NEMA ICS 2.

G. Discharge Devices: Factory installed and wired for each switched group of power capacitors.

H. Inductors: Air-core type, rated to limit switching surges to be within contactor ratings.

I. Pre-charge Power Capacitor Circuit: Resistive, pre-charge circuit to charge power capacitors prior to switching and to limit switching surges to within contactor ratings.

J. Enclosure: As directed, NEMA 250, Type 1, Type 3R, Type 4 or Type 12, steel or aluminum, with hinged door and hand-operated catch. Door shall be interlocked with controls or main circuit breaker to de-energize power capacitors when door is opened.

1. Factory Finish: Manufacturer's standard enamel over corrosion-resistant treatment or primer coat.
2. Comply with equipment identification requirements in Section 260553 "Identification for Electrical Systems."

K. Local Display: LED or LCD type, mounted in door of enclosure, indicating the following:

1. Target and actual power factors accurate to plus or minus 1 percent of reading.
2. Steps energized.
3. Step reconnection delay.
4. Real and reactive currents.
5. Voltage total harmonic distortion.
6. Alarm codes.

L. System Alarms: Alarm relay and local display indication of the following conditions:

1. Low power factor.
2. Leading power factor.
3. Frequency not detected.
4. Overcurrent.
5. Overvoltage.
6. Overtemperature.
7. Excessive voltage total harmonic distortion.
8. Power capacitor overload.
9. Loss of capacitance.

2.6 ARC-FLASH WARNING LABELS

A. Arc Flash Study: Comply with requirements in Section 260573.19 "Arc-Flash Hazard Analysis." Produce a 3.5-by-5-inch (76-by-127-mm) thermal transfer label of high-adhesion polyester for each work location included in the analysis.

B. Electrical Identification: Comply with requirements in Section 260553 "Identification for Electrical Systems." Produce a 3.5-by-5-inch (76-by-127-mm) thermal transfer label of high-adhesion polyester for each work location included in the analysis. Labels shall be machine printed, with no field-applied markings.

1. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:

a. Location designation.
b. Nominal voltage.

c. Flash protection boundary.
d. Hazard risk category.
e. Incident energy.
f. Working distance.
g. Engineering report number, revision number, and issue date.

2.7 SOURCE QUALITY CONTROL

A. Factory test power factor correction equipment before shipment. Include the following:

1. Routine power capacitor production tests, including short-time overvoltage, capacitance, leak, discharge resistor, loss determination, and fuse capability tests.
2. Functional test of all operations, controls, indicators, sensors, and protective devices.

PART 3 - EXECUTION

3.1 EXAMINATION

A. On delivery of power capacitor bank, and prior to unloading, inspect equipment for damage.

B. Handling: Handle power capacitor bank according to manufacturer's recommendations; avoid damage to the enclosure, termination compartments, base, frame, capacitors, and internal components. Do not subject bank to impact, jolting, jarring, or rough handling.

C. Examine roughing-in of conduits and grounding systems to verify that wiring entries comply with Drawings.

3.2 INSTALLATION

A. Comply with NECA 1.

B. As directed, for installation as part of switchgear, switchboard or motor-control center, comply with the installation requirements of that Section.

C. Install freestanding equipment on concrete bases. Cast-in-place concrete is specified in Section 033000 "Cast-in-Place Concrete."

1. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
2. Maintain minimum workspace according to manufacturer's written instructions.

D. Install arc-flash labels as required by NFPA 70.

E. Identify components according to Section 260553 "Identification for Electrical Systems."

F. As directed, engage a factory-authorized service representative to perform or Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Connect and run installed motors and equipment to verify the automatic switching of the power capacitors. Verification shall include automatic switching of the total capacity of installed power capacitors.

3.3 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections with the assistance of a factory-authorized service representative.

E. Tests and Inspections:

1. Visual and Mechanical Inspection:

   a. Inspect physical and mechanical condition.
   b. Inspect anchorage, alignment, grounding, and clearances.
   c. Verify that unit is clean.
   d. Verify that capacitors are electrically connected in their specified configuration.
   e. Inspect bolted electrical connections for high resistance using one of the two following methods:

      1) Use a low-resistance ohmmeter.

         a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

      2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12.

         a) Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.

2. Infrared Inspection: After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of the electrical power connections of the power capacitor bank. Perform infrared inspection during periods of maximum possible loading. Remove all necessary covers prior to the inspection.

   a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchgear 11 months after date of Substantial Completion.

b. Instrument: Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1 deg. C at 30 deg. C.
c. Record of Infrared Inspection: Prepare a certified report that identifies the testing technician and equipment used and that lists the following results:

1) Description of equipment to be tested.
2) Discrepancies.
3) Temperature difference between the area of concern and the reference area.
4) Probable cause of temperature difference.
5) Areas inspected. Identify inaccessible and unobservable areas and equipment.
6) Load conditions at time of inspection.
7) Photographs and thermograms of the deficient area.

d. Act on inspection results according to recommendations of NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Owner's operations permit. Retest until deficiencies are corrected.

3. Electrical Tests:

a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
b. Perform insulation-resistance tests from phase terminals to case for one minute. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.1.
c. Measure capacitance of all terminal combinations. Investigate capacitance values differing from manufacturer's published data.
d. Measure resistance of the internal discharge resistors. Investigate capacitance values differing from manufacturer's published data. Measure capacitor residual voltage at one minute after disconnecting the power capacitor bank from its power supply. Investigate the cause if the residual voltage exceeds 50 V.
e. Electrical Tests of Current Transformers:

1) Perform insulation-resistance test of each current transformer and its secondary wiring for ground at 1000-V dc for one minute. For units with solid-state components that cannot tolerate the applied voltage, follow manufacturer's recommendations. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.5.
2) Perform a polarity test of each current transformer according to IEEE C57.13.1. Polarity results shall agree with transformer markings.
3) Perform a ratio-verification test using the voltage or current method according to IEEE C57.13.1. Ratio errors shall be according to IEEE C57.13.
4) Perform an excitation test on transformers used for relaying applications according to IEEE C57.13.1. Excitation results shall match the curve supplied by manufacturer or be according to IEEE C57.13.1.

5) Measure current circuit burdens at transformer terminals according to IEEE C57.13.1. Measured burdens shall be compared to, and shall match, instrument transformer ratings.
6) Perform insulation-resistance tests on the primary winding with the secondary grounded. Test voltages shall be according to NETA ATS, Table 100.5.
7) Perform dielectric withstand tests on the primary winding with the secondary grounded. Test voltages shall be according to NETA ATS, Table 100.9.
8) Perform power factor or dissipation-factor tests according to test equipment manufacturer's published data.
9) Verify that current-transformer secondary circuits are grounded and have only one grounding point according to IEEE C57.13.3.

3.4 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain automatic power factor correction units.

END OF SECTION 263533

SECTION 263600 - TRANSFER SWITCHES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes automatic and nonautomatic transfer switches rated 600 V and less as directed.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include plans, elevations, sections, details showing minimum clearances, conductor entry provisions, gutter space, and installed features and devices.
2. Single-Line Diagram: Show connections between transfer switch, power sources, and load.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for transfer switches, accessories, and components, from manufacturer.

B. Source quality control reports.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of transfer switch or transfer switch components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: As directed, 12 months, 18 months or Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NEMA ICS 1.

C. Comply with NFPA 99.

D. Comply with NFPA 110.

E. Comply with UL 1008 unless requirements of these Specifications are stricter.

F. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.

G. Tested Fault-Current Closing and Short-Circuit Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.

1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.
2. Short-time withstand capability for three or 30 cycles as directed.

H. Repetitive Accuracy of Solid-State Controls: All settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.

I. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.62. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

J. Electrical Operation: Accomplish by a non-fused, momentarily energized solenoid or electric-motor-operated mechanism. Switches for emergency or standby purposes shall be mechanically and electrically interlocked in both directions to prevent simultaneous connection to both power sources unless closed transition.

K. Service-Rated Transfer Switch:

1. Comply with UL 869A and UL 489.
2. Provide terminals for bonding the grounding electrode conductor to the grounded service conductor.
3. In systems with a neutral, the bonding connection shall be on the neutral bus.
4. Provide removable link for temporary separation of the service and load grounded conductors.
5. Surge Protective Device: Service rated.
6. Ground-Fault Protection: Comply with UL 1008 for normal bus or normal and alternative buses as directed.

7. Service Disconnecting Means: Externally operated, manual mechanically or electrically actuated as directed.

L. Neutral Switching: Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles or overlapping neutral contacts as directed.

M. Neutral Terminal: Solid and fully rated unless otherwise indicated.

N. Oversize Neutral: Ampacity and switch rating of neutral path through units indicated for oversize neutral shall be double the nominal rating of circuit in which switch is installed.

O. Battery Charger: For generator starting batteries.

1. Float type, rated 2 or 10 A as directed.
2. Ammeter to display charging current.
3. Fused ac inputs and dc outputs.

P. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, by color-code or by numbered or lettered wire and cable with printed, tape or shrinkable sleeve markers at terminations as directed. Color-coding and wire and cable markers are specified in Section 260553 "Identification for Electrical Systems."

1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
4. Accessible via rear or front access as directed.

Q. Enclosures: As directed, General-purpose NEMA 250, Type 1, Type 3R, Type 4X or Type 12, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

2.2 CONTACTOR-TYPE AUTOMATIC TRANSFER SWITCHES

A. Comply with Level 1 equipment according to NFPA 110.

B. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are unacceptable.
2. Switch Action: Double throw; mechanically held in both directions.
3. Contacts: Silver composition or silver alloy for load-current switching. Contactor-style automatic transfer-switch units, rated 600 A and higher, shall have separate arcing contacts.
4. Conductor Connectors: Suitable for use with conductor material and sizes.
5. Material: As directed, Tin-plated aluminum or Hard-drawn copper, 98 percent conductivity.
6. Main and Neutral Lugs: As directed, Compression or Mechanical type.

7. Ground Lugs and Bus-Configured Terminators: As directed, Compression or Mechanical type.
8. Ground bar.
9. Connectors shall be marked for conductor size and type according to UL 1008.

C. Automatic Open-Transition Transfer Switches: Interlocked to prevent the load from being closed on both sources at the same time.

1. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.

D. Automatic Delayed-Transition Transfer Switches: Pauses or stops in intermediate position to momentarily disconnect both sources, with transition controlled by programming in the automatic transfer-switch controller. Interlocked to prevent the load from being closed on both sources at the same time.

1. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals for alternative source. Adjustable from zero to six seconds, and factory set for one second.
2. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.
3. Fully automatic break-before-make operation with center off position.
4. Fully automatic break-before-make operation with transfer when two sources have near zero phase difference.

E. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval shall be adjustable from 1 to 30 seconds.

F. Automatic Transfer-Switch Controller Features:

1. Controller operates through a period of loss of control power.
2. Undervoltage Sensing for Each Phase of Normal and Alternate Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage shall be adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
4. Time Delay for Retransfer to Normal Source: Adjustable from zero to 30 minutes, and factory set for 10 minutes. Override shall automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
5. Test Switch: Simulate normal-source failure.
6. Switch-Position Pilot Lights: Indicate source to which load is connected.
7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.

    a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
    b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."

8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
9. Transfer Override Switch: Overrides automatic retransfer control so transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
11. Engine Shutdown Contacts: Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.
12. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
13. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods shall be adjustable from 10 to 30 minutes. Factory settings shall be for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:

    a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
    b. Push-button programming control with digital display of settings.
    c. Integral battery operation of time switch when normal control power is unavailable.

G. Large-Motor-Load Power Transfer:

1. In-Phase Monitor: Factory-wired, internal relay controls transfer so contacts close only when the two sources are synchronized in phase and frequency. Relay shall compare phase relationship and frequency difference between normal and emergency sources and initiate transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer shall be initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.
2. Motor Disconnect and Timing Relay Controls: Designated starters in loss of power scenario shall disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters shall be through wiring external to automatic transfer switch. Provide adjustable time delay between 1 and 60 seconds for reconnecting individual motor loads. Provide relay contacts rated for motor-control circuit inrush and for actual seal currents to be encountered.
3. Programmed Neutral Switch Position: Switch operator with programmed neutral position arranged to provide a midpoint between the two working switch positions, with an intentional, time-controlled pause at midpoint during transfer. Adjustable pause from 0.5 to 30 seconds minimum, and factory set for 0.5 second unless otherwise indicated. Time delay occurs for both transfer directions. Disable pause unless both sources are live.

2.3 MOLDED-CASE-TYPE AUTOMATIC TRANSFER SWITCHES

A. Comply with Level 1 equipment according to NFPA 110.

B. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. Limitation: Switches using contactor-based components are unacceptable.
2. Switch Action: Double throw; mechanically held in both directions.
3. Contacts: Silver composition or silver alloy for load-current switching.
4. Conductor Connectors: Suitable for use with conductor material and sizes.
5. Material: As directed, Tin-plated aluminum or Hard-drawn copper, 98 percent conductivity.
6. Main and Neutral Lugs: As directed, Compression or Mechanical type.
7. Ground Lugs and Bus-Configured Terminators: As directed, Compression or Mechanical type.
8. Ground bar.
9. Connectors shall be marked for conductor size and type according to UL 1008.

C. Automatic Open-Transition Transfer Switches: Interlocked to prevent the load from being closed on both sources at the same time.

1. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.

D. Automatic Delayed-Transition Transfer Switches: Pauses or stops in intermediate position to momentarily disconnect both sources, with transition controlled by programming in the automatic transfer-switch controller. Interlocked to prevent the load from being closed on both sources at the same time.

1. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals for alternative source. Adjustable from zero to six seconds, and factory set for one second.
2. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.
3. Fully automatic break-before-make operation with center off position.
4. Fully automatic break-before-make operation with transfer when two sources have near zero phase difference.

E. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval shall be adjustable from 1 to 30 seconds.

F. Transfer Switches Based on Molded-Case-Switch Components: Comply with UL 489 and UL 869A.

G. Automatic Transfer-Switch Controller Features:

1. Controller operates through a period of loss of control power.
2. Undervoltage Sensing for Each Phase of Normal and Alternative Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage shall be adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at

90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.

4. Time Delay for Retransfer to Normal Source: Adjustable from zero to 30 minutes, and factory set for 10 minutes. Override shall automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
5. Test Switch: Simulate normal-source failure.
6. Switch-Position Pilot Lights: Indicate source to which load is connected.
7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.

    a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
    b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."

8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
9. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
11. Engine Shutdown Contacts: Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.
12. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
13. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods shall be adjustable from 10 to 30 minutes. Factory settings shall be for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:

    a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
    b. Push-button programming control with digital display of settings.
    c. Integral battery operation of time switch when normal control power is unavailable.

H. Large-Motor-Load Power Transfer:

1. In-Phase Monitor: Factory-wired, internal relay controls transfer so contacts close only when the two sources are synchronized in phase and frequency. Relay shall compare phase relationship and frequency difference between normal and emergency sources and initiate transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer shall be initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.
2. Motor Disconnect and Timing Relay Controls: Designated starters in loss of power scenario shall disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters shall be

through wiring external to automatic transfer switch. Provide adjustable time delay between 1 and 60 seconds for reconnecting individual motor loads. Provide relay contacts rated for motor-control circuit inrush and for actual seal currents to be encountered.

3. Programmed Neutral Switch Position: Switch operator with programmed neutral position arranged to provide a midpoint between the two working switch positions, with an intentional, time-controlled pause at midpoint during transfer. Adjustable pause from 0.5 to 30 seconds minimum, and factory set for 0.5 second unless otherwise indicated. Time delay occurs for both transfer directions. Disable pause unless both sources are live.

2.4 NONAUTOMATIC TRANSFER SWITCHES

A. Electrically Operated: Electrically actuated by push buttons designated "Normal Source" and "Alternative Source." Switch shall be capable of transferring load in either direction with either or both sources energized.

B. Manual and Electrically Operated: Electrically actuated by push buttons designated "Normal Source" and "Alternative Source." Manual handle provides quick-make, quick-break manual-switching action. Switch shall be capable of electrically or manually transferring load in either direction with either or both sources energized. Control circuit disconnects from electrical operator during manual operation.

C. Double-Throw Switching Arrangement: Incapable of pauses or intermediate position stops during switching sequence.

D. Pilot Lights: Indicate source to which load is connected.

E. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and alternative-source sensing circuits.

1. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
2. Emergency Power Supervision: Red light with nameplate engraved "Alternative Source Available."

F. Unassigned Auxiliary Contacts: Switch shall have one set of normally closed contacts for each switch position, rated 10 A at 240-V ac.

G. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. Switch Action: Double throw; mechanically held in both directions.
2. Contacts: Silver composition or silver alloy for load-current switching.
3. Conductor Connectors: Suitable for use with conductor material and sizes.
4. Material: As directed, Tin-plated aluminum or Hard-drawn copper, 98 percent conductivity.
5. Main and Neutral Lugs: As directed, Compression or Mechanical type.
6. Ground Lugs and Bus-Configured Terminators: As directed, Compression or Mechanical type.
7. Ground bar.

8. Connectors shall be marked for conductor size and type according to UL 1008.

2.5 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect components, assembled switches, and associated equipment according to UL 1008. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

B. Prepare test and inspection reports.

1. For each of the tests required by UL 1008, performed on representative devices, for emergency or legally required systems as directed. Include results of test for the following conditions:

a. Overvoltage.
b. Undervoltage.
c. Loss of supply voltage.
d. Reduction of supply voltage.
e. Alternative supply voltage or frequency is at minimum acceptable values.
f. Temperature rise.
g. Dielectric voltage-withstand; before and after short-circuit test.
h. Overload.
i. Contact opening.
j. Endurance.
k. Short circuit.
l. Short-time current capability.
m. Receptacle withstand capability.
n. Insulating base and supports damage.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Floor-Mounting Switch: Anchor to floor by bolting.

1. Install transfer switches on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.
2. Comply with requirements for seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."
3. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.
4. Provide workspace and clearances required by NFPA 70.

B. Annunciator and Control Panel Mounting: Flush in wall unless otherwise indicated.

C. Identify components according to Section 260553 "Identification for Electrical Systems."

D. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

E. Comply with NECA 1.

3.2 CONNECTIONS

A. Wiring to Remote Components: Match type and number of cables and conductors to generator sets, motor controls, control, and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to owner if necessary to accommodate required wiring.

B. Wiring Method: Install cables in raceways and cable trays except within electrical enclosures. Conceal raceway and cables except in unfinished spaces.

1. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.

D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

E. Connect twisted pair cable according to Section 260523 "Control-Voltage Electrical Power Cables."

F. Connect twisted pair cable according to Section 271513 "Communications Copper Horizontal Cabling."

G. Route and brace conductors according to manufacturer's written instructions and Section 260529 "Hangers and Supports for Electrical Systems." Do not obscure manufacturer's markings and labels.

H. Brace and support equipment according to Section 260548.16 "Seismic Controls for Electrical Systems."

I. Final connections to equipment shall be made with liquidtight, flexible metallic conduit no more than 18 inches (457 mm) in length.

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Visual and Mechanical Inspection:

a. Compare equipment nameplate data with Drawings and Specifications.
b. Inspect physical and mechanical condition.
c. Inspect anchorage, alignment, grounding, and required clearances.
d. Verify that the unit is clean.

e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
f. Verify that manual transfer warnings are attached and visible.
g. Verify tightness of all control connections.
h. Inspect bolted electrical connections for high resistance using one of the following methods, or both:

1) Use of low-resistance ohmmeter.
2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data.

i. Perform manual transfer operation.
j. Verify positive mechanical interlocking between normal and alternate sources.
k. Perform visual and mechanical inspection of surge arresters.
l. Inspect control power transformers.

1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
2) Verify that primary and secondary fuse or circuit-breaker ratings match Drawings.
3) Verify correct functioning of drawout disconnecting contacts, grounding contacts, and interlocks.

2. Electrical Tests:

a. Perform insulation-resistance tests on all control wiring with respect to ground.
b. Perform a contact/pole-resistance test. Compare measured values with manufacturer's acceptable values.
c. Verify settings and operation of control devices.
d. Calibrate and set all relays and timers.
e. Verify phase rotation, phasing, and synchronized operation.
f. Perform automatic transfer tests.
g. Verify correct operation and timing of the following functions:

1) Normal source voltage-sensing and frequency-sensing relays.
2) Engine start sequence.
3) Time delay on transfer.
4) Alternative source voltage-sensing and frequency-sensing relays.
5) Automatic transfer operation.
6) Interlocks and limit switch function.
7) Time delay and retransfer on normal power restoration.
8) Engine cool-down and shutdown feature.

3. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.

a. Check for electrical continuity of circuits and for short circuits.
b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.

c. Verify that manual transfer warnings are properly placed.
d. Perform manual transfer operation.

4. After energizing circuits, perform each electrical test for transfer switches stated in NETA ATS and demonstrate interlocking sequence and operational function for each switch at least three times.

   a. Simulate power failures of normal source to automatic transfer switches and retransfer from emergency source with normal source available.
   b. Simulate loss of phase-to-ground voltage for each phase of normal source.
   c. Verify time-delay settings.
   d. Verify pickup and dropout voltages by data readout or inspection of control settings.
   e. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for one pole deviating by more than 50 percent from other poles.
   f. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

5. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.

   a. Verify grounding connections and locations and ratings of sensors.

B. Coordinate tests with tests of generator and run them concurrently.

C. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

D. Transfer switches will be considered defective if they do not pass tests and inspections.

E. Remove and replace malfunctioning units and retest as specified above.

F. Prepare test and inspection reports.

G. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.

1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
2. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
3. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.

3.4 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment.

B. Training shall include testing ground-fault protective devices and instructions to determine when the ground-fault system shall be retested. Include instructions on where ground-fault sensors are located and how to avoid negating the ground-fault protection scheme during testing and circuit modifications.

C. Coordinate this training with that for generator equipment.

END OF SECTION 263600

SECTION 264113 - LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes lightning protection system for the following:

1. Ordinary structures.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include layouts of the lightning protection system, with details of the components to be used in the installation.
2. Include raceway locations needed for the installation of conductors.
3. Details of air terminals, ground rods, ground rings, conductor supports, splices, and terminations, including concealment requirements.
4. Calculations required by NFPA 780 for bonding of metal bodies.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Lightning protection system Shop Drawings, drawn to scale, coordinated with each other, using input from installers of the items involved:

B. Qualification Data: For Installer.

C. Product certificates.

D. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance data.

B. Completion Certificate:

1. As directed, UL Master Label Certificate or LPI Master Certificate.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: UL-listed installer, category OWAY or LPI Master Installer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. NFPA Lightning Protection Standard: As directed, comply with NFPA 780 requirements for Class I or Class II buildings.

B. UL Lightning Protection Standard: As directed, comply with UL 96A requirements for Class I or Class II buildings.

C. Lightning Protection Components, Devices, and Accessories: Listed and labeled by a qualified testing agency as complying with UL 96, and marked for intended location and application.

2.3 MATERIALS

A. Air Terminals:

1. Copper, Stainless steel or Aluminum unless otherwise indicated.
2. As directed, 3/8-inch (10-mm), 1/2-inch (12.7-mm) or 5/8-inch (16-mm) diameter by 10 inches (254 mm), 12 inches (305 mm), 15 inches (380 mm), 18 inches (450 mm) or 24 inches (610 mm) long.
3. As directed, Pointed or Rounded tip.
4. As directed, Integral base support or Threaded base support.

B. Class 1 Main Conductors:

1. Stranded Copper: 57,400 circular mils in diameter.
2. Aluminum: 98,600 circular mils in diameter.

C. Class II Main Conductors:

1. Stranded Copper: 115,000 circular mils in diameter.
2. Aluminum: 192,000 circular mils in diameter.

D. Secondary Conductors:

1. Stranded Copper: 26,240 circular mils in diameter.
2. Aluminum: 41,400 circular mils in diameter.

E. Ground Loop Conductor: As directed, Stranded copper or Tinned copper.

F. Ground Rods:

1. Material: As directed, Solid copper, Copper-clad steel or Stainless steel.
2. Diameter: As directed, 5/8 inch (16 mm) or 3/4 inch (19 mm).
3. Rods shall be not less than 120 inches (3050 mm) long.
4. Sectional type, with integral threads.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install lightning protection components and systems according to UL 96A or NFPA 780 as directed.

B. Install conductors with direct paths from air terminals to ground connections. Avoid bends less than 90 degrees and 8 inches (203 mm) in radius and narrow loops.

C. Conceal conductors within normal view from exterior locations at grade within 200 feet (60 m) of building. As directed, Comply with requirements for concealed installations in UL 96A or concealed systems in NFPA 780.

D. Ground Ring Electrode: The conductor shall be not less than the main-size lightning conductor.

3.2 CONNECTIONS

A. Aboveground concealed connections, and connections in earth or concrete, shall be done by exothermic welds or by high-compression fittings listed for the purpose.

B. Aboveground exposed connections shall be done using the following types of connectors, listed and labeled for the purpose: As directed, bolted connectors, exothermic weld, high compression or crimp.

C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.

3.3 FIELD QUALITY CONTROL

A. Special Inspections: As directed, Owner will engage or Engage a qualified special inspector to perform the following special inspections:

1. Perform inspections as required to obtain a UL Master Label for system.
2. Perform inspections to obtain an LPI certification.

B. Prepare test and inspection reports and certificates.

END OF SECTION 264113

SECTION 264313 - SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes field-mounted SPDs for low-voltage (120 to 600 V) power distribution and control equipment.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Copy of UL Category Code VZCA certification, as a minimum, listing the tested values for VPRs, Inominal ratings, MCOVs, type designations, OCPD requirements, model numbers, system voltages, and modes of protection.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample Warranty: For manufacturer's special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.5 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to replace or replace SPDs that fail in materials or workmanship within specified warranty period.

1. Warranty Period: As directed, Five or Ten years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL SPD REQUIREMENTS

A. SPD with Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

C. Comply with UL 1449.

D. MCOV of the SPD shall be the nominal system voltage.

2.2 SERVICE ENTRANCE AND TRANSFER SWITCH SUPPRESSOR

A. SPDs: Comply with UL 1449, Type 1 or Type 2 as directed.

1. SPDs with the following features and accessories:

a. Integral disconnect switch.
b. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
c. Indicator light display for protection status.

B. Peak Surge Current Rating: As directed, the minimum single-pulse surge current withstand rating per phase shall not be less than 200 kA, 240kA, 320 kA or 480 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.

C. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V or 208Y/120 V as directed, three-phase, four-wire circuits shall not exceed the following:

1. Line to Neutral: 1200 V for 480Y/277 V or 700 V for 208Y/120 V as directed.
2. Line to Ground: 1200 V for 480Y/277 V or 1200 V for 208Y/120 V as directed.
3. Line to Line: 2000 V for 480Y/277 V or 1000 V for 208Y/120 V as directed.

D. Protection modes and UL 1449 VPR for 240/120 V, single-phase, three-wire circuits shall not exceed the following:

1. Line to Neutral: 700 V.
2. Line to Ground: 700 V or 1000 V as directed.
3. Line to Line: 1000 V.

E. SCCR: Equal or exceed As directed, 100 kA or 200 kA.

F. Inominal Rating: 20 kA.

2.3 PANEL SUPPRESSORS

A. SPDs: As directed, Comply with UL 1449, Type 1 or Type 2.

1. Include LED indicator lights for power and protection status.
2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.

B. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 100 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.

C. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V or 208Y/120 V as directed, three-phase, four-wire circuits shall not exceed the following:

1. Line to Neutral: 1200 V for 480Y/277 V or 700 V for 208Y/120 V as directed.
2. Line to Ground: 1200 V for 480Y/277 V or 700 V for 208Y/120 V as directed.
3. Neutral to Ground: 1200 V for 480Y/277 V or 700 V for 208Y/120 V as directed.
4. Line to Line: 2000 V for 480Y/277 V or 1200 V for 208Y/120 V as directed.

D. Protection modes and UL 1449 VPR for 240/120-V, single-phase, three-wire circuits shall not exceed the following:

1. Line to Neutral: 700 V.
2. Line to Ground: 700 V.
3. Neutral to Ground: 700 V.
4. Line to Line: 1200 V.

E. SCCR: Equal or exceed as directed, 100 kA or 200 kA.

F. Inominal Rating: As directed, 20 kA or 10 kA.

2.4 ENCLOSURES

A. Indoor Enclosures: NEMA 250, Type 1.

B. Outdoor Enclosures: As directed, NEMA 250, Type 3R, Type 4 or Type 4X.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Install an OCPD or disconnect as required to comply with the UL listing of the SPD.

C. Install SPDs with conductors between suppressor and points of attachment as short and straight as possible and adjust circuit-breaker positions to achieve shortest and straightest leads. Do not splice and extend SPD leads unless specifically permitted by manufacturer. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.

D. Use crimped connectors and splices only. Wire nuts are unacceptable.

E. Complete startup checks according to manufacturer's written instructions. Energize SPDs after power system has been energized, stabilized, and tested.

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative.

1. Compare equipment nameplate data for compliance with Drawings and Specifications.
2. Inspect anchorage, alignment, grounding, and clearances.
3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.

B. An SPD will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.3 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to operate and maintain SPDs.

END OF SECTION 264313

SECTION 265113 - INCANDESCENT INTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Interior incandescent luminaires and lamps.
2. Luminaire supports.

B. Related Requirements:

1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
2. Section 260926 "Lighting Control Panelboards" for panelboards used for lighting control.
3. Section 260933 "Central Dimming Controls" or Section 260936 "Modular Dimming Controls" for architectural dimming systems.
4. Section 260943.16 "Addressable-Luminaire Lighting Controls" and Section 260943.23 "Relay-Based Lighting Controls" for manual or programmable control systems with low-voltage control wiring or data communication circuits.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product, arranged by designation.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, and coordinated with each other, using input from installers of the items involved.

B. Seismic Qualification Data: For luminaires, accessories, and components, from manufacturer.

C. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

B. Seismic Performance: Luminaires and lamps shall be labeled vibration and shock resistant.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

2.2 LUMINAIRE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.

C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

D. UL Compliance: Comply with UL 1598.

E. Nominal Operating Voltage: As directed, 120 V ac, 240 V ac or 277 V ac.

F. Recessed Luminaires: Comply with NEMA LE 4.

G. Lamp:

1. Bulb shape complying with ANSI C79.1.
2. Edison socket.
3. CRI of 100. CCT of 2700 K, 3000 K or 4100 K as directed.
4. Dimmable from 100 percent to 0 percent of maximum light output.

2.3 LUMINAIRE TYPES

A. Cylinder:
   1. As directed, Ceiling, Pendant or Wall mounted.
   2. Diameter: 6 inches (150 mm).
   3. With integral mounting provisions.
   4. Aluminum reflector.

B. Downlight: 6-inch (150-mm) aperture.

C. Universal mounting bracket.

D. Integral junction box with conduit fittings.

E. Aluminum reflector.

2.4 MATERIALS

A. Metal Parts: Steel unless otherwise indicated. Free of sharp edges and burrs. Form and support to prevent warping and sagging.

B. Doors, Frames and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

C. Lenses, Diffusers, and Globes:

   1. Lighting Diffusers: As directed, Tempered Fresnel glass, clear glass or clear, UV-stabilized acrylic.
   2. Glass: Annealed crystal glass unless otherwise indicated.
   3. Acrylic: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

D. Housings:

   1. Extruded-aluminum housing and heat sink.
   2. Clear anodized, powder-coat or painted finish as directed.

2.5 METAL FINISHES

A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.6 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.

C. Wires: ASTM A641/A641M, Class 3, soft temper, zinc-coated steel, 12 gauge (2.68 mm).

D. Rod Hangers: 3/16-inch (5 mm) minimum diameter, cadmium-plated, threaded steel rod.

E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports: Sized and rated for luminaire weight.

E. Flush-Mounted Luminaire Support:

1. Secured to outlet box.
2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
3. Trim ring flush with finished surface.

F. Wall-Mounted Luminaire Support:

1. Attached to structural members in walls, attached to a minimum 1/8-inch (3-mm) backing plate attached to wall structural members or Attached using through bolts and backing plates on either side of wall as directed.
2. Do not attach luminaires directly to gypsum board.

G. Suspended Lighting Luminaire Support:

1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers.
3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of luminaire chassis.
4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

H. Ceiling-Grid-Mounted Luminaires:

1. Secure to any required outlet box.
2. Secure luminaire, using approved fasteners in a minimum of four locations, spaced near corners of luminaire.

I. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

J. Identify system components, wiring, cabling, and terminals. Install wiring labels with panel and circuit numbers on concealed junction and outlet boxes. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 265113

SECTION 265116 - FLUORESCENT INTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Interior fluorescent luminaires, lamps, and ballasts.
2. Luminaire supports.

B. Related Requirements:

1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
2. Section 260926 "Lighting Control Panelboards" for panelboards used for lighting control.
3. Section 260933 "Central Dimming Controls" or Section 260936 "Modular Dimming Controls" for architectural dimming systems and for fluorescent dimming controls with dimming.
4. Section 260943.16 "Addressable-Luminaire Lighting Controls" and Section 260943.23 "Relay-Based Lighting Controls" for manual or programmable control systems with low-voltage control wiring or data communication circuits.

1.2 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating

E. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product, arranged by designation.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Sustainable Design Submittals:

D. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale and coordinated with each other, using input from installers of the items involved.

B. Seismic Qualification Certificates: For luminaires, accessories, and components, from manufacturer.

C. Product Certificates: For each type of ballast for bi-level and dimmer-controlled luminaires, from manufacturer.

D. Sample warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

B. Seismic Performance: Luminaires and lamps shall be labeled vibration and shock resistant.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

2.2 LUMINAIRE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.

C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

D. UL Compliance: Comply with UL 1598.

E. Nominal Operating Voltage: As directed, 120 V ac, 240 V ac or 277 V ac.

F. Recessed Luminaires: Comply with NEMA LE 4.

2.3 BALLASTS FOR LINEAR FLUORESCENT LAMPS

A. General Requirements for Electronic Ballasts:

1. Comply with UL 935 and with ANSI C82.11.
2. Designed for type and quantity of lamps served.
3. Ballasts shall be designed, for full light output unless another BF, dimmer, or bi-level control is indicated.
4. Sound Rating: As directed, Class A or Class A, except Class B for T12/HO and T12/Slimline lamp ballasts.
5. THD Rating: As directed, less than 10 or 20 percent.
6. Surge Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
7. Operating Frequency: 42 kHz or higher.

B. Electromagnetic Ballasts: Comply with ANSI C82.11; energy saving, high-power factor, Class P, and having automatic-reset thermal protection.

1. Ballast Manufacturer Certification: Indicated by label.

C. Single Ballasts for Multiple Luminaires: Factory wired with ballast arrangements and bundled extension wiring to suit final installation conditions without modification or rewiring in the field.

D. Ballasts for Residential Applications: Luminaires designated as "residential" may use low-power-factor electronic ballasts having a Class B sound rating and THD of approximately 30 percent.

E. Ballasts for Dimmer-Controlled Luminaires: Electronic type.

1. Dimming Range: 100 to 5 percent of rated lamp lumens.
2. Ballast Input Watts: Can be reduced to 20 percent of normal.
3. Compatibility: Certified by manufacturer for use with specific dimming control system and lamp type indicated.

F. Ballasts for Bi-Level Controlled Luminaires: Electronic type.

1. Operating Modes: Ballast circuit and leads provide for remote control of the light output of the associated lamp between high- and low-level operation and off.

a. High-Level Operation: 100 percent of rated lamp lumens.
b. Low-Level Operation: 30 percent of rated lamp lumens.

2. Ballast shall provide equal current to each lamp in each operating mode.
3. Compatibility: Certified by manufacturer for use with specific bi-level control system and lamp type indicated.

G. Ballasts for Tri-Level Controlled Luminaires: Electronic type.

1. Operating Modes: Ballast circuit and leads provide for remote control of the light output of the associated lamp between high- and low-level operation and off.

a. High-Level Operation: 100 percent of rated lamp lumens.
b. Low-Level Operation: As directed, 30 and 50 or 30 and 60 percent of rated lamp lumens.

2. Ballast shall provide equal current to each lamp in each operating mode.
3. Compatibility: Certified by manufacturer for use with specific tri-level control system and lamp type indicated.

2.4 BALLASTS FOR COMPACT FLUORESCENT LAMPS

A. Description: Electronic-programmed rapid-start type, complying with UL 935 and with ANSI C 82.11, designed for type and quantity of lamps indicated. Ballast shall be designed for full light output unless dimmer or bi-level control is indicated:

1. Lamp end-of-life detection and shutdown circuit.
2. Sound Rating: Class A.
3. THD Rating: Less than 20 percent.
4. Operating Frequency: 20 kHz or higher.
5. BF: 0.95 or higher unless otherwise indicated.
6. Power Factor: As directed, 0.95 or 0.98, except luminaires designated as "residential" may use low-power-factor electronic ballasts or higher.
7. Interference: Comply with 47 CFR 18, Ch. 1, Subpart C, for limitations on EMI and RFI for non-consumer equipment.

2.5 EMERGENCY FLUORESCENT POWER UNIT

A. Internal Type: Self-contained, modular, battery-inverter unit, factory mounted within luminaire body and compatible with ballast. Comply with UL 924.

1. Emergency Connection: Operate one fluorescent lamp(s) continuously at an output of 1100 lumens each. Connect unswitched circuit to battery-inverter unit and switched circuit to luminaire ballast.
2. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.

3. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

B. External Type: Self-contained, modular, battery-inverter unit, suitable for powering one or more fluorescent lamps, remote mounted from luminaire. Comply with UL 924.

1. Emergency Connection: Operate one fluorescent lamp continuously. Connect unswitched circuit to battery-inverter unit and switched circuit to luminaire ballast.
2. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
3. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.6 FLUORESCENT LAMPS

A. T8 rapid-start lamps, rated 32-W maximum, nominal length of 48 inches (1220 mm), 2800 initial lumens (minimum), CRI of 75 (minimum), color temperature of 3500 K, and average rated life of 20,000 hours unless otherwise indicated.

B. T8 rapid-start lamps, rated 17-W maximum, nominal length of 24 inches (610 mm), 1300 initial lumens (minimum), CRI of 75 (minimum), color temperature of 3500 K, and average rated life of 20,000 hours unless otherwise indicated.

C. T5 rapid-start lamps, rated 28-W maximum, nominal length of 45.2 inches (1150 mm), 2900 initial lumens (minimum), CRI of 85 (minimum), color temperature of 3000 K, and average rated life of 20,000 hours unless otherwise indicated.

D. T5HO rapid-start, high-output lamps, rated 54-W maximum, nominal length of 45.2 inches (1150 mm), 5000 initial lumens (minimum), CRI of 85 (minimum), color temperature of 4100 K, and average rated life of 20,000 hours unless otherwise indicated.

E. Compact Fluorescent Lamps: Four-pin, CRI of 80 (minimum), color temperature of 3500 K, average rated life of 10,000 hours at three hours of operation per start, and suitable for use with dimming ballasts unless otherwise indicated.

1. 13 W: T4, double or triple tube, rated 900 initial lumens (minimum).
2. 18 W: T4, double or triple tube, rated 1200 initial lumens (minimum).
3. 26 W: T4, double or triple tube, rated 1800 initial lumens (minimum).
4. 32 W: T4, triple tube, rated 2400 initial lumens (minimum).
5. 42 W: T4, triple tube, rated 3200 initial lumens (minimum).
6. 57 W: T4, triple tube, rated 4300 initial lumens (minimum).
7. 70 W: T4, triple tube, rated 5200 initial lumens (minimum).

2.7 CYLINDER

A. With integral mounting provisions.

B. With integral mounting provisions.

2.8 DOWNLIGHT

A. Universal mounting bracket.

B. Integral junction box with conduit fittings.

2.9 LOWBAY

2.10 PARKING GARAGE

A. Low-profile housing and heat sink.

B. Fully gasketed and sealed. IP 65 rated.

C. Stainless-steel latches.

D. Integral pressure equalizer.

2.11 RECESSED LINEAR

A. Integral junction box with conduit fittings.

2.12 STRIP LIGHT

A. Integral junction box with conduit fittings.

2.13 SURFACE MOUNT, LINEAR

A. Universal mounting bracket.

B. Integral junction box with conduit fittings.

2.14 SURFACE MOUNT, NONLINEAR

A. Universal mounting bracket.

B. Integral junction box with conduit fittings.

2.15 SUSPENDED, LINEAR

A. Ceiling mounted with two 5/32-inch- (4-mm-) diameter aircraft cable supports adjustable to 120 inches (6 m) in length.

2.16 SUSPENDED, NONLINEAR

A. Universal mounting bracket.

B. Integral junction box with conduit fittings.

2.17 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit re-lamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during re-lamping and when secured in operating position.

C. Diffusers and Globes:

1. As directed, Tempered Fresnel glass, prismatic glass, diffuse glass, clear glass, prismatic acrylic or clear, UV-stabilized acrylic.
2. Glass: Annealed crystal glass unless otherwise indicated.
3. Acrylic: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
4. Lens Thickness: At least 0.125-inch (3.175 mm) minimum unless otherwise indicated.

D. Housings:

1. Extruded-aluminum housing and heat sink.
2. As directed, Clear anodized, powder-coat or painted finish.

2.18 METAL FINISHES

A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.19 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish shall match luminaire.

C. Wires: ASTM A641/A641M, Class 3, soft temper, zinc-coated steel, 12 gauge (2.68 mm).

D. Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.

E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Remote Mounting of Ballasts: Distance between the ballast and luminaire shall not exceed that recommended by ballast manufacturer. Verify, with ballast manufacturers, maximum distance between ballast and luminaire.

C. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

D. Install lamps in each luminaire.

E. Supports: Sized and rated for luminaire weight.

F. Ceiling-Grid-Mounted Luminaire Supports:

1. Install ceiling support system rods or wires, independent of the ceiling suspension devices, for each luminaire. Locate not more than 6 inches (150 mm) from luminaire corners.
2. Support Clips: Fasten to luminaires and to ceiling grid members at or near each luminaire corner with clips that are UL listed for the application.
3. Luminaires of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support luminaires independently with at least two 3/4-inch (20-mm) metal channels spanning and secured to ceiling tees.
4. Install at least one independent support rod or wire from structure to a tab on luminaire. Wire or rod shall have breaking strength of the luminaire weight at a safety factor of 3.

G. Flush-Mounted Luminaire Support:

1. Secured to outlet box.
2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
3. Trim ring flush with finished surface.

H. Wall-Mounted Luminaire Support:

1. As directed, attached to structural members in walls, attached to a minimum 20 gauge backing plate attached to wall structural members or Attached using through bolts and backing plates on either side of wall.
2. Do not attach luminaires directly to gypsum board.

I. Suspended Luminaire Support:

1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
3. Continuous Rows of Luminaires: As directed, use tubing or stem for wiring at one point and tubing or rod or wire support for suspension for each unit length of luminaire chassis, including one at each end.
4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

J. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and Section 260533 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.

K. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 265116

SECTION 265119 - LED INTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following types of LED luminaires:

1. Cylinder.
2. Downlight.
3. Highbay, linear.
4. Highbay, nonlinear.
5. Linear industrial.
6. Lowbay.
7. Parking garage.
8. Recessed, linear.
9. Strip light.
10. Surface mount, linear.
11. Surface mount, nonlinear.
12. Suspended, linear.
13. Suspended, nonlinear.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
2. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Sustainable Design Submittals:

D. Samples: For each luminaire and for each color and texture with standard factory-applied finish.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale and coordinated with each other, using input from installers of the items involved.

B. Seismic Qualification Data: For luminaires, accessories, and components, from manufacturer.

C. Product Certificates: For each type of luminaire.

D. Product test reports.

E. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products, and complying with the applicable IES testing standards.

C. Provide luminaires from a single manufacturer for each luminaire type.

D. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

1.6 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

B. Warranty Period: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

B. Seismic Performance: Luminaires and lamps shall be labeled vibration and shock resistant.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

C. Ambient Temperature: As directed, 41 to 104 deg F (5 to 40 deg C) or 5 to 104 deg F (Minus 15 to plus 40 deg C).

1. Relative Humidity: Zero to 95 percent.

D. Altitude: Sea level to 1000 feet (300 m).

2.2 LUMINAIRE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp characteristics:

a. "USE ONLY" and include specific lamp type.
b. Lamp diameter, shape, size, wattage, and coating.
c. CCT and CRI.

C. Recessed luminaires shall comply with NEMA LE 4.

D. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.

E. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

F. California Title 24 compliant.

2.3 CYLINDER

A. Nominal Operating Voltage: As directed, 120 V ac, 240 V ac, 277 V ac, 12 V dc or 24 V dc.

B. Lamp:

1. Minimum As directed, 250, 575 or 1000 lm.
2. Minimum allowable efficacy of 80 lm/W.
3. As directed, CRI of minimum, 65, 70 or 80. CCT of 2700 K, 3000 K or 4100 K.
4. As directed, Rated lamp life of 35,000 or 50,000 hours to L70.
5. Dimmable from 100 percent to 0 percent of maximum light output.
6. Internal driver.
7. User-Replaceable Lamps:

a. Bulb shape complying with ANSI C78.79.
b. Lamp base complying with ANSI C81.61 or IEC 60061-1.

8. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

C. Housings:

1. Extruded-aluminum housing and heat sink.
2. Clear anodized, powder-coat or painted finish.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit re-lamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during re-lamping and when secured in operating position.

E. Diffusers and Globes:

1. As directed, Tempered Fresnel glass, Prismatic glass, Diffuse glass, Clear glass, Prismatic acrylic or Clear, UV-stabilized acrylic.
2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Glass: Annealed crystal glass unless otherwise indicated.
4. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

F. With integral mounting provisions.

G. Standards:

1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.

2.4 DOWNLIGHT.

A. Nominal Operating Voltage: As directed, 120 V ac, 240 V ac, 277 V ac, 12 V dc or 24 V dc.

B. Lamp:

1. Minimum 250, 575 or 1000 lm as directed.
2. Minimum allowable efficacy of 80 lm/W.
3. As directed, CRI of minimum, 65, 70 or 80. CCT of 2700 K, 3000 K or 4100 K.
4. Rated lamp life of 35,000 or 50,000 hours to L70 as directed.
5. Dimmable from 100 percent to 0 percent of maximum light output.
6. Internal driver.
7. User-Replaceable Lamps:

a. Bulb shape complying with ANSI C78.79.
b. Lamp base complying with ANSI C81.61 or IEC 60061-1.

8. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

C. Housings:

1. As directed, Extruded-aluminum housing and heat sink.
2. As directed, Clear anodized, powder-coat or painted finish.
3. Universal mounting bracket.
4. Integral junction box with conduit fittings.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit re-lamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during re-lamping and when secured in operating position.

E. Diffusers and Globes:

1. As directed, Fixed or Adjustable lens.
2. As directed, Spot, Medium or Wide light distribution.
3. As directed, Tempered Fresnel glass, Prismatic glass, Diffuse glass, Clear glass, Prismatic acrylic or Clear, UV-stabilized acrylic.
4. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
5. Glass: Annealed crystal glass unless otherwise indicated.
6. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

F. Standards:

1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.
4. Recessed luminaires shall comply with NEMA LE 4.

2.5 LINEAR INDUSTRIAL.

A. Lamp:

1. Minimum 5,000 lm.
2. Minimum allowable efficacy of 80 lm/W.
3. As directed, CRI of minimum, 65, 70 or 80. CCT of 2700 K, 3000 K or 4100 K.
4. As directed, Rated lamp life of 35,000 or 50,000 hours to L70.
5. Dimmable from 100 percent to 0 percent of maximum light output.
6. Internal driver.
7. User-Replaceable Lamps:

    a. Bulb shape complying with ANSI C78.79.
    b. Lamp base complying with ANSI C81.61 or IEC 60061-1.

8. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

B. Housings:

1. Extruded-aluminum housing and heat sink.

2. As directed, Clear anodized, powder-coat or painted finish.

C. Housing and Heat Sink Rating:

1. As directed, Class 1, Division 2 Group(s) A, B, C and D.
2. NEMA 4X.
3. IP 54.
4. IP 66.
5. Marine and wet locations.
6. CSA C22.2 No 137.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit re-lamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during re-lamping and when secured in operating position.

E. Diffusers and Globes:

1. As directed, Tempered Fresnel glass, Prismatic glass, Diffuse glass, Clear glass, Prismatic acrylic or Clear, UV-stabilized acrylic.
2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Glass: Annealed crystal glass unless otherwise indicated.
4. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

F. With integral mounting provisions.

G. Standards:

1. ENERGY STAR certified.
2. RoHS compliant.

2.6 LOWBAY

A. Nominal Operating Voltage: As directed, 120 V ac, 240 V ac, 277 V ac, 12 V dc or 24 V dc.

B. Lamp:

1. Minimum 5,000 or 10,000 lm as directed.
2. Minimum allowable efficacy of 80 lm/W.
3. As directed, CRI of minimum, 65, 70 or 80. CCT of 2700 K, 3000 K or 4100 K.
4. As directed, Rated lamp life of 35,000 or 50,000 hours to L70.
5. Dimmable from 100 percent to 0 percent of maximum light output.
6. Internal driver.
7. User-Replaceable Lamps:

    a. Bulb shape complying with ANSI C78.79.
    b. Lamp base complying with ANSI C81.61 or IEC 60061-1.

8. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

C. Housings:

1. Extruded-aluminum housing and heat sink.
2. As directed, Clear anodized, powder-coat or painted finish.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit re-lamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during re-lamping and when secured in operating position.

E. Diffusers and Globes:

1. As directed, Tempered Fresnel glass, Prismatic glass, Diffuse glass, Clear glass, Prismatic acrylic or Clear, UV-stabilized acrylic.
2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Glass: Annealed crystal glass unless otherwise indicated.
4. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

F. Standards:

1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.

2.7 RECESSED, LINEAR

A. Nominal Operating Voltage: As directed, 120 V ac, 240 V ac, 277 V ac, 12 V dc or 24 V dc.

B. Lamp:

1. As directed, Minimum 1,500, 2,000 or 3,000 lm.
2. Minimum allowable efficacy of 85 lm/W.
3. As directed, CRI of minimum, 65, 70 or 80. CCT of 2700 K, 3000 K or 4100 K.
4. As directed, Rated lamp life of 35,000 or 50,000 hours to L70.
5. Dimmable from 100 percent to 0 percent of maximum light output.
6. Internal driver.
7. User-Replaceable Lamps:

    a. Bulb shape complying with ANSI C78.79.
    b. Lamp base complying with ANSI C81.61 or IEC 60061-1.

8. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

C. Housings:

1. Extruded-aluminum housing and heat sink.
2. As directed, Clear anodized, powder-coat or painted finish.
3. With integral mounting provisions.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit re-lamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during re-lamping and when secured in operating position.

E. Diffusers and Globes:

1. As directed, Tempered Fresnel glass, Prismatic glass, Diffuse glass, Clear glass, Prismatic acrylic or Clear, UV-stabilized acrylic.
2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Glass: Annealed crystal glass unless otherwise indicated.
4. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

F. Standards:

1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.
4. NEMA LE 4.

2.8 STRIP LIGHT.

A. Nominal Operating Voltage: As directed, 120 V ac, 240 V ac, 277 V ac, 12 V dc or 24 V dc.

B. Lamp:

1. Minimum 750 lm.
2. Minimum allowable efficacy of 75 or 80 lm/W.
3. As directed, CRI of minimum, 65, 70 or 80. CCT of 2700 K, 3000 K or 4100 K.
4. As directed, Rated lamp life of 35,000 or 50,000 hours to L70.
5. Dimmable from 100 percent to 0 percent of maximum light output.
6. Internal driver.
7. User-Replaceable Lamps:

    a. Bulb shape complying with ANSI C78.79.
    b. Lamp base complying with ANSI C81.61 or IEC 60061-1.

8. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

C. Housings:

1. Extruded-aluminum housing and heat sink.
2. As directed, Clear anodized, powder-coat or painted finish.
3. With integral mounting provisions.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping of luminaire without use of tools.

Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

E. Diffusers and Globes:

1. As directed, Tempered Fresnel glass, Prismatic glass, Diffuse glass, Clear glass, Prismatic acrylic or Clear, UV-stabilized acrylic.
2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Glass: Annealed crystal glass unless otherwise indicated.
4. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

F. Standards:

1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.

2.9 SURFACE MOUNT, LINEAR.

A. Nominal Operating Voltage: As directed, 120 V ac, 240 V ac, 277 V ac, 12 V dc or 24 V dc.

B. Lamp:

1. Minimum 750 lm.
2. Minimum allowable efficacy of 75 or 80 lm/W.
3. As directed, CRI of minimum, 65, 70 or 80. CCT of 2700 K, 3000 K or 4100 K.
4. As directed, Rated lamp life of 35,000 or 50,000 hours to L70.
5. Dimmable from 100 percent to 0 percent of maximum light output.
6. Internal driver.
7. User-Replaceable Lamps:

    a. Bulb shape complying with ANSI C78.79.
    b. Lamp base complying with ANSI C81.61 or IEC 60061-1.

8. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

C. Housings:

1. As directed, extruded-aluminum housing and heat sink.
2. As directed, clear anodized, powder-coat or painted finish.
3. With integral mounting provisions.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit re-lamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during re-lamping and when secured in operating position.

E. Diffusers and Globes:

1. As directed, Tempered Fresnel glass, Prismatic glass, Diffuse glass, Clear glass, Prismatic acrylic or Clear, UV-stabilized acrylic.
2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Glass: Annealed crystal glass unless otherwise indicated.
4. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

F. Standards:

1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.

2.10 SURFACE MOUNT, NONLINEAR

A. Nominal Operating Voltage: As directed, 120 V ac, 240 V ac, 277 V ac, 12 V dc or 24 V dc.

B. Lamp:

1. Minimum 750 lm.
2. As directed, Minimum allowable efficacy of 75 or 80 lm/W.
3. As directed, CRI of minimum, 65, 70 or 80. CCT of 2700 K, 3000 K or 4100 K.
4. As directed, Rated lamp life of 35,000 or 50,000 hours to L70.
5. Dimmable from 100 percent to 0 percent of maximum light output.
6. Internal driver.
7. User-Replaceable Lamps:

    a. Bulb shape complying with ANSI C78.79.
    b. As directed, lamp base complying with ANSI C81.61 or IEC 60061-1.

8. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

C. Housings:

1. Extruded-aluminum housing and heat sink.
2. As directed, clear anodized, powder-coat or painted finish.
3. With integral mounting provisions.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit re-lamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during re-lamping and when secured in operating position.

E. Diffusers and Globes:

1. As directed, Tempered Fresnel glass, Prismatic glass, Diffuse glass, Clear glass, Prismatic acrylic or Clear, UV-stabilized acrylic.
2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Glass: Annealed crystal glass unless otherwise indicated.

4. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

F. Standards:

1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.

2.11 SUSPENDED, LINEAR.

A. Nominal Operating Voltage: As directed, 120 V ac, 240 V ac, 277 V ac, 12 V dc or 24 V dc.

B. Lamp:

1. As directed, Minimum 1,500, 2,000 or 3,000 lm.
2. Minimum allowable efficacy of 85 lm/W.
3. As directed, CRI of minimum, 65, 70 or 80. CCT of 2700 K, 3000 K or 4100 K.
4. As directed, Rated lamp life of 35,000 or 50,000 hours to L70.
5. Dimmable from 100 percent to 0 percent of maximum light output.
6. Internal driver.
7. User-Replaceable Lamps:

a. Bulb shape complying with ANSI C78.79.
b. Lamp base complying with ANSI C81.61 or IEC 60061-1.

8. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

C. Housings:

1. Extruded-aluminum housing and heat sink.
2. As directed, Clear anodized, powder-coat or painted finish.
3. With integral mounting provisions.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit re-lamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during re-lamping and when secured in operating position.

E. Diffusers and Globes:

1. As directed, Tempered Fresnel glass, Prismatic glass, Diffuse glass, Clear glass, Prismatic acrylic or Clear, UV-stabilized acrylic.
2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Glass: Annealed crystal glass unless otherwise indicated.
4. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

F. Standards:

1. ENERGY STAR certified.

2. RoHS compliant.
3. UL Listing: Listed for damp location.

2.12 SUSPENDED, NONLINEAR.

A. Nominal Operating Voltage: As directed, 120 V ac, 240 V ac, 277 V ac, 12 V dc or 24 V dc.

B. Lamp:

1. As directed, Minimum 1,500, 2,000 or 3,000 lm.
2. Minimum allowable efficacy of 85 lm/W.
3. As directed, CRI of minimum, 65, 70 or 80. CCT of 2700 K, 3000 K or 4100 K.
4. As directed, rated lamp life of 35,000 or 50,000 hours to L70.
5. Dimmable from 100 percent to 0 percent of maximum light output.
6. Internal driver.
7. User-Replaceable Lamps:

    a. Bulb shape complying with ANSI C78.79.
    b. Lamp base complying with ANSI C81.61 or IEC 60061-1.

8. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

C. Housings:

1. Extruded-aluminum housing and heat sink.
2. Clear anodized, powder-coat or painted finish.
3. Universal mounting bracket.
4. Integral junction box with conduit fittings.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit re-lamping without use of tools. Components are designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during re-lamping and when secured in operating position.

E. Diffusers and Globes:

1. As directed, Tempered Fresnel glass, Prismatic glass, Diffuse glass, Clear glass, Prismatic acrylic or Clear, UV-stabilized acrylic.
2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
3. Glass: Annealed crystal glass unless otherwise indicated.
4. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

F. Standards:

1. ENERGY STAR certified.
2. RoHS compliant.
3. UL Listing: Listed for damp location.

2.13 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for sheet steel.

C. Stainless Steel:

1. 1. Manufacturer's standard grade.
2. 2. Manufacturer's standard type, ASTM A240/240M.

D. Galvanized Steel: ASTM A653/A653M.

E. Aluminum: ASTM B209.

2.14 METAL FINISHES

A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.15 LUMINAIRE SUPPORT

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.

C. Wires: ASTM A641/A641M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm).

D. Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.

E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and re-lamping.
3. Provide support for luminaire without causing deflection of ceiling or wall.
4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.

E. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

3.2 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

3.4 STARTUP SERVICE

A. Comply with requirements for startup specified in Section 260943.16 "Addressable-Luminaire Lighting Controls."

B. Comply with requirements for startup specified in Section 260943.23 "Relay-Based Lighting Controls."

END OF SECTION 265119

SECTION 265123 - HID INTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Interior HID luminaires and lamps and ballasts.
2. Luminaire supports.

B. Related Requirements:

1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
2. Section 260926 "Lighting Control Panelboards" for panelboards used for lighting control.
3. Section 260933 "Central Dimming Controls" or Section 260936 "Modular Dimming Controls" for architectural dimming systems and for dimming controls with dimming ballasts.
4. Section 260943.16 "Addressable-Luminaire Lighting Controls" and Section 260943.23 "Relay-Based Lighting Controls" for manual or programmable control systems with low-voltage control wiring or data communication circuits.

1.2 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Fixture: See "Luminaire."

D. Lumen: Measured output of lamp and luminaire, or both.

E. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product, arranged by designation.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

D. Sustainable Design Submittals:

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale and coordinated with each other, using input from installers of the items involved.

B. Seismic Qualification Data: For luminaires, accessories, and components, from manufacturer.

C. Product Certificates: For each type of ballast for bi-level and dimmer-controlled luminaires, from manufacturer.

D. Sample warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

B. Seismic Performance: Luminaires and lamps shall be labeled vibration and shock resistant.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

2.2 LUMINAIRE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.

C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

D. UL Compliance: Comply with UL 1598.

E. Nominal Operating Voltage: As directed, 120 V ac, 240 V ac or 277 V ac.

F. Recessed Luminaires: Comply with NEMA LE 4.

2.3 BALLASTS FOR HID LAMPS

A. Electromagnetic Ballast for Metal Halide Lamps: Comply with ANSI C82.4 and UL 1029. Include the following features unless otherwise indicated:

1. Ballast Circuit: Constant-wattage autotransformer or regulating high-power-factor type.
2. Minimum Starting Temperature: Minus 22 deg F (Minus 30 deg C) for single-lamp ballasts.
3. Rated Ambient Operating Temperature: 104 deg F (40 deg C).
4. Open-circuit operation that will not reduce average life.

B. Electronic Ballast for Metal Halide Lamps: Include the following features unless otherwise indicated:

1. Sound Rating: Class A.
2. Total Harmonic Distortion Rating: Less than 20 percent.
3. Surge Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
4. Lamp Current Crest Factor: 1.5 or less.
5. Power Factor: 0.90 or higher.
6. Interference: Comply with 47 CFR 18, Ch. 1, Subpart C, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment.
7. Protection: Class P thermal cutout.

2.4 QUARTZ LAMP LIGHTING CONTROLLER

A. General Requirements for Controllers: Factory installed by luminaire manufacturer. Comply with UL 1598.

B. Standby (Quartz Restrike): Automatically switches quartz lamp on when an HID lamp in the fixture is initially energized and during the HID lamp restrike period after brief power outages.

C. Connections: Designed for a single branch-circuit connection.

D. Switching Off: Automatically switches quartz lamp off when HID lamp strikes.

E. Switching Off: Automatically switches quartz lamp off when HID lamp reaches approximately 60 percent light output.

2.5 HID LAMPS

A. High-Pressure Sodium Lamps: ANSI C78.42, CRI of 21 (minimum), color temperature 1900 K, and average rated life of 24,000 hours, minimum.

B. Metal Halide Lamps: ANSI C78.43, with minimum CRI of 65 and color temperature 4000 K.

2.6 DOWNLIGHT

A. Universal mounting bracket.

B. Integral junction box with conduit fittings.

2.7 HIGHBAY, NONLINEAR

A. Universal mounting bracket.

B. Integral junction box with conduit fittings.

2.8 LOWBAY

2.9 SUSPENDED, NONLINEAR

A. Universal mounting bracket.

B. Integral junction box with conduit fittings.

2.10 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit re-lamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during re-lamping and when secured in operating position.

C. Diffusers and Globes:

1. As directed, Tempered Fresnel glass, prismatic glass, diffuse glass, clear glass, prismatic acrylic or clear, UV-stabilized acrylic.
2. Glass: Annealed crystal glass unless otherwise indicated.
3. Acrylic: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

4. Lens Thickness: At least 0.125-inch (3.175 mm) minimum unless otherwise indicated.

D. Housings:

1. Extruded-aluminum housing and heat sink.
2. As directed, Clear anodized, powder-coat or painted finish.

2.11 METAL FINISHES

A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.12 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish shall match fixture.

C. Wires for Humid Spaces: ASTM A580/A580M, Composition 302 or 304, annealed stainless steel, 12 gauge (2.68 mm).

D. Wires: ASTM A641/A641M, Class 3, soft-temper, zinc-coated steel, 12 gauge (2.68 mm).

E. Rod Hangers: 3/16-inch- (5-mm-) minimum diameter, cadmium-plated, threaded steel rod.

F. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Remote Mounting of Ballasts: Distance between the ballast and fixture shall not exceed that recommended by ballast manufacturer. Verify, with ballast manufacturers, maximum distance between ballast and luminaire.

C. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

D. Install lamps in each luminaire.

E. Coordinate layout and installation of luminaires and suspension system with other construction that penetrates ceilings or is supported by them.

F. Supports: Sized and rated for luminaire weight.

G. Ceiling-Grid-Mounted Luminaire Supports:

H. Flush-Mounted Luminaire Support:

1. Secured to outlet box.
2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
3. Trim ring flush with finished surface.

I. Wall-Mounted Luminaire Support:

1. As directed, attached to structural members in walls, attached to a minimum 20 gauge backing plate attached to wall structural members or Attached using through bolts and backing plates on either side of wall.
2. Do not attach luminaires directly to gypsum board.

J. Suspended Luminaire Support:

1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of fixture oscillations. Support outlet box vertically to building structure using approved devices.
3. Continuous Rows of Luminaires: As directed, use tubing or stem for wiring at one point and tubing or rod or wire support for suspension for each unit length of fixture chassis, including one at each end.
4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

K. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and Section 260533 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.

L. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 265123

SECTION 265213 - EMERGENCY AND EXIT LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Emergency lighting units.
2. Exit signs.
3. Luminaire supports.

1.2 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Emergency Lighting Unit: A lighting unit with integral or remote emergency battery powered supply and the means for controlling and charging the battery and unit operation.

D. Fixture: See "Luminaire" Paragraph.

E. Lumen: Measured output of lamp and luminaire, or both.

F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of emergency lighting unit, exit sign, and emergency lighting support, arranged by designation.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Sustainable Design Submittals:

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, coordinated with each other, using input from installers of the items involved:

B. Product Certificates: For each type of luminaire.

C. Seismic Qualification Data: Certificates, for luminaires, accessories, and components, from manufacturer.

D. Sample Warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two year(s) from date of Substantial Completion.

B. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. Luminaires and lamps shall be labeled vibration and shock resistant.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

2.2 GENERAL REQUIREMENTS FOR EMERGENCY LIGHTING

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NRTL Compliance: Fabricate and label emergency lighting units, exit signs, and batteries to comply with UL 924.

C. Comply with NFPA 70 and NFPA 101.

D. Comply with NEMA LE 4 for recessed luminaires.

E. Comply with UL 1598 for recessed luminaires.

F. Internal Type Emergency Power Unit: Self-contained, modular, battery-inverter unit, factory mounted within luminaire body and compatible with ballast.

1. Emergency Connection: Operate one lamp(s) continuously at an output of 1100 lumens each upon loss of normal power. Connect unswitched circuit to battery-inverter unit and switched circuit to fixture ballast.
2. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
3. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

    a. Ambient Temperature: Less than 0 deg F (minus 18 deg C) or exceeding 104 deg F (40 deg C), with an average value exceeding 95 deg F (35 deg C) over a 24-hour period.
    b. Ambient Storage Temperature: Not less than minus 4 deg F (minus 20 deg C) and not exceeding 140 deg F (60 deg C).
    c. Humidity: More than 95 percent (condensing).
    d. Altitude: Exceeding 3300 feet (1000 m).

4. Test Push-Button and Indicator Light: Visible and accessible without opening fixture or entering ceiling space.

    a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
    b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

5. Battery: As directed, Sealed, maintenance-free, nickel-cadmium or lead-acid type.
6. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
7. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

G. External Type: Self-contained, modular, battery-inverter unit, suitable for powering one or more lamps, remote mounted from luminaire.

1. Emergency Connection: As directed, Operate one fluorescent, incandescent or LED lamp continuously. Connect unswitched circuit to battery-inverter unit and switched circuit to luminaire ballast.
2. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
3. Nightlight Connection: Operate lamp in a remote fixture continuously.
4. Battery: As directed, Sealed, maintenance-free, nickel-cadmium or lead-acid type.
5. Charger: Fully automatic, solid-state, constant-current type.

6. Housing: NEMA 250, Type 1 enclosure listed for installation inside, on top of, or remote from luminaire. As directed, Remote assembly shall be located no less than half the distance recommended by the ballast or emergency power unit manufacturer, whichever is less.
7. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
8. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
9. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.3 EMERGENCY LIGHTING

A. General Requirements for Emergency Lighting Units: Self-contained units.

B. Emergency Luminaires:
1. Emergency Luminaires: as indicated on Interior Luminaire Schedule, Drawings and described in Section, with the following additional features:

a. As directed, Operating at nominal voltage of 120 V ac, 277 V ac, 6 V dc, 9.6 V dc, 12 V dc or 24 V dc.
b. As directed, Internal or External emergency power unit.
c. Rated for installation in damp locations, and for sealed and gasketed fixtures in wet locations.
d. As directed, UL 94 5VA, 5VB, V-0, V-1, V-2 or HB flame rating.

C. Emergency Lighting Unit:
1. Emergency Lighting Unit: as indicated on Interior Luminaire Schedule or Drawings.
2. As directed, Operating at nominal voltage of 120 V ac, 277 V ac, 6 V dc, 9.6 V dc, 12 V dc or 24 V dc.
3. Wall with universal junction box adaptor.
4. UV stable thermoplastic housing, rated for damp locations.
5. As directed, Two alogen, Krypton or LED lamp heads.
6. As directed, Internal or External emergency power unit.
7. External emergency power unit.

2.4 EXIT SIGNS

A. Internally Lighted Signs:
1. As directed, Operating at nominal voltage of 120 V ac, 277 V ac, 6 V dc, 9.6 V dc or 12 V dc or 24 V dc.
2. Lamps for AC Operation: Fluorescent, two for each fixture; 20,000 hours of rated lamp life.
3. Lamps for AC Operation: LEDs; 50,000 hours minimum rated lamp life.
4. Self-Powered Exit Signs (Battery Type): Internal emergency power unit.

B. Self-Luminous Signs:

1. Powered by tritium gas, with universal bracket for flush-ceiling, wall, or end mounting. As directed, Signs shall be guaranteed by manufacturer to maintain the minimum brightness requirements in UL 924 for 10, 15 or 20 years.
2. Use strontium oxide aluminate compound to store ambient light and release the stored energy when the light is removed. Include universal bracket for flush-ceiling, wall, or end mounting.

2.5 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access:

1. Smooth operating, free of light leakage under operating conditions.
2. Designed to permit re-lamping without use of tools.
3. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during re-lamping and when secured in operating position.

C. Diffusers and Globes:

1. As directed, Tempered Fresnel glass, Prismatic glass, Diffuse glass, Clear glass, Prismatic acrylic or Clear, UV-stabilized acrylic.
2. Glass: Annealed crystal glass unless otherwise indicated.
3. Acrylic: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
4. Lens Thickness: At least 0.125-inch (3.175 mm) minimum unless otherwise indicated.

D. Housings:

1. Extruded aluminum housing and heat sink.
2. As directed, Clear anodized, powder coat or painted finish.

E. Conduit: As directed, Rigid galvanized steel, Electrical metallic tubing or Flexible metallic conduit, minimum 3/4 inch (21 mm) in diameter.

2.6 METAL FINISHES

A. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.7 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.

C. Install lamps in each luminaire.

D. Supports:

1. Sized and rated for luminaire and emergency power unit weight.
2. Able to maintain luminaire position when testing emergency power unit.
3. Provide support for luminaire and emergency power unit without causing deflection of ceiling or wall.
4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire and emergency power unit weight and vertical force of 400 percent of fixture weight.

E. Wall-Mounted Luminaire Support:

1. As directed, attached to structural members in walls, attached to a minimum 20-gage backing plate attached to wall structural members or Attached using through bolts and backing plates on either side of wall.
2. Do not attach fixtures directly to gypsum board.

F. Suspended Luminaire Support:

1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of fixture oscillations. Support outlet box vertically to building structure using approved devices.
3. Continuous Rows of Luminaires: As directed, use tubing or stem for wiring at one point and tubing or rod or wire support for suspension for each unit length of fixture chassis, including one at each end.
4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

G. Ceiling Grid Mounted Luminaires:

1. Secure to any required outlet box.
2. Secure emergency power unit using approved fasteners in a minimum of four locations, spaced near corners of emergency power unit.

H. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

B. Luminaire will be considered defective if it does not pass operation tests and inspections.

C. Prepare test and inspection reports.

END OF SECTION 265213

SECTION 265561 - THEATRICAL LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Dimmer racks.
2. Control console and control devices.
3. Luminaires and accessories.
4. Distribution components.

1.2 DEFINITIONS

A. Fade Time: The time it takes all zones to fade from one lighting scene to another, with all zones arriving at the next scene at the same time.

B. Control Voltage: As defined in NFPA 70, term for circuits and equipment operating at less than 50 V or for remote-control, signaling, and power-limited circuits.

C. Scene: The lighting effect created by adjusting several zones of lighting to the desired intensity.

D. Channel: An individual control output on a control console, accessed and regulated by a slider, switch, or button; or in some cases, accessed by a discretely assigned address and regulated by a data input apparatus.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For theatrical lighting.

1. As directed, include plans, elevations, sections, and mounting or attachment details.
2. Detail fabrication and installation for dimmer racks and arrangements, characteristics, and circuit assignments of various modules and rack-mounted accessories.
3. Include diagrams for power, signal, and control wiring. Show connections, circuits, and channel assignments.
4. Equipment legend showing a unified system of designations for lighting instruments, panels, dimmers, circuits, and equipment.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, reflected ceiling plan(s), and other details drawn to scale, and coordinated with each other, using input from installers of the items involved.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On USB drive or compact disk, complete with data files.
3. Device address list if applicable.
4. Printout of software application and graphic screens.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of the complete dimming control system and luminaires that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Cost to repair or replace parts for two years from date of Substantial Completion.
2. Extended Warranty Period: Cost of replacement parts (materials only, f.o.b. the nearest shipping point to Project site), for eight years.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Dimmer racks shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NFPA 70.

2.2 PLUG CONNECTORS

A. Pin Type: ANSI E1.24, two pole, three wire, 20 A.

B. Twist-Locking Type: NEMA WD 6, two pole, three wire, 20 A.

2.3 LUMINAIRES AND ACCESSORIES

A. Luminaire Assembly Description:

1. Comply with UL 1573 and listed and labeled by an NRTL.
2. Luminaires: Equipped with pigtail, yoke with pipe clamp, safety cable for batten mounting, and filter holder.
3. Metal Parts: Free of burrs, sharp corners, and edges.
4. Sheet Metal Components: Steel unless otherwise indicated. Form and support to prevent warping and sagging.
5. Luminaire Doors and Their Internal Access: Smooth operating, free of light leakage under operating conditions, and arranged to permit re-lamping without use of tools. Doors, lenses, diffusers, and other pieces arranged to prevent accidental falling during re-lamping and when secured in operating position.
6. Pigtail: Factory wired, 36-inch- (900-mm-) long, three-wire cord and plug connector assembly with cord encased in woven fiberglass or silicone tubing.
7. Lamp Sockets: Re-lampable without disturbing alignment or focus adjustment.
8. Luminaire Ventilation Openings: Baffled against light leaks.
9. Luminaire Operating Controls and Handles: Thermally insulated.
10. Lenses: Borosilicate glass in silicone mountings.
11. Framing Shutters: Stainless steel, four way; with each blade in a separate plane under adjustable tension mounting. Blades adjust plus or minus 30 degrees of rotation in gate for 120-degree-minimum total angular rotation between adjacent blades.
12. Color Filter Frame Holder: Attached to front of luminaire.
13. Luminaire Yoke: Rigid metal, arranged for vertical aiming of unit and equipped with T-bolt or hand screw to lock alignment.

B. Fresnel Lens Spotlights:
1. Die-cast extruded-aluminum housing, with hinged front for re-lamping.
2. Tag: FLS-1.

a. Lamp: As directed, 1000 W Q1000T7/4CL, ANSI EGT or 750 W ANSI HPL.
b. Lens: 6 inches (152 mm).
c. Illumination Performance Rating When Operated with ANSI 1.9, EGT Lamp:

1) 175,000-beam candlepower at 12.5-degree field angle in spot focus.
2) 12,000-beam candlepower at 74.6-degree field angle in flood focus.

d. Illumination Performance Rating When Operated with ANSI 1.9, HPL Lamp:

1) 124,300-beam candlepower at 20-degree field angle in spot focus.
2) 17,600-beam candlepower at 65-degree field angle in flood focus.

e. Barn Doors: Two four-leaf rotatable metal flaps for every three luminaires.

C. PAR Lamp Holders:
1. Tag: PLH-1:

a. Lamp: 300 W PAR 38.
b. Housing: Steel or aluminum, flat black color, with porcelain-plated shell socket.
c. Barn Doors: Two four-leaf rotatable metal flaps for every three luminaires.

2. Tag:

a. Lamp: 575 W tungsten halogen; 90 GLA 575 W; 120 V; color: 3050 K, ANSI GKV.
b. Housing: Steel or aluminum, with porcelain-plated shell socket and color frame.
c. Barn Doors: Two four-leaf rotatable metal flaps for every three luminaires.
d. With Lens Holder and Replaceable Lenses:

1) Drawing designation as directed: Very narrow spot.
2) Drawing designation as directed: Narrow spot.
3) Drawing designation as directed: Medium flood.
4) Drawing designation as directed: Wide flood.
5) Drawing designation as directed: Very wide flood.

e. As directed, Motorized or Manual color wheel.

D. Borderlight Units: As directed, compartmented, three-circuit striplight with nine 120-W, PAR 38/SP, 120-W, PAR 38/FL or 250-W, PAR 38/SP lamps in porcelain sockets and steel sheet housing, 90 inches (2286 mm) long. As directed, Compartments shall be in line and wired on two, three or four alternate circuits, each producing a different color.
1. Front Door: Spring loaded; designed to hold either filter frames or color roundels.
2. Color Roundels: One for each lamp; alternating red, blue, and clear.

a. Additional Roundels: Number of amber roundels as directed, and number green roundels as directed.

3. Hanger: Adjustable, steel-strap type equipped at each end with pipe clamp and safety cable for suspension from a batten.
4. Housing shall be constructed of 0.036 inches (0.9-mm) steel with louvers for heat dissipation and baffles for control of light leaks within luminaire.

E. Cyclorama Lights: Suitable for lighting cycloramas from above.
1. Tag: CL-1:

a. Lamp: 1000 W Q1000T3/1CL, ANSI FFT.
b. Housing: Aluminum or steel, flat black color, with color frame.

F. Black Lights: Portable, producing a wash of UV light for special effects.
1. Tag: BL-1:

a. Lamp: 250-W blacklight flood, H37KB-250, with integral filter to eliminate far-UV effect while maximizing the near-UV effect.
b. Housing: As directed, steel or aluminum, flat black color, with carry handle.
c. C-clamp for using on light pipe.

G. Moving Lights:
1. Tag: ML-1:

a. General: 700-W, 120-V, metal halide, motorized remote-controlled lighting instrument; NRTL listed.
b. Lamp: Short-arc metal halide, 14,500 lumens; color temperature of 5600 K, CRI of 80.
c. Color System: Three-filter CYM (cyan, yellow, magenta) cross-fading mechanism, and 11 standard colors on a fixed wheel.
d. Optics: Zoom optics with continuously variable field angle from 18.5 to 42 degrees, programmable over a timed range of 2 seconds to 20 minutes; with a mechanical iris for beam-size control. Variable beam focus to soften the edges of gobos and light beams. Zoom combined with iris can project a beam with a field angle of 8 degrees.
e. Dimming: Coated glass dimmer wheel, with controls to provide smooth timed fades.
f. Strobe for strobe lighting effects.
g. Gobo: One rotating wheel with five rotatable wheel positions and one open position. One fixed gobo wheel with 11 pattern positions and one open position.
h. Beam Orientation Control: Smooth pan and tilt using a three-phase stepper motor system. Pan, 540 degrees; tilt, 270 degrees at 0.3-degree repeatability on either axis.
i. Control: ANSI E1.11 (USITT DMX512-A) protocol using five pin connectors.

2.4 DISTRIBUTION COMPONENTS

A. Connector Strip: Listed and labeled by an NRTL; factory-wired wireway and receptacle assembly.

1. Wireway: Steel or extruded aluminum, with removable cover and nominal cross-section dimensions of 3 by 4-1/2 inches (75 by 115 mm).
2. Accessories: Cable clamps, support cradles, and cable strain relief grips for each cable.
3. Receptacles: Pigtail mounted, 18 inches (450 mm) long, with strain relief at wireway wall penetration.
4. Receptacles: Flush mounted in wireway cover.
5. Receptacle Wiring: For connecting to terminal blocks; with 125 deg C, crosslinked, PE-insulated, identification-labeled wire.
6. Terminal Blocks: Molded-barrier type with screw lugs to suit supply conductors.
7. Mounting Hardware: Furnished with each unit; permits surface, single-pipe-bracket, or double-pipe-bracket mounting.
8. Finish: Semigloss or matte black.

B. Plug-in Boxes: Listed and labeled by an NRTL; factory-wired wireway and receptacle assembly, 24 inches (600 mm) long unless otherwise indicated; with the following features:

1. Wireway: Steel or extruded aluminum, with removable cover and nominal cross-section dimensions of 3 by 4-1/2 inches (75 by 115 mm).
2. Accessories: Cable clamps, support cradles, and cable strain relief grips for each cable.
3. Receptacles: Pigtail mounted, 18 inches (450 mm) long, with strain relief at wireway wall penetration.

4. Receptacles: Flush mounted in wireway cover.
5. Receptacle Wiring: For connecting to terminal blocks; with 125 deg C, crosslinked, PE-insulated, identification-labeled wire.
6. Terminal Blocks: Molded-barrier type with screw lugs to suit supply conductors.
7. Surface or Grid Mounting: With accessories for surface mounting or with pipe-mounting accessory bracket.
8. Recessed Mounting: With flanged cover suitable for recessed mounting in wall.
9. Finish: Semigloss or matte black.

C. Gridiron Junction Boxes: Listed and labeled by an NRTL; factory wired with terminal strips and concentric knockouts on all sides.

1. Terminal Blocks: Molded-barrier type with screw lugs to suit supply conductors.
2. Accessories: Cable clamps, support cradles, and cable strain relief grips for each cable; and brackets for surface or pipe mounting.
3. Finish: Semigloss or matte black.

2.5 WIRE AND CABLE

A. Building Wire in Raceways: Comply with requirements specified in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Portable Power Cable: Listed and labeled by an NRTL; flexible stage and lighting power cable; Type SC, SCE, or SCT; 600 V; multiconductor; 60 deg C temperature rating.

C. Ethernet Cabling: Comply with requirements specified in Section 260523 "Control-Voltage Electrical Power Cables."

1. For 10/100BaseT, comply with provisions for UTP cable and hardware.
2. As directed, for 10Base-FL, comply with provisions for 50/125 or 62.5/125-micrometer, multimode, optical-fiber cable and hardware.

D. ANSI E1.11 (USITT DMX512-A) Control Cabling: Comply with requirements specified in Section 260523 "Control-Voltage Electrical Power Cables."

1. Standard Cable: NFPA 70, Type CM or Type CMG.

a. Paired, low-capacitance computer cable for ANSI E1.11 (USITT DMX512-A) applications. As directed, two pairs, twisted, No. 22 AWG or No. 24 AWG, stranded, tinned-copper conductors.
b. PE insulation.
c. Inner Shield: 100 percent coverage, aluminum foil-polyester tape.
d. Outer Shield: 90 percent coverage, tinned-copper braid.
e. Outer Shield Drain Wire: Stranded, tinned copper.
f. PVC jacket.
g. Flame Resistance: Comply with UL 1581.

2. Plenum-Rated Cable: NFPA 70, Type CMP.

a. Paired, low-capacitance computer cable for ANSI E1.11 (USITT DMX512-A) applications. As directed, two pairs, twisted, No. 22 AWG or No. 24 AWG, stranded, tinned-copper conductors.
b. Insulation: Foam fluoridated ethylene propylene.
c. Inner Shield: 100 percent coverage, aluminum foil-polyester tape.
d. Outer Shield: 90 percent coverage, tinned-copper braid.
e. Outer Shield Drain Wire: Stranded, tinned copper.
f. Low-smoke PVC jacket.
g. Flame Resistance: Comply with NFPA 262.

E. Control-Voltage Control Cabling:

1. Control-Cable Conductors:

a. Class 1 Control Circuits: Stranded copper, Type THHN-THWN, in raceway; complying with UL 83.
b. Class 1 Control Circuits: Stranded copper, Type THHN, in raceway; complying with UL 44.
c. Class 2 Control Circuits: As directed, Stranded copper, Type THHN-THWN, in raceway, power-limited cable, concealed in building finishes or power-limited tray cable, in cable tray; complying with UL 83.
d. Class 2 Control Circuits: As directed, Stranded copper, Type THHN, in raceway, power-limited cable, concealed in building finishes or power-limited tray cable, in cable tray; complying with UL 44.
e. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type TW or Type TF; complying with UL 83.

2. Paired Cable: NFPA 70, Type CMG.

a. One pair, twisted, No. 16 AWG, stranded, tinned-copper conductors.
b. PVC insulation.
c. Unshielded.
d. PVC jacket.
e. Flame Resistance: Comply with UL 1581.

3. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.

a. One pair, twisted, No. 16 AWG, stranded (19x29), tinned-copper conductors.
b. PVC insulation.
c. Unshielded.
d. PVC jacket.
e. Flame Resistance: Comply with NFPA 262.

4. Paired Cable: NFPA 70, Type CMG.

a. One pair, twisted, No. 18 AWG, stranded (19x30), tinned-copper conductors.
b. PVC insulation.
c. Unshielded.
d. PVC jacket.
e. Flame Resistance: Comply with UL 1581.

5. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.

    a. One pair, twisted, No. 18 AWG, stranded (19x30), tinned-copper conductors.
    b. Fluorinated ethylene propylene insulation.
    c. Unshielded.
    d. Plastic jacket.
    e. Flame Resistance: Comply with NFPA 262.

2.6 LIGHTING CONTROL SYSTEM

A. Description: Microprocessor-based modular system consisting of dimmer and control modules operated from remote-control stations and a control console.

1. Comply with UL 508.
2. Comply with ANSI E1.11 (USITT DMX512-A) RDM and or ACN for data transmission.

B. Dimmer Racks: As directed, Listed and labeled by an NRTL; dead-front, front-access, wall-mounted or freestanding rack for mounting modular dimmers; formed-steel or extruded-aluminum structural members; completely enclosed with steel or aluminum panels. Painted with manufacturer's standard corrosion-resistant primer and finish coats, and having the following features:

1. Primary Circuit Breaker: As directed, Fault-current withstand rating of the rack; not less than 10,000 A or 50,000 A, symmetrical.
2. Hinged, locking front door, with openings to allow air intake across the face of all dimmer modules.
3. Individual rack sections shall not exceed 84 inches high by 25 inches deep by 30 inches wide (2134 mm high by 635 mm deep by 762 mm wide). Multisection racks shall be interconnected with busbars.
4. For each module position, provide support rails and control-pin configurations, constructed for precise alignment of dimmer modules into power and signal connector sockets, with keyed connections for power capacity restrictions.
5. Forced-air cooling of each rack for maintaining operating temperature at each dimmer, assuming full load, in ambient temperature not to exceed 40 deg C. Exhaust rates shall be variable, using temperature sensors and fan-speed control electronics. Individual control of multiple fans is acceptable in lieu of fan-speed control. Fan(s) shall start and stop automatically. Fan noise at full load shall be less than 3.1 sones.
6. Each rack shall have an automatic air-temperature sensor to shut off all dimmers in the rack, should the internal temperature rise above maximum safe operating limits. In an overheat condition, the fan shall continue operating. When a safe operating temperature is restored, the system shall automatically reset to allow normal user control.
7. Fabricate and test dimmer racks to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."

C. Dimmers: Modular solid-state units that operate smoothly over their operating ranges without audible lamp noise or radio-frequency interference at any setting. Modules shall be dead-front, draw-out type with floating line, load, and control sockets for smooth insertion and withdrawal; with load-side thermal-magnetic circuit breaker, speed-controlled cooling fan, and overtemperature sensor.

1. Non-Dim Units: On-off relay control only. Capable of serving inductive loads, such as motors or HID luminaires.
2. Surge Protection: Modules shall withstand power-line surges of 6000 V/3000 A according to IEEE C62.41.1 and IEEE C62.41.2.
3. Filter each dimmed circuit to provide a minimum 350-mic.sec., current-rise time at a 90-degree conduction angle at 50 percent of rated dimmer capacity. At any load within rating, rate of current rise shall not exceed 30 mA/mic. sec., measured from 10 to 90 percent of load current waveform.

D. Control System: Microprocessor-based control system, ANSI E1.11 (USITT DMX512-A) RDM and or ACN protocol, with a nonvolatile system memory to adjust dimmer channel settings for different scenes, to patch dimmers to channels, and to manually or automatically change dimmer settings from one preset scene to another.

1. Control shall support Ethernet-based LAN at devices.
2. Provide means to create and monitor show data on a PC using software by console manufacturer. Software shall be capable of the following:

    a. Creating show and providing for use of show files.
    b. Playing back show in a console-simulation mode.
    c. Accessing all remote-control stations associated with the console and control system.
    d. Providing standard Ethernet connection between the console control system and the lighting system components.

3. Display the following system status information on a color, 17-inch (430-mm) LCD monitor associated with the control console:

    a. Current channel intensities.
    b. Cue information.
    c. Monitor.

4. Moving Lights: Include a standard control library, a program patch specific to luminaire(s) provided, and selective programming with ANSI E1.11 (USITT DMX512-A) RDM and or ACN addressing of fade, focus points, beam, image, color, and position.

E. Control Console: Tabletop unit with manual and computer-based programming controls, memory units, indicating devices, and the following features:

1. Grand-master level control.
2. Blackout switch.
3. Multiple submaster level controls with overlapping pile-on performance.
4. Bump buttons for momentary control of channels or submasters, one for each submaster level control.
5. Two cross-fade controls for split dipless fade between scenes, each with its own fade progress indicator.
6. One set of scene level controls for each scene when used in two-scene preset mode. Second set of scene level controls to allow setting levels into memory for expanded single scenes when used in multiple single-channel scene mode. Each set shall have same quantity of scene level controls as is used for submaster level controls.
7. Multi-button keypad for programming in multi-scene memory mode.

8. Fade time control for assigning fade time to cues, with individual cue adjustment from one second to five minutes, minimum.
9. Digital display, for operating menus and memory readout.
10. Controls for setting levels into memory.
11. Cord and connector for connecting console to outlets for console power and control.

F. System Operation: Selectable between multichannel two-scene preset and four-channel single-scene memory. Console features include electronic patching of control signals for up to 512 dimmers and off-line data storage using USB drive port. Operational capability includes the following:

1. Live and blind programming.
2. Special effects programmability for automatic operation of lights in pulsating, sequential dimming and brightening, and other special operating modes. Special effects menu displays operator guidance for programming and individual step levels.
3. Signal from fire-alarm control panel that automatically brings selected circuits to fully on or fully bright condition, overriding normal dimming and on-off controls.
4. Inserting cues between designated cues without renumbering.
5. Out-of-sequence playback of cues.
6. Controlling houselights and stage lights from console by assigning their dimmers or non-dim on-off controls to a channel.
7. Retaining programmed cues in memory for minimum of one year after power outage.
8. Automatic sequential execution of programmed cues.
9. Printing cues using parallel or serial printer port, cable, and printer. Cable and printer are not included with this system.

G. Console Power and Control Outlets: Multiple receptacles matched to connector on console connector cord.

H. House Lighting Control Station: Architectural-type, multichannel, remote-dimmer-control station with the following features:

1. System controls designated houselights, stage lights, and other lights.
2. Stage lighting controls compatible with dimming and control system.
3. Flush mounting.
4. As directed, Four, Eight or Sixteen channels, each with slider potentiometer control.
5. Master-slider potentiometer that controls lights on all channels proportionally from completely dimmed to degree of brightness that corresponds to individual slider positions.
6. Fully on switch that turns all channels on at full brightness regardless of slider position.
7. Take-control/off switch that places station in control of channels and sets lighting to levels dictated by channel and master-slider controls.
8. Legend on face of wall plate that identifies items as "House Lighting Control Station" and identifies functions of each slider and switch position, with slider positions individually graduated from zero to maximum.
9. Illuminated push buttons for activating preset scenes of house lighting and labeled "Entry", "Panic" or "Entry" and "Panic" as directed
10. Flush wall mounted unless otherwise indicated.

I. Emergency Lighting Control Station: Key-operated push button activates indicating light and brings selected dimmers to fully bright condition (i.e., the "Panic" preset). Operating push button a second time returns dimmers to previous setting.

1. Emergency mode indicating light.
2. Labeled "Emergency Lights."
3. Flush wall mounted unless otherwise indicated.

2.7 Desktop Operator Workstation

A. Performance Requirements:

1. Performance requirements may dictate equipment exceeding minimum requirements indicated.
2. Capable of running Microsoft Windows.
3. Energy Star compliant.

B. Personal Computer:

1. Minimum Processor Speed:
2. RAM:

a. Capacity: As directed, 2, 4 or 8.
b. Speed and Type: 1333 MHz.

3. Hard Drive:

a. Number of Hard Drives: As directed, One or Two.
b. Capacity: As directed.
c. Minimum Average Seek Time: As directed.
d. Cache Buffer Size: As directed.

4. Second Hard Drive:

a. Capacity: As directed.
b. Minimum Average Seek Time: As directed.
c. Cache Buffer Size: As directed.

5. Optical Drive:

a. Type: As directed.
b. Minimum Average Access Time: As directed.
c. Data Transfer Speed: As directed, MB or TB/s.
d. Reading Formats: Data, audio, recordable, and rewritable.

6. Optical Read and Write Drive:

a. Include with at least 2 MB of data buffer.
b. Type: As directed.
c. Minimum Data Buffer Capacity: As directed.
d. Minimum Average Access Time: As directed.

e. Nominal Data Transfer Rates:

1) Reading: As directed, MB or TB/s.
2) Writing: As directed, MB or TB/s.

f. Average access time of 150 ms or less.
g. MTBF of at least 100,000 power-on hours.

7. Expansion Slots: As directed, minimum of 4, 32 or 64 bit.
8. Video Card:

a. Capable of supporting as directed, one, two, three or four monitors.
b. Resolution: 1920 by 1200 pixels minimum for each monitor.
c. RAM: As directed, MB, GB or TB.
d. Controller Speed: As directed, Number of MHz or GHz.
e. On-Board Memory Speed: As directed, Number of MHz or GHz.
f. On-Board Memory Data Width: As directed, Number of bit.

9. Sound Card:

a. At least 128 voice wavetable synthesis.
b. Capable of delivering three-dimensional sound effects.
c. High-resolution 16-bit stereo digital audio recording and playback with user-selectable sample rates up to 48,000 Hz.

10. Network Interface Card: Include card with connection, as applicable.

a. 10-100-1000 base TX Ethernet with RJ45 connector port.
b. 100 base FX Ethernet with SC or ST port.

11. Wireless Ethernet, 802.11 a/b/g/n.
12. Optical Modem: Full duplex link for connection to fiber-optic cable provided.
13. I/O Ports:

a. Two USB 3.0 ports on front panel, six on back panel, and three internal on motherboard.
b. One serial port.
c. One parallel port.
d. Two PS/2 ports.
e. One RJ-45.
f. One stereo line-in and line-out on back panel.
g. One microphone and headphone connector on front panel.
h. One IEEE 1394 on front and back panel with PCI-e card.
i. One ESATA port on back panel.

14. Battery: Life of at least three years to maintain system clock/calendar and ROM, as a minimum.

C. Keyboard:

1. 101 enhanced keyboard.

2. Full upper- and lowercase ASCII keyset, numeric keypad, dedicated cursor control keypad, and 12 programmable function keys.
3. Wireless operation within up to 72 inches (1800 mm) in front of workstation.

D. Pointing Device:

1. Either a two- or three-button mouse.
2. Wireless operation within up to 72 inches (1800 mm) in front of workstation.

E. Flat Panel Display Monitor:

1. Number of Displays: As directed, One or Two.

    a. Display Support: As directed, individual tilt adjustable base, Desk mounted, adjustable bracket capable of supporting number of monitors specified above with integral power and display cable organization or Wall mounted, adjustable bracket capable of supporting number of monitors specified above with integral power and display cable organization.

2. Color display with Inches (mm) of diagonal viewable area as directed.
3. Aspect Ratio: 16 to 9.
4. Resolution: 1920 by 1080 pixels at 60 Hz with pixel size of 0.277 mm or smaller.
5. Digital or analog input signal.
6. Response Time: Number of ms as directed.
7. Dynamic Contrast Ratio: 50000 to 1.
8. Brightness: 250 cd/sq. m.
9. Energy Star compliant.
10. Antiglare display.

F. Speakers:

1. Two, with individual controls for volume, bass, and treble.
2. Signal to Noise Ratio: At least 65 dB.
3. Power: At least 4 W per speaker/channel.
4. Magnetic shielding to prevent distortion on the video monitor.

G. I/O Cabling: Include applicable cabling to connect I/O devices.

H. Software:

1. Factory-installed operating system.
2. Uninterruptable power supply (UPS) unit for the workstation.

    a. Provide continuous, regulated output power without using their batteries during brown-out, surge, and spike conditions.

        1) Load served shall not exceed 75 percent of UPS rated capacity, including power factor of connected loads, but excluding the printer. UPS shall provide 15 minutes of battery power.

    b. Performance:

1) Input Voltage: Single phase, 120-V ac, compatible with field power source.
2) Load Power Factor Range (Crest Factor): 0.65 to 1.0.
3) Output Voltage: 101- to 132-V ac, while input voltage varies between 89- and 152-V ac.
4) On-Battery Output Voltage: Sine wave.
5) Inverter overload capacity shall be minimum 150 percent for 30 seconds.
6) Recharge time shall be a maximum of six hours to 90 percent capacity after full discharge to cutoff.
7) Transfer Time: 6 ms.

c. UPS shall be automatic during fault or overload conditions.
d. Unit with integral line-interactive, power condition topology to eliminate all power contaminants.
e. Include front panel with power switch and visual indication of power, battery, fault, and temperature.
f. Unit shall include an audible alarm of faults and front panel silence feature.
g. Unit with four 120-V, 15-A receptacles.
h. UPS shall include dry contacts (digital output points) for low battery condition and battery-on (primary utility power failure) and connect the points to the monitoring and control system.
i. Batteries shall be sealed lead-acid type and be maintenance free. Battery replacement shall be front accessible by user without dropping load.
j. Include tower models installed in ventilated cabinets at the particular installation location.

2.8 RIGGING COMPONENTS

A. Pipe Clamps: Malleable iron, suitable for clamping luminaires or items to pipe from 3/4 to 2 inches (20 to 51 mm) in OD. Arranged for horizontal rotation of yoke for aiming; equipped with T-bolt to lock alignment.

B. Safety Cables: Heavy-duty, flexible steel; 30-inch (762-mm) nominal length, with spring clip at one end and steel ring at the other end.

C. Cable Grips: As directed, Stainless or Galvanized steel; basket-weave type for supporting stage cables.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Set permanently mounted items level, plumb, and square with ceilings and walls.

C. Indicated mounting heights are to bottom of unit for suspended items and to center of unit for wall-mounted items.

D. Mount and connect luminaires and install and connect distribution devices.

1. If arrangement is not indicated, install so each luminaire, dimmer, house lighting circuit, control channel, and outlet circuit can be operated, and complete system demonstrated, in all operating modes.
2. Install safety cables secured to stage rigging or gridiron for all pipe-mounted electrical luminaires and equipment.

E. Dimmer Rack Mounting: Install and anchor dimmer racks level on 4-inch- (100-mm-) high concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.
2. For dimmer racks, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to dimmer racks.

F. Comply with mounting and anchoring requirements specified in Section 260529 "Hangers and Supports for Electrical Systems" and Section 260548.16 "Seismic Controls for Electrical Systems."

3.2 WIRING

A. Power Wiring:

1. Install wiring as specified in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for hardwired connections. Install wiring in raceways except cable and plug connections. Install cable strain relief device on power and control cable drops.
2. Install power wiring with a separate neutral for each output circuit from main dimmer and for each house and stage lighting circuit.

B. Signaling, Remote-Control, and Power-Limited Circuits:

1. Comply with requirements specified in Section 260523 "Control-Voltage Electrical Power Cables" for installation of wiring. Install wiring in raceways except cable and plug connections.
2. Comply with the following unless otherwise indicated:

    a. Size conductors according to lighting control device manufacturer's written instructions.
    b. Select cable insulation, shielding, drain wire, and jacket complying with lighting control device manufacturer's written instructions.
    c. Install circuits to eliminate RFI and electromagnetic interference.

3. Remote-control circuits associated with emergency lighting control shall be installed complying with Class 1 circuit standards in NFPA 70.

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes and in terminal cabinets and equipment enclosures.

E. Remove wall plates and protect devices and assemblies during painting.

F. Support luminaires, distribution components, and accessories as specified in Section 260529 "Hangers and Supports for Electrical Systems." Equip all pipe-mounted equipment with safety cables that are secured to supporting pipe.

G. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.3 IDENTIFICATION

A. Identify components and power and control wiring according to Section 260553 "Identification for Electrical Systems."

B. Label each luminaire, lighting outlet, distribution device, and dimmer module with unique designation. Labels on elevated components shall be readable from the floor.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Schedule visual and mechanical inspections and electrical tests with at least seven days' advance notice.
2. Visual and Mechanical Tests and Inspections:

    a. Inspect each luminaire, outlet, module, control, and device for defects, finish failure, corrosion, physical damage, labeling by an NRTL, and nameplate.
    b. Exercise and perform operational tests on mechanical parts and operable devices according to manufacturer's written instructions.
    c. Check tightness of electrical connections with torque wrench.
    d. Verify proper protective device settings, fuse types, and ratings.
    e. Record results of tests and inspections.

3. Electrical Tests: Perform tests according to manufacturer's written instructions.

    a. Continuity tests of circuits.
    b. Operational Tests: Connect each outlet to a luminaire and a dimmer output circuit, so each dimmer module, dimmer-control and output circuit, outlet, and luminaire in a typical operating mode will be sequentially tested. Set and operate controls to demonstrate luminaires, outlets, dimmers, and controls in a sequence that cues and reproduces actual operating functions for a typical system of the size and scope installed. Include operation and control of houselights and stage lights from each control location and station, including optional plug-in, control-console outlet

locations. Record luminaire and outlet assignments, control settings, operations, cues, and observations of performance.

B. Stage lighting will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

1. Prepare a schedule of lighting outlets by number; indicate circuits, dimmers, connected luminaires, and control-channel assignments. Prepare a schedule of control settings and circuit assignments for house control channels. Prepare written reports of tests and observations. Report defective materials, workmanship, and unsatisfactory test results. Include records of repairs and adjustments made.

3.5 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.6 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's staff to adjust, operate, and maintain stage lighting equipment.

1. As directed, Training shall be one or two four-hour session or sessions.
2. Include costs associated with the training with the equipment installation.
3. Provide a 14-day notice to Owner prior to scheduling training period.

END OF SECTION 265561

SECTION 265613 - LIGHTING POLES AND STANDARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Poles and accessories for support of luminaires.
2. Luminaire-lowering devices.

1.2 DEFINITIONS

A. EPA: Equivalent projected area.

B. Luminaire: Complete luminaire.

C. Pole: Luminaire-supporting structure, including tower used for large-area illumination.

D. Standard: See "Pole."

1.3 ACTION SUBMITTALS

A. Product Data: For each pole, accessory, and luminaire-supporting and -lowering device.

B. Sustainable Design Submittals:

C. Shop Drawings:

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly of poles and pole accessories.
4. Foundation construction details, including material descriptions, dimensions, anchor bolts, support devices, and calculations, signed and sealed by a professional engineer licensed in the state of installation.
5. Anchor bolt templates keyed to specific poles and certified by manufacturer.
6. Method and procedure of pole installation. Include manufacturer's written installations.

1.4 INFORMATIONAL SUBMITTALS

A. Pole and Support Component Certificates: Signed by manufacturers of poles, certifying that products are designed for indicated load requirements according to AASHTO LTS-6-M and that load imposed by luminaire and attachments has been included in design. The certification shall be based on design calculations signed and sealed by a professional engineer.

B. Seismic Qualification Certificates: As Directed For equipment, accessories, and components, from manufacturer.

C. Material test reports.

D. Field quality-control reports.

E. Sample warranty.

F. Soil test reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data for pole-lowering devices and pole-mounted accessories.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of pole(s) and luminaire-lowering device(s) that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within a specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs from special warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design pole foundation and pole power system.

B. Seismic Performance: Foundation and pole shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the system will remain in place without separation of any parts when subjected to the seismic forces specified and the system will be fully operational after the seismic event."
2. Component Importance Factor: As directed 1.5 or 1.0.

C. Structural Characteristics: Comply with AASHTO LTS-6-M.

D. Dead Load: Weight of luminaire and its horizontal and vertical supports, lowering devices, and supporting structure, applied according to AASHTO LTS-6-M.

E. Live Load: Single load of 500 lbf (2200 N) distributed according to AASHTO LTS-6-M.

F. Ice Load: Load of 3 lbf/sq. ft. (145 Pa), applied according to AASHTO LTS-6-M for applicable areas on the Ice Load Map.

G. Wind Load: Pressure of wind on pole and luminaire, calculated and applied according to AASHTO LTS-6-M.

1. Basic wind speed for calculating wind load for poles exceeding 50 feet (15 m) in height is 100 mph (45 m/s) or 90 mph (40 m/s) as directed.

   a. Wind Importance Factor: 1.0.
   b. Minimum Design Life: 50 years.
   c. Velocity Conversion Factor: 1.0.

2. Basic wind speed for calculating wind load for poles 50 feet (15 m) high or less is 100 mph (45 m/s) or 90 mph (40 m/s) as directed.

   a. Wind Importance Factor: 1.0.
   b. Minimum Design Life: 25 years.
   c. Velocity Conversion Factor: 1.0.

H. Strength Analysis: For each pole, multiply the actual EPA of luminaires and brackets by a factor of 1.1 to obtain the EPA to be used in pole selection strength analysis.

I. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.

2.2 STEEL POLES

A. Source Limitations: Obtain poles from single manufacturer or producer.

B. Source Limitations: For poles, obtain each color, grade, finish, type, and variety of pole from single source with resources to provide products of consistent quality in appearance and physical properties.

C. Poles: Comply with ASTM A500/A500M, Grade B carbon steel with a minimum yield of 46,000 psig (317 MPa); one-piece construction up to 40 feet (12 m) in height with access handhole in pole wall.

1. Shape: As directed Round, tapered, Round, straight, Square, tapered or Square, straight.
2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.

D. Poles: As directed Comply with ASTM A240/A240M or ASTM A666, stainless steel with a minimum yield of 55,000 psig (379 MPa); one-piece construction up to 40 feet (12 m) in height with access handhole in pole wall.

1. Shape: As directed Round, tapered, Round, straight, Square, tapered or Square, straight.
2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.

E. Steel Mast Arms: As directed Single-arm, Truss or Davit type, continuously welded to pole attachment plate. Material and finish same as plate.

F. Brackets for Luminaires: Detachable, cantilever, without underbrace.

1. Adaptor fitting welded to pole, allowing the bracket to be bolted to the pole-mounted adapter, then bolted together with stainless or galvanized-steel bolts as directed.
2. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire. Match pole material and finish.

G. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.

H. Fasteners: As directed Stainless steel or Galvanized steel, size and type as determined by manufacturer. Corrosion-resistant items compatible with support components.

1. Materials: Compatible with poles and standards as well as the substrates to which poles and standards are fastened and shall not cause galvanic action at contact points.
2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.

I. Grounding and Bonding Lugs: Welded 1/2-inch (13-mm) threaded lug, complying with requirements in Section 260526 "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size indicated, and accessible through handhole.

J. Handhole: Oval shaped, with minimum clear opening of 2-1/2 by 5 inches (65 by 130 mm), with cover secured by stainless-steel captive screws.

K. Intermediate Handhole and Cable Support: Weatherproof, 3-by-5-inch (76-by-130-mm) handhole located at midpoint of pole, with cover for access to internal welded attachment lug for electric cable support grip.

L. Cable Support Grip: Wire-mesh type with rotating attachment eye, sized for diameter of cable and rated for a minimum load equal to weight of supported load multiplied by a 5.0 safety factor.

M. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.

N. Galvanized Finish: After fabrication, hot-dip galvanize according to ASTM A123/A123M.

O. Factory-Painted Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces according to SSPC-SP 1 to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, according to SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
2. Interior Surfaces of Pole: One coat of bituminous paint, or otherwise treat for equal corrosion protection.

3. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high gloss, high-build polyurethane enamel.

    a. Color: As indicated by manufacturer's designations, Match Architect's sample or As selected by Architect from manufacturer's full range.

P. Powder-Coat Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces according to SSPC-SP 1 to remove dirt, oil, grease, and other contaminants that could impair powder coat bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, according to SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
2. Powder Coat: Comply with AAMA 2604.

    a. Electrostatic-applied powder coating; single application and cured to a minimum 2.5- to 3.5-mils dry film thickness. Coat interior and exterior of pole for equal corrosion protection.
    b. Color: As indicated by manufacturer's designations, Match Architect's sample or as selected by Architect from manufacturer's full range.

2.3 ALUMINUM POLES

A. Poles: As directed Seamed or Seamless, extruded structural tube complying with ASTM B221, Alloy 6063-T6, with access handhole in pole wall.

B. Poles: As directed Seamed or Seamless, extruded structural tube complying with ASTM B221, Alloy 6061-T6, with access handhole in in pole wall.

1. Shape: As directed Round, tapered, Round, straight, Square, tapered or Square, straight.
2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.

C. Mast Arms: As directed Aluminum, Steel, Single-arm, Truss or Davit type, continuously welded to pole attachment plate. Material and finish same as plate.

D. Brackets for Luminaires: Detachable, cantilever, without underbrace.

1. Adaptor fitting welded to pole, allowing the bracket to be bolted to the pole-mounted adapter, then bolted together with stainless or galvanized-steel bolts as directed.
2. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire. Match pole material and finish.

E. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.

F. Grounding and Bonding Lugs: Bolted 1/2-inch (13-mm) threaded lug, complying with requirements in Section 260526 "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.

G. Fasteners: As directed Stainless steel or Galvanized steel, size and type as determined by manufacturer. Corrosion-resistant items compatible with support components.

1. Materials: Compatible with poles and standards as well as to substrates to which poles and standards are fastened and shall not cause galvanic action at contact points.
2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.

H. Handhole: Oval shaped, with minimum clear opening of 2-1/2 by 5 inches (65 by 130 mm), with cover secured by stainless-steel captive screws.

I. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.

J. Aluminum Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" recommendations for applying and designating finishes.

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20 requirements; and seal aluminum surfaces with clear, hard-coat wax.
3. Class I, Clear-Anodic Finish: AA-M32C22A41 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I clear coating of 0.018 mm or thicker), complying with AAMA 611.
4. Class I, Color-Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: Medium; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I integrally colored or electrolytically deposited color coating 0.018 mm or thicker), complying with AAMA 611.

K. Factory-Painted Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1 to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, according to SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
2. Interior Surfaces of Pole: One coat of bituminous paint, or otherwise treat for equal corrosion protection.
3. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.

    a. Color: As indicated by manufacturer's designations, Match Architect's sample or As selected by Architect from manufacturer's full range.

L. Powder-Coat Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1 to remove dirt, oil, grease, and other contaminants that could impair powder coat bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, according to SSPC-SP 5/NACE No. 1 or SSPC-SP 8.

2. Powder coat shall comply with AAMA 2604.

    a. Electrostatic applied powder coating; single application with a minimum 2.5- to 3.5-mils dry film thickness; cured according to manufacturer's instructions. Coat interior and exterior of pole for equal corrosion protection.
    b. Color: As indicated by manufacturer's designations, Match Architect's sample or as selected by Architect from manufacturer's full range.

2.4 WOOD POLES

A. Poles: As directed Douglas fir, Southern yellow pine, machine trimmed by turning, for wood species used; and bored, roofed, and grained before treatment.

1. Pole Brand: Brand the manufacturer's trademark and date of treatment, height and class of pole, wood species, preservation code, and retention. Brand shall be placed so that the bottom of the brand is minimum 10 feet (3 m) from pole butt.
2. Mounting Provisions: Embedded.

B. Fasteners: As directed Stainless steel or Galvanized steel, size and type as determined by manufacturer. Corrosion-resistant items compatible with support components.

1. Materials: Compatible with poles and standards as well as the substrates to which poles and standards are fastened and shall not cause galvanic action at contact points.
2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.

C. Preservative Treatment: As directed Treat according to AWPA UC4A, AWPA UC4B or AWPA UC4C.

D. Luminaire Brackets: Comply with ANSI C136.13.

2.5 POLE ACCESSORIES

A. Base Covers: Manufacturers' standard metal units, finished same as pole, and arranged to cover pole's mounting bolts and nuts.

B. Transformer-Type Base: Same material and color as pole. As directed Coordinate dimensions to suit pole's base flange and to accept ballast(s) or indicated accessories. Include removable flanged access cover secured with bolts or screws.

2.6 MOUNTING HARDWARE

A. Anchor Bolts: Manufactured to ASTM F1554, Grade 55, with a minimum yield strength of 55,000 psi (380,000 kPa).

1. Galvanizing: As directed Hot dip galvanized according to ASTM A153, Class C or Mechanically deposited galvanization according to ASTM B695, Class 50.

2. Bent or Headed rods inches (mm) in diameter as directed by inches (mm) in length as directed.
3. Threading: As directed Uniform National Coarse or Uniform National 8, Class 2A.

B. Nuts: ASTM A563, Grade A, Heavy-Hex

1. Galvanizing: As directed Hot dip galvanized according to ASTM A153, Class C or Mechanically deposited galvanization according to ASTM B695, Class 50.
2. As directed Two or Four nuts provided per anchor bolt, shipped with nuts pre-assembled to the anchor bolts.

C. Washers: ASTM F436, Type 1.

1. Galvanizing: Hot dip galvanized according to ASTM A153, Class C Mechanically deposited galvanization according to ASTM B695, Class 50.
2. As directed One or Two washers provided per anchor bolt.

2.7 GENERAL FINISH REQUIREMENTS

A. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Appearance of Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

PART 3 - EXECUTION

3.1 POLE FOUNDATION

A. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Structural steel complying with ASTM A36/A36M and hot-dip galvanized according to ASTM A123/A123M; and with top-plate and mounting bolts to match pole-base flange and strength required to support pole, luminaire, and accessories. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."

B. Pre-Cast Foundations: Factory fabricated, with structural steel complying with ASTM A36/A36M and hot-dip galvanized according to ASTM A123/A123M; and with top-plate and mounting bolts to match pole-base flange and strength required to support pole, luminaire, and accessories. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."

C. Power-Installed Screw Foundations: Factory fabricated by pole manufacturer, with structural steel complying with ASTM A36/A36M and hot-dip galvanized according to ASTM A123/A123M; and with top-plate and mounting bolts to match pole-base flange and strength required to support pole, luminaire, and accessories.

1. Baseplate: Stamped with manufacturer's name, date of production, and cable entry.

D. Direct-Buried Foundations: Install to depth indicated on Drawings, but not less than one-sixth of pole height or as indicated. Add backfill in 6-inch (150-mm) to 9-inch (230-mm) layers, tamping each layer before adding the next or as shown on Drawings. To ensure a plumb installation, continuously check pole orientation with plumb bob while tamping.

E. Direct-Buried Poles with Concrete Backfill: Set poles in augered holes to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height or as indicated. To ensure a plumb installation, continuously check pole orientation with plumb bob while tamping.

1. Make holes 6 inches (150 mm) in diameter larger than pole diameter.
2. Fill augered hole around pole with air-entrained concrete having a minimum compressive strength of 3000 psi (20 MPa) at 28 days and finish in a dome above finished grade.
3. Use a short piece of 1/2-inch (13-mm) diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.
4. Cure concrete a minimum of 72 hours before performing work on pole.

F. Anchor Bolts: As directed Install plumb using manufacturer-supplied steel or plywood template, uniformly spaced.

3.2 POLE INSTALLATION

A. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Section 033000 "Cast-in-Place Concrete."

B. Foundation-Mounted Poles: Mount pole with leveling nuts and tighten top nuts to torque level according to pole manufacturer's written instructions.

C. Poles and Pole Foundations Set in Concrete-Paved Areas: Install poles with a minimum 6-inch-(150-mm-) wide, unpaved gap between the pole or pole foundation and the edge of the adjacent concrete slab. Fill unpaved ring with pea gravel. Insert material to a level 1 inch (25 mm) below top of concrete slab.

D. Raise and set pole using web fabric slings (not chain or cable) at locations indicated by manufacturer.

3.3 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum using insulating fittings or treatment.

B. Steel Conduits: Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- (0.254-mm-) thick, pipe-wrapping plastic tape applied with a 50-percent overlap.

3.4 GROUNDING

A. Ground Metal Poles and Support Structures: Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

1. Install grounding electrode for each pole unless otherwise indicated.
2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.

B. Ground Nonmetallic Poles and Support Structures: Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

1. Install grounding electrode for each pole.
2. Install grounding conductor and conductor protector.
3. Ground metallic components of pole accessories and foundation.

END OF SECTION 265613

SECTION 265617 - FLUORESCENT EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Exterior fluorescent luminaires, lamps, and ballasts.
2. Luminaire-mounted photoelectric relays.

1.2 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color rendering index.

C. Fixture: See "Luminaire."

D. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of luminaire.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Sustainable Design Submittals:

D. Delegated-Design Submittal: For luminaire supports.

1. Include design calculations for luminaire supports and seismic restraints and for designing vibration isolation bases.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale, and coordinated.

B. Seismic Qualification Data: For luminaires, accessories, and components, from manufacturer.

C. Product Certificates: For each type of the following:

1. Ballast for bi-level and dimmable luminaires.
2. Lamp.
3. Photoelectric relay.

D. Sample warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 FIELD CONDITIONS

A. Mark locations of exterior luminaires for approval by Architect prior to the start of luminaire installation.

1.7 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

B. Seismic Performance: Luminaires and lamps shall be labeled vibration and shock resistant.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

2.2 LUMINAIRE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NRTL Compliance: Luminaires shall comply with UL 1598 and be listed and labeled for indicated class and division of hazard by an NRTL.

C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

D. UL Compliance: Comply with UL 1598. As directed, Luminaire assembly consists of UL-recognized components or Luminaire assembly listed for wet location.

E. As directed, Lamp base complying with ANSI C81.61 or IEC 60061-1.

F. Nominal Operating Voltage: As directed, 120 V ac, 240 V ac, 277 V ac or 480 V ac.

G. EMI Filters: Factory installed to suppress conducted EMI as required by MIL-STD-461E. Fabricate luminaires with one filter on each ballast that is indicated to require a filter.

H. In-line Fusing: As directed, install on the ballast primary for each luminaire or Provide a separate in-line fuse for each luminaire.

I. Lamp Rating: Lamp marked for outdoor use and in enclosed locations.

J. Source Limitations: Obtain luminaires from single source from a single manufacturer.

K. Source Limitations: For luminaires, obtain each color, grade, finish, type, and variety of luminaire from single source with resources to provide products of consistent quality in appearance and physical properties.

2.3 FLUORESCENT LAMPS

A. T8 rapid-start lamps, rated 32-W maximum, nominal length of 48 inches (1220 mm), 2800 initial lumens (minimum), CRI of 75 (minimum), color temperature of 3500 K, and average rated life of 20,000 hours unless otherwise indicated.

B. T8 rapid-start lamps, rated 17-W maximum, nominal length of 24 inches (610 mm), 1300 initial lumens (minimum), CRI of 75 (minimum), color temperature of 3500 K, and average rated life of 20,000 hours unless otherwise indicated.

C. T5 rapid-start lamps, rated 28-W maximum, nominal length of 45.2 inches (1150 mm), 2900 initial lumens (minimum), CRI of 85 (minimum), color temperature of 3000 K, and average rated life of 20,000 hours unless otherwise indicated.

D. T5HO rapid-start, high-output lamps, rated 54-W maximum, nominal length of 45.2 inches (1150 mm), 5000 initial lumens (minimum), CRI of 85 (minimum), color temperature of 4100 K, and average rated life of 20,000 hours unless otherwise indicated.

E. Compact Fluorescent Lamps: Four-pin, CRI of 80 (minimum), color temperature of 3500 K, average rated life of 10,000 hours at three hours of operation per start, and suitable for use with dimming ballasts unless otherwise indicated.

1. 13 W: T4, double or triple tube, rated 900 initial lumens (minimum).
2. 18 W: T4, double or triple tube, rated 1200 initial lumens (minimum).
3. 26 W: T4, double or triple tube, rated 1800 initial lumens (minimum).
4. 32 W: T4, triple tube, rated 2400 initial lumens (minimum).
5. 42 W: T4, triple tube, rated 3200 initial lumens (minimum).

6. 57 W: T4, triple tube, rated 4300 initial lumens (minimum).
7. 70 W: T4, triple tube, rated 5200 initial lumens (minimum).

2.4 BALLASTS FOR FLUORESCENT LAMPS

A. General Requirements for Electronic Ballasts:

1. Comply with UL 935 and with ANSI C82.11.
2. Designed for type and quantity of lamps served.
3. Sound Rating: As directed, Class A or Class A, except Class B for T12/HO and T12/Slimline lamp ballasts.
4. THD Rating: As directed, Less than 10 or 20 percent.
5. Surge Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
6. Operating Frequency: 42 kHz or higher.
7. Lamp Current Crest Factor: 1.7 or less.
8. BF: 0.88 or higher.
9. Power Factor: 0.95 or 0.98 or higher.

B. Electronic Programmed-Start Ballasts for T5, T8, T5HO or T5 and T5HO Lamps as directed: Comply with ANSI C82.11 and the following:

1. Lamp end-of-life detection and shutdown circuit for T5 diameter lamps.
2. Automatic lamp starting after lamp replacement.

C. Electromagnetic Ballasts: Comply with ANSI C82.11; energy saving, high-power factor, Class P, and having automatic-reset thermal protection.

1. Ballast Manufacturer Certification: Indicated by label.

D. Single Ballasts for Multiple Luminaires: Factory wired with ballast arrangements and bundled extension wiring to suit final installation conditions without modification or rewiring in the field.

E. Ballasts for Low-Temperature Environments:

1. Temperatures 0 Deg F (Minus 17 Deg C) and Higher: As directed, Electronic or electromagnetic type rated for 0 deg F (minus 17 deg C) starting and operating temperature with indicated lamp types.
2. Temperatures Minus 20 Deg F (Minus 29 Deg C) and Higher: Electromagnetic type designed for use with indicated lamp types.
3. Control: Coordinate wiring from ballast to control device to ensure that ballast, controller, and connecting wiring are compatible.

2.5 LUMINAIRE TYPES

A. Area and Site:
1. Luminaire Shape: As directed, Round, Square or Hexagonal.
2. Mounting: As directed, Pole or Building with extruded-aluminum or stainless-steel, rectangular or round arm, 11 inches (280 mm) or 13 inches (330 mm) in length.

3. Luminaire-Mounting Height: As directed.
4. Distribution: As directed, Type I, Type II, Type III, Type IV or Type V.
5. Diffusers and Globes: As directed, Tempered Fresnel glass, Prismatic glass, Diffuse glass, Clear glass, Prismatic acrylic, Clear, UV-stabilized acrylic or Clear polycarbonate.
6. Housings:

    a. Extruded-aluminum housing and heat sink.
    b. Clear anodized, powder-coat or painted finish as directed.

B. Bollard:
1. Shape: As directed, Round, Square, Hexagonal or Fluted.
2. Height from Finished Grade: As directed, 24 inches (600 mm), 30 inches (762 mm) or 36 inches (900 mm).
3. Overall Height: As directed, 30 inches (762 mm) or 36 inches (900 mm).
4. Diameter: 6 inches (150 mm).
5. Mounting: Three-point cast-aluminum base.
6. Distribution: As directed, Type III or Type V.
7. Diffusers and Globes: As directed, Tempered Fresnel glass, Prismatic glass, Diffuse glass, Clear glass, Prismatic acrylic, Clear, UV-stabilized acrylic or Clear polycarbonate.
8. Housings:

    a. Extruded-aluminum housing and heat sink.
    b. As directed, Clear anodized, powder-coat or painted finish.

C. Canopy:
1. Shape: As directed, Round or Square.
2. Dimensions: As directed, 12 inches (300 mm), square or in diameter.
3. Diffusers and Globes: As directed, Tempered Fresnel glass, Prismatic glass, Diffuse glass, Clear glass, Prismatic acrylic, Clear, UV-stabilized acrylic or Clear polycarbonate.
4. Housings:

    a. Extruded-aluminum housing and heat sink.
    b. As directed, Clear anodized, powder-coat or painted finish.

2.6 MATERIALS

A. Metal Parts: Free of burrs and sharp corners and edges.

B. Sheet Metal Components: As directed, Corrosion-resistant aluminum, Stainless steel oe Epoxy-coated steel. Form and support to prevent warping and sagging.

C. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses. Ballast shall automatically disconnect when door opens.

D. Diffusers and Globes:

1. Acrylic Diffusers: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
2. Glass: Annealed crystal glass unless otherwise indicated.
3. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

E. Lens and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

F. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:

1. White Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.

G. Housings:

1. Rigidly formed, weather- and light-tight enclosure that will not warp, sag, or deform in use.
2. Provide filter/breather for enclosed luminaires.

2.7 FINISHES

A. Variations in Finishes: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

B. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.

C. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20 requirements; and seal aluminum surfaces with clear, hard-coat wax.
3. Class I, Clear-Anodic Finish: AA-M32C22A41 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker), complying with AAMA 611.
4. Class I, Color-Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker), complying with AAMA 611.

    a. Color: As directed, Light bronze, Medium bronze, Dark bronze or Black.

D. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1 to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.

a. Color: As selected from manufacturer's standard catalog of colors.
b. Color: Match Architect's sample of manufacturer's standard or custom color.
c. Color: As selected by Architect from manufacturer's full range.

2.8 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish shall match luminaire.

C. Wires: ASTM A641/A641M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm).

D. Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

A. Comply with NECA 1.

B. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.

C. Install lamps in each luminaire.

D. Fasten luminaire to structural support.

E. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and relamping.
3. Support luminaires without causing deflection of finished surface.
4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.

F. Wall-Mounted Luminaire Support:

1. As directed, attached to structural members in walls, attached to a minimum 1/8-inch (3-mm) backing plate attached to wall structural members or Attached using through bolts and backing plates on either side of wall.

G. Wiring Method: Install cables in raceways. Conceal raceways and cables.

H. Install luminaires level, plumb, and square with finished grade unless otherwise indicated. Install luminaires at height and aiming angle as indicated on Drawings.

I. Coordinate layout and installation of luminaires with other construction.

J. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.

K. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and Section 260533 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.

3.2 BOLLARD LUMINAIRE INSTALLATION

A. Align units for optimum directional alignment of light distribution.

1. Install on concrete base with top 4 inches (100 mm) above finished grade or surface at luminaire location. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 033000 "Cast-in-Place Concrete."

3.3 INSTALLATION OF INDIVIDUAL GROUND-MOUNTED LUMINAIRES

A. Install on concrete base with top 4 inches (100 mm) above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 033000 "Cast-in-Place Concrete."

3.4 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Section 260533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- (0.254-mm-) thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.5 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.6 FIELD QUALITY CONTROL

A. Inspect each installed luminaire for damage. Replace damaged luminaires and components.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Verify operation of photoelectric controls.

C. Illumination Tests:

1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IES testing guide(s):

a. IES LM-5.
b. IES LM-50.
c. IES LM-52.
d. IES LM-64.
e. IES LM-72.

2. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.

D. Luminaire will be considered defective if it does not pass tests and inspections.

E. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain luminaires and photocell relays.

END OF SECTION 265617

SECTION 265619 - LED EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Exterior solid-state luminaires that are designed for and exclusively use LED lamp technology.
2. Luminaire supports.
3. Luminaire-mounted photoelectric relays.

B. Related Requirements:

1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
2. Section 260926 "Lighting Control Panelboards" for panelboard-based lighting control.
3. Section 260943.16 "Addressable-Luminaire Lighting Controls" and Section 260943.23 "Relay-Based Lighting Controls" for manual or programmable control systems with low-voltage control wiring or data communication circuits.
4. Section 265613 "Lighting Poles and Standards" for poles and standards used to support exterior lighting equipment.

1.2 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color rendering index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating

E. Lumen: Measured output of lamp and luminaire, or both.

F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of luminaire.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.

2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Sustainable Design Submittals:

D. Delegated-Design Submittal: For luminaire supports.

1. Include design calculations for luminaire supports and seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale and coordinated.

B. Seismic Qualification Data: For luminaires, accessories, and components, from manufacturer.

C. Product Certificates: For each type of the following:

1. Luminaire.
2. Photoelectric relay.

D. Sample warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1. Provide a list of all lamp types used on Project. Use ANSI and manufacturers' codes.
2. Provide a list of all photoelectric relay types used on Project; use manufacturers' codes.

1.6 FIELD CONDITIONS

A. Mark locations of exterior luminaires for approval by Architect prior to the start of luminaire installation.

1.7 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 2 year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

B. Seismic Performance: Luminaires and lamps shall be labeled vibration and shock resistant.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

2.2 LUMINAIRE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NRTL Compliance: Luminaires shall be listed and labeled for indicated class and division of hazard by an NRTL.

C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

D. UL Compliance: Comply with UL 1598 and listed for wet location.

E. Lamp base complying with ANSI C81.61 or IEC 60061-1.

F. As directed, CRI of minimum, 65, 70 or 80. CCT of 2700 K, 3000 K or 4100 K.

G. As directed, L70 lamp life of 35,000 or 50,000 hours.

H. Lamps dimmable from 100 percent to 0 percent of maximum light output.

I. Nominal Operating Voltage: As directed, 120 V ac, 240 V ac, 277 V ac, 12 V dc or 24 V dc.

J. In-line Fusing: As directed, on the primary for each luminaire or Separate in-line fuse for each luminaire.

K. Lamp Rating: Lamp marked for outdoor use and in enclosed locations.

L. Source Limitations: Obtain luminaires from single source from a single manufacturer.

M. Source Limitations: For luminaires, obtain each color, grade, finish, type, and variety of luminaire from single source with resources to provide products of consistent quality in appearance and physical properties.

2.3 LUMINAIRE TYPES

A. Area and Site:
   1. Luminaire Shape: As directed, Round, Square or Hexagonal.
   2. Mounting: As directed, Pole or Building with extruded-aluminum, stainless-steel, rectangular or round arm, 11 inches (280 mm) or 13 inches (330 mm) in length.
   3. Luminaire-Mounting Height: As directed.
   4. Distribution: As directed, Type I, Type II, Type III, Type IV or Type V.

B. Canopy:
   1. Shape: As directed, Round or Square.
   2. Dimensions: As directed, 12 inches (300 mm), square or in diameter.

C. Decorative Post Top:
   1. Luminaire-Mounting Height: As directed.
   2. Mounting Type: As directed, Arm, Tenon or Ring.
   3. Distribution: As directed, Type I, Type II, Type III, Type IV or Type V.

2.4 MATERIALS

A. Metal Parts: Free of burrs and sharp corners and edges.

B. Sheet Metal Components: As directed, Corrosion-resistant aluminum, Stainless steel or Epoxy-coated steel. Form and support to prevent warping and sagging.

C. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other- components from falling accidentally during re-lamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses.

D. Diffusers and Globes:

   1. Acrylic Diffusers: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
   2. Glass: Annealed crystal glass unless otherwise indicated.
   3. Lens Thickness: At least 0.125-inch (3.175 mm) minimum unless otherwise indicated.

E. Lens and Refractor Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

F. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:

   1. White Surfaces: 85 percent.
   2. Specular Surfaces: 83 percent.
   3. Diffusing Specular Surfaces: 75 percent.

G. Housings:

1. Rigidly formed, weather- and light-tight enclosure that will not warp, sag, or deform in use.
2. Provide filter/breather for enclosed luminaires.

2.5 FINISHES

A. Variations in Finishes: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

B. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.

C. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20 requirements; and seal aluminum surfaces with clear, hard-coat wax.
3. Class I, Clear-Anodic Finish: AA-M32C22A41 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
4. Class I, Color-Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker), complying with AAMA 611.

    a. Color: As directed, Light bronze, Medium bronze, Dark bronze or Black.

D. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.

    a. Color: As selected from manufacturer's standard catalog of colors.
    b. Color: Match Architect's sample of manufacturer's standard or custom color as directed.
    c. Color: As selected by Architect from manufacturer's full range.

2.6 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

A. Comply with NECA 1.

B. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.

C. Install lamps in each luminaire.

D. Fasten luminaire to structural support.

E. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and re-lamping.
3. Support luminaires without causing deflection of finished surface.
4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.

F. Wall-Mounted Luminaire Support:

1. As directed, attached to structural members in walls, attached to a minimum 1/8 inch (3 mm) backing plate attached to wall structural members or Attached using through bolts and backing plates on either side of wall.

G. Wiring Method: Install cables in raceways. Conceal raceways and cables.

H. Install luminaires level, plumb, and square with finished grade unless otherwise indicated. Install luminaires at height and aiming angle as indicated on Drawings.

I. Coordinate layout and installation of luminaires with other construction.

J. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.

K. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and Section 260533 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.

3.2 INSTALLATION OF INDIVIDUAL GROUND-MOUNTED LUMINAIRES

A. Aim as indicated on Drawings.

B. Install on concrete base with top 4 inches (100 mm) above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 033000 "Cast-in-Place Concrete."

3.3 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Section 260533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- (0.254-mm-) thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Inspect each installed luminaire for damage. Replace damaged luminaires and components.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Verify operation of photoelectric controls.

C. Illumination Tests:

1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IES testing guide(s):

    a. IES LM-5.
    b. IES LM-50.
    c. IES LM-52.
    d. IES LM-64.
    e. IES LM-72.

2. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.

D. Luminaire will be considered defective if it does not pass tests and inspections.

E. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.6 DEMONSTRATION

A. Train owner's maintenance personnel to adjust, operate, and maintain luminaires and photocell relays.

END OF SECTION 265619

SECTION 265621 - HID EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Exterior HID luminaires, lamps, and ballasts.
2. Luminaire-mounted photoelectric relays.
3. Quartz lighting controllers.

B. Related Requirements:

1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
2. Section 260926 "Lighting Control Panelboards" for panelboard-based lighting control.
3. Section 260943.16 "Addressable-Luminaire Lighting Controls" and Section 260943.23 "Relay-Based Lighting Controls" for manual or programmable control systems with low-voltage control wiring or data communication circuits.
4. Section 265613 "Lighting Poles and Standards" for poles and standards used to support lighting equipment.

1.2 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color rendering index.

C. Fixture: See "Luminaire."

D. HID: High-intensity discharge.

E. Lumen: Measured output of lamp and luminaire, or both.

F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

G. Pole: Luminaire support structure, including tower used for large-area illumination.

H. Standard: See "Pole."

1.3 ACTION SUBMITTALS

A. Product Data: For each type of luminaire.

B. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Sustainable Design Submittals:

D. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

E. Delegated-Design Submittal: For luminaire supports.

1. Include design calculations for luminaire supports and seismic restraints and for designing vibration isolation bases.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale and coordinated.

B. Seismic Qualification Data: For luminaires, accessories, and components, from manufacturer.

C. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Product Certificates: For each type of the following:

1. Ballast for bi-level and dimmable luminaires.
2. Lamp.
3. Photoelectric relay.

E. Sample warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.6 FIELD CONDITIONS

A. Mark locations of exterior luminaires for approval by Architect prior to the start of luminaire installation.

1.7 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

B. Warranty Period: Two year(s) from date of Substantial Completion

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

B. Seismic Performance: Luminaires and lamps shall be labeled vibration and shock resistant.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

2.2 LUMINAIRE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. NRTL Compliance: Luminaires shall comply with UL 1598 and be listed and labeled for indicated class and division of hazard by an NRTL.

C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

D. Lateral Light Distribution Patterns: Comply with IES RP-8 for parameters of lateral light distribution patterns indicated for luminaires.

E. UL Compliance: Listed for wet location. Luminaire assembled from UL-recognized components.

F. Lamp base complying with ANSI C81.61 or IEC 60061-1.

G. Nominal Operating Voltage: As directed, 120 V ac, 240 V ac or 277 V ac.

H. In-line Fusing: As directed, install on the ballast primary for each luminaire or Provide a separate in-line fuse for each luminaire.

I. Lamp Rating: Lamp marked for outdoor use and in enclosed locations.

2.3 BALLASTS FOR HID LAMPS

A. Electromagnetic Ballast for Metal-Halide Lamps: Comply with ANSI C82.4 and UL 1029. Include the following features unless otherwise indicated:

1. Ballast Circuit: Constant-wattage autotransformer or regulating high-power-factor type.

2. Minimum Starting Temperature: Minus 22 deg F (Minus 30 deg C) for single-lamp ballasts.
3. Rated Ambient Operating Temperature: 104 deg F (40 deg C).
4. Open-circuit operation that does not reduce average life.
5. Low-Noise Ballasts: Manufacturers' standard epoxy-encapsulated models designed to minimize audible luminaire noise.
6. Dimming: Step or Bi-level ballasts, capable of adjusting luminaire input power from 100 to 60 percent of rated power.

B. Electronic Ballast for Metal-Halide Lamps: Include the following features unless otherwise indicated:

1. Minimum Starting Temperature: Minus 20 deg F (Minus 29 deg C) for single-lamp ballasts.
2. Rated Ambient Operating Temperature: 130 deg F (54 deg C).
3. Sound Rating: Class A.
4. Total Harmonic Distortion Rating: Less than 20 percent.
5. Surge Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
6. Lamp Current Crest Factor: 1.5 or less.
7. Power Factor: 0.90 or higher.
8. Interference: Comply with 47 CFR 18, Ch. 1, Subpart C, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment.
9. Protection: Class P thermal cutout.
10. Minimum Starting Temperature: Minus 40 deg F (Minus 40 deg C).
11. UL Bench Top Rise Letter Code: As directed, A, B, C, D, E or F.
12. Dimming: Continuous level ballasts, capable of adjusting luminaire input power from 100 to 30 percent of rated power.

2.4 HID LAMPS

A. High-Pressure Sodium Lamps: ANSI C78.42, with CRI 21, CCT 1900 K, and average rated life of 24,000 hours, minimum.

B. Metal-Halide Lamps: ANSI C78.43, with CRI 65 and CCT 4000 K, minimum.

C. Pulse-Start Metal-Halide Lamps: CRI 65 and CCT 4000 K, minimum.

D. Ceramic Pulse-Start Metal-Halide Lamps: CRI 80 and CCT 4000 K, minimum.

2.5 QUARTZ LAMP-LIGHTING CONTROLLER

A. General Requirements for Controllers: Factory installed by luminaire manufacturer. Comply with UL 1598.

B. Standby (Quartz Restrike): Automatically switches quartz lamp on when an HID lamp in the luminaire is initially energized and during the HID lamp restrike period after brief power outages.

C. Connections: Designed for a single branch-circuit connection.

D. Switching Off: Automatically switches quartz lamp off when HID lamp strikes.

E. Switching Off: Automatically switches quartz lamp off when HID lamp reaches approximately 60 percent light output.

2.6 LUMINAIRE-MOUNTED PHOTOELECTRIC RELAYS

A. Comply with UL 773 or UL 773A.

B. Contact Relays: Factory mounted, single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 fc (16 to 32 lx) and off at 4.5 to 10 fc (48 to 108 lx) with 15-second minimum time delay. Relay shall have directional lens in front of photocell to prevent artificial light sources from causing false turnoff.

1. Relay with locking-type receptacle shall comply with ANSI C136.10.
2. Adjustable window slide for adjusting on-off set points.

2.7 LUMINAIRE TYPES

A. Area and Site:
1. Luminaire Shape: As directed, Round, Square or Hexagonal.
2. Mounting: As directed, Pole or Building with extruded-aluminum or stainless-steel, rectangular or round arm, 11 inches (280 mm) or 13 inches (330 mm) in length.
3. Luminaire-Mounting Height: As directed.
4. Distribution: As directed, Type I, Type II, Type III, Type IV or Type V.
5. Diffusers and Globes: As directed, Tempered Fresnel glass, Prismatic glass, Diffuse glass, Clear glass, Prismatic acrylic, Clear, UV-stabilized acrylic or Clear polycarbonate.
6. Housings:
    a. Extruded-aluminum housing and heat sink.
    b. As directed, Clear, anodized, powder-coat or painted finish.

B. Bollard:
1. Shape: As directed, Round, Square, Hexagonal or Fluted.
2. Height from Finished Grade: As directed, 24 inches (600 mm), 30 inches (762 mm) or 36 inches (900 mm).
3. Overall Height: As directed, 30 inches (762 mm) or 36 inches (900 mm).
4. Diameter: 6 inches (150 mm).
5. Mounting: Three-point cast-aluminum base.
6. Distribution: As directed, Type III or Type V.
7. Diffusers and Globes: As directed, Tempered Fresnel glass, Prismatic glass, Diffuse glass, Clear glass, Prismatic acrylic, Clear, UV-stabilized acrylic or Clear polycarbonate.
8. Housings:
    a. Extruded-aluminum housing and heat sink.
    b. Clear, anodized, powder-coat or painted finish.

C. Canopy:
1. Shape: As directed, Round or Square.

2. Dimensions: As directed, 12 inches (305 mm), square or in diameter.
3. Diffusers and Globes: As directed, Tempered Fresnel glass, Prismatic glass, Diffuse glass, Clear glass, Prismatic acrylic, Clear, UV-stabilized acrylic or Clear polycarbonate.
4. Housings:

    a. Extruded-aluminum housing and heat sink.
    b. As directed, Clear, anodized, powder-coat or painted finish.

D. Roadway:
1. Luminaire-Mounting Height: As directed.
2. Mounting Type: As directed, Arm, Tenon or Ring.
3. Distribution: As directed, Type I, Type II, Type III, Type IV or Type V.
4. Diffusers and Globes: As directed, Tempered Fresnel glass, Prismatic glass, Diffuse glass, Clear glass, Prismatic acrylic, Clear, UV-stabilized acrylic or Clear polycarbonate.
5. Housings:

    a. Extruded-aluminum housing and heat sink.
    b. As directed, Clear, anodized, powder-coat or painted finish.

2.8 MATERIALS

A. Metal Parts: Free of burrs and sharp corners and edges.

B. Sheet Metal Components: As directed, Corrosion-resistant aluminum, Stainless steel or Epoxy-coated steel unless otherwise indicated. Form and support to prevent warping and sagging.

C. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

D. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses. Ballast shall automatically disconnect ballast when door opens.

E. Diffusers and Globes:

1. Acrylic Diffusers: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
2. Glass: Annealed crystal glass unless otherwise indicated.
3. Lens Thickness: At least 0.125-inch (3.175-mm) minimum unless otherwise indicated.

F. Lens and Refractor Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

G. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:

1. White Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.

3. Diffusing Specular Surfaces: 75 percent.

H. Housings:

1. Rigidly formed, weather- and light-tight enclosure that will not warp, sag, or deform in use.
2. Provide filter/breather for enclosed luminaires.

2.9 METAL FINISHES

A. Variations in Finishes: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

A. Comply with NECA 1.

B. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.

C. Install lamps in each luminaire.

D. Wiring Method: Install cables in raceways. Conceal raceway and cables.

E. Supports:

1. Sized and rated for luminaire weight.
2. Able to maintain luminaire position after cleaning and re-lamping.
3. Support luminaires without causing deflection of finished surface.
4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.

F. Wall-Mounted Luminaire Support:

1. As directed, attached to structural members in walls, attached to a minimum 1/8-inch (3-mm) backing plate attached to wall structural members or Attached using through bolts and backing plates on either side of wall.

G. Install luminaires level, plumb, and square with finished grade unless otherwise indicated. Install luminaires at height and aiming angle as indicated on Drawings.

H. Coordinate layout and installation of luminaires with other construction.

I. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.

J. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and Section 260533 "Raceways and Boxes for Electrical Systems;" for wiring connections and wiring methods.

3.2 BOLLARD LUMINAIRE INSTALLATION

A. Align units for optimum directional alignment of light distribution.

1. Install on concrete base with top 4 inches (100 mm) above finished grade or surface at location. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 033000 "Cast-in-Place Concrete."

3.3 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Section 260533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- (0.254-mm-) thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Inspect each installed luminaire for damage. Replace damaged luminaires and components.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Photoelectric Control Operation: Verify operation of photoelectric controls.

C. Illumination Tests:

1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IES testing guide(s):

a. IES LM-5.
b. IES LM-50.
c. IES LM-52.
d. IES LM-64.
e. IES LM-72.

D. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.6 DEMONSTRATION

A. Train owner's maintenance personnel to adjust, operate, and maintain luminaires and photocell relays.

END OF SECTION 265621

SECTION 265668 - EXTERIOR ATHLETIC LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes lighting for the following outdoor sports venues:

1. Baseball fields.
2. Softball fields.
3. Football fields.
4. Soccer fields.
5. Outdoor tennis courts.

1.2 DEFINITIONS

A. Coefficient of Variation (CV): A statistical measure of the weighted average of all relevant illumination values for the playing area, expressed as the ratio of the standard deviation for all illuminance values to the mean illuminance value.

B. Fixture: See "Luminaire."

C. Illuminance: The metric most commonly used to evaluate lighting systems. It is the density of luminous flux, or flow of light, reaching a surface divided by the area of that surface.

1. Horizontal Illuminance: Measurement in foot-candles (lux), on a horizontal surface 36 inches (914 mm) above ground unless otherwise indicated.
2. Target Illuminance: Average maintained illuminance level, calculated by multiplying initial illuminance by LLF.
3. Vertical Illuminance: Measurement in foot-candles (lux), in two or four directions on a vertical surface as directed, at an elevation coinciding with plane height of horizontal measurements.

D. LC: Lighting Certified.

E. Light-Loss Factor (LLF): A factor used in calculating the level of illumination after a given period of time and under given conditions. It takes into account temperature, dirt accumulation on the luminaire, lamp depreciation, maintenance procedures, and atmospheric conditions. An LLF includes a recoverable light-loss factor.

F. Luminaire: A complete lighting unit, internally lighted exit sign, or emergency lighting unit. Luminaires include lamps and the parts required to distribute light, position and protect lamps, and connect lamps to power supply. Note that "fixture" and "luminaire" may be used interchangeably and the "IES Lighting Handbook" uses "luminaire" over "fixture."

G. Pole: Luminaire support structure, including tower used for large area illumination.

H. Uniformity Gradient (UG): The rate of change of illuminance on the playing field, expressed as a ratio between the illuminances of adjacent measuring points on a uniform grid.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of lighting product.

B. Delegated-Design Submittal: For exterior athletic lighting indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Drawings and specifications for construction of lighting system.
2. Manufacturer's determination of LLF used in design calculations.
3. Lighting system design calculations for the following:

    a. Target illuminance.
    b. Point calculations of horizontal and vertical illuminance, CV, and UG at minimum grid size and area.
    c. Point calculations of horizontal and vertical illuminance in indicated areas of concern for spill light.
    d. Calculations of source intensity of luminaires observed at eye level from indicated properties near the playing fields.

4. Electrical system design calculations for the following:

    a. Short-circuit current calculations for rating of panelboards.
    b. Total connected and estimated peak-demand electrical load, in kilowatts, of lighting system.
    c. As directed, Capacity of feeder or service required to supply lighting system.

5. Wiring requirements, including required conductors, cables, and wiring methods.
6. Structural analysis data and calculations used for pole selection.

    a. Manufacturer Wind-Load Strength Certification: Submit certification that selected total support system, including poles, complies with AASHTO LTS-6-M for location of Project.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans drawn to scale and coordinated.

B. Seismic Qualification Data: Certificates, for luminaires, accessories, and components, from manufacturer.

C. Product Certificates:

1. For each type of ballast for bi-level and dimmer-controlled luminaire, from manufacturer.
2. For support structures, including brackets, arms, appurtenances, bases, anchorages, and foundations, from manufacturer.

D. Field quality-control reports.

E. Sample warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of luminaires, lamps, and luminaire alignment products and to correct misalignment that occurs subsequent to successful acceptance tests. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, and unauthorized repairs and alterations from special warranty coverage.

B. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Illumination Criteria:

1. Minimum average target illuminance level for each lighted area for each sports venue and for the indicated class of play according to IES RP-6.
2. CV and maximum-to-minimum uniformity ratios for each lighted area equal to or less than those listed in IES RP-6 for the indicated class of play.
3. UG levels within each lighted area equal to or less than those listed in IES RP-6 for the indicated speed of sport.

B. Illumination Calculations: Computer-analyzed point method complying with IES RP-6 to optimize selection, location, and aiming of luminaires.

1. Grid Pattern Dimensions: For playing areas of each sport and areas of concern for spill-light control, correlate and reference calculated parameters to the grid areas. Each grid point represents the center of the grid area defined by the length and width of the grid spacing.
2. Spill-Light Control: Minimize spill light for each playing area on adjacent and nearby areas.

a. Prevent light trespass on properties near Project as defined by authorities having jurisdiction as directed.

b. For areas indicated on Drawings as "spill-light critical," limit the level of illuminance directed into the area from any luminaire or group of luminaires, and measured 36 inches (914 mm) above grade to the following:

1) Maximum Horizontal Illuminance: As directed, 0.25 fc (2.7 lux), 0.5 fc (5.4 lux) or 0.75 fc (8.1 lux).
2) Maximum Vertical Illuminance from the Direction of the Greatest Contribution of Light: As directed, 1.0 fc (10.8 lux), 2.0 fc (21.5 lux) or 3.0 fc (32.3 lux).

c. Calculate the horizontal and vertical illuminance due to spill light for points spaced 20 feet (6 m) apart in areas indicated on Drawings as "spill-light critical," to ensure that design complies with the above limits.

3. Glare Control: Design illumination for each playing area to minimize direct glare in adjacent and nearby areas.

a. As directed, design source intensity of luminaires that may be observed at an elevation of 60 inches (1524 mm) above finished grade from nearby properties to be less than 12,000, 20,000 or 30,000 candela when so observed.
b. As directed, design source intensity of luminaires that may be observed at an elevation of 60 inches (1524 mm) above finished grade from designated "spill-light critical" areas to be less than 12,000, 20,000 or 30,000 candela when so observed.

4. Determine LLF according to IES RP-6 and manufacturer's test data.

a. Use LLD at 100 percent of rated lamp life. LLF shall be applied to initial illumination to ensure that target illumination is achieved at 100 percent of lamp life and shall include consideration of field factor.
b. LLF shall not be higher than 70 percent and may be lower when determined by manufacturer after application of the ballast output and optical system output according to IES RP-6.

5. Luminaire-Mounting Height: Comply with IES RP-6, with consideration for requirements to minimize spill light and glare.
6. Luminaire Placement: Luminaire clusters shall be outside the glare zones defined by IES RP-6.

C. Baseball Fields:

1. IES RP-6: As directed, Class of Play I, Class of Play II, Class of Play III or Class of Play IV.
2. Speed of Sport: As directed, Fast, Moderate or Slow.
3. Grid Pattern Dimensions: 30 by 30 feet (9 by 9 m).

D. Softball Fields:

1. IES RP-6: As directed, Class of Play I, Class of Play II, Class of Play III or Class of Play IV.
2. Speed of Sport: As directed, Fast, Moderate or Slow.
3. Grid Pattern Dimensions: 20 by 20 feet (6 by 6 m).

E. Football Fields:

1. IES RP-6: As directed, Class of Play I, Class of Play II, Class of Play III or Class of Play IV.
2. Speed of Sport: As directed, Fast, Moderate or Slow.
3. Grid Pattern Dimensions: 30 by 30 feet (9 by 9 m).

F. Soccer Fields:

1. IES RP-6: As directed, Class of Play I, Class of Play II, Class of Play III or Class of Play IV.
2. Speed of Sport: As directed, Fast, Moderate or Slow.
3. Grid Pattern Dimensions: 30 by 30 feet (9 by 9 m).

G. Outdoor Tennis Courts:

1. IES RP-6: As directed, Class of Play I, Class of Play II, Class of Play III or Class of Play IV.
2. Speed of Sport: As directed, Fast, Moderate or Slow.
3. Grid Pattern Dimensions: 10 by 10 feet (3 by 3 m).

H. Lighting Control: Manual, low voltage, or digital; providing the following functions, integrated into a single control station, with multiple subcontrol stations as indicated:

1. Control Station: Key-operated master switch, manual push-button controls, and system status indicator lights. Test switch of egress lighting system.
2. Light Levels: Two levels of control - 100/50 percent of minimum target illumination.

I. Electric Power Distribution Requirements:

1. Electric Power: As directed, 208, 230 or 480 V; three phase.

    a. Include roughing-in of service indicated for nonsports improvements on Project site.
    b. Balance load between phases. Install wiring to balance three phases at each support structure.
    c. Include required overcurrent protective devices and individual lighting control for each sports field or venue.
    d. Include indicated feeder capacity and panelboard provisions for future lighted sports field construction.

J. Maximum Total Load: As directed.

1. Maximum Total Voltage Drop from Source to Load: 5 percent, including voltage drops in branch circuit, subfeeder, and feeder.

K. Seismic Performance: Luminaires, ballasts, and support structures shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational after the seismic event."

2.3 LUMINAIRES, LAMPS, AND BALLASTS

A. Luminaires: Complying with requirements described in Section 265619 "LED Exterior Lighting" or Section 265621 "HID Exterior Lighting" as directed

1. Listed and labeled, by an NRTL acceptable to authorities having jurisdiction, for compliance with UL 1598 for installation in wet locations.
2. Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions, and arranged to permit re-lamping without using tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent their accidental falling during re-lamping and when secured in operating position. Doors shall be removable for cleaning or replacing lens. Designed to disconnect ballast when door opens.
3. Exposed Hardware: Stainless-steel latches, fasteners, and hinges.
4. Spill-Light Control Devices: Internal louvers and external baffles furnished by manufacturer and designed for secure attachment to specific luminaire.
5. Luminaires for tennis courts shall be bracket-mounted, full-cutoff type with integral ballasts.
6. Lamps for Tennis Court Luminaires: As directed, Metal halide or LED, rated 100 or 1000 W.

B. Ballast Mounting: As directed, grouped in cabinets, remote from or at location of associated luminaires unless otherwise indicated.

2.4 SUPPORT STRUCTURES

A. Support Structures: As directed, Steel, Aluminum or Concrete poles and other support structures, brackets, arms, appurtenances, bases, anchorages and foundations as complying with requirements described in Section 265613 "Lighting Poles and Standards."

2.5 POWER DISTRIBUTION AND CONTROL

A. Wiring Method for Feeders, Subfeeders, Branch Circuits, and Control Wiring: Underground nonmetallic raceway; No. 10 AWG minimum conductor size for power wiring.

B. Overhead-, pole-, or structure-supported wiring and transformers are not permitted.

C. Electrical Enclosures Exposed to Weather: NEMA 250, Type 3R enclosure constructed from stainless steel or corrosion-resistant material, with hinged doors fitted with padlock hasps or lockable latches.

2.6 SURGE PROTECTION

A. Surge Protection: Comply with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits" and include surge suppressors with the following requirements:

1. Panelboard type.
2. Nonmodular, with digital indicator lights and one set of dry contacts.
3. Peak Single-Impulse Surge Current Rating: Number kA per phase as directed.

2.7 POLE AND BASE PROTECTION

A. Pole Pads: Wraparound pad, with 4 inches (100 mm) of extra-firm polyfoam, 360-degree coverage of ground-mounted poles and supports, continuous hook-and-loop fastening; and not less than 72 inches (1820 mm) high.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Install cables in raceways, except when cables are installed within boxes and poles. Conceal raceways and cables.

1. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and Section 260533 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.

C. Use web fabric slings (not chain or cable) to raise and set structural members. Protect equipment during installation to prevent corrosion.

D. Install poles and other structural units level, plumb, and square.

E. Except for embedded structural members, grout void between pole base and foundation. Use non-shrinking or expanding concrete grout firmly packed in entire void space. Use a short piece of 1/2-inch- (13-mm-) diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole. Non-shrink grout is specified in Section 055000 "Metal Fabrications."

F. Install pole pads at all poles inside playing field boundaries and when located within 20 feet (6 m) of the field boundary.

G. Extend cast-in-place bolted base foundations 36 inches (914 mm) above grade, minimum.

H. As directed, install protective pipe bollards on two or three sides of each embedded pole installed in paved areas. See Section 055000 "Metal Fabrications" for pipe bollards.

I. Install controls and ballast housings in cabinets mounted on support structure at least 10 feet (3 m) above finished grade.

J. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. After installing sports lighting system and after electrical circuits have been energized, perform proof-of-performance field measurements and analysis for compliance with requirements.
2. Playing and Other Designated Areas: Make field measurements at intersections of grids, dimensioned and located as specified in "Performance Requirements" Article and as described below:

    a. Baseball Fields: Measure at least 25 points of the infield and 87 points of the outfield. Extend the grid 15 feet (5 m) outside the foul lines, extending to outfield boundary or fence.
    b. Softball Fields: Measure at least 16 points of the infield and 48 points of the outfield. Extend the grid 15 feet (5 m) outside the foul lines, extending to outfield boundary.
    c. Football Fields: Lighted area is 180 by 360 feet (55 by 110 m). Measure at least 91 points.
    d. Soccer Fields: Lighted area is 210 by 370 feet (64 by 113 m). Measure at least 91 points.
    e. Tennis Courts: Measure at least 30 points for a double court.
    f. Sports Venue, as Directed: Measure at least a specific number points as directed.

3. Make field measurements at established test points in areas of concern for spill light and glare.
4. Perform analysis to demonstrate correlation of field measurements with specified illumination quality and quantity values and corresponding computer-generated values that were submitted with engineered design documents. Submit a report of the analysis. For computer-generated values, use manufacturer's lamp lumens that are adjusted to lamp age at time of field testing.

B. Correction of Illumination Deficiencies for Playing Areas: Make corrections to illumination quality or quantity, measured in field quality-control tests, that varies from specified illumination criteria by plus or minus 10 percent.

1. Add or replace luminaires; change mounting height and aiming; or install louvers, shields, or baffles.
2. If luminaires are added or mounting height is changed, revise aiming and recalculate and modify or replace support structures if indicated.
3. Do not replace luminaires with units of higher or lower wattage without Architect's approval.
4. Retest as specified above after repairs, adjustments, or replacements are made.
5. Report results in writing.

C. Correction of Excessive Illumination in Spill-Light-Critical Areas: If measurements indicate that specified limits for spill light are exceeded, make corrections to illumination quantity, measured in field quality-control tests, that reduce levels to within specified maximum values.

1. Replace luminaires; change mounting heights and revise aiming; or install louvers, shields, or baffles.
2. Obtain Architect's approval to replace luminaires with units of higher or lower wattage.
3. If mounting height is changed, revise aiming and recalculate and modify or replace support structures if indicated.
4. Retest as specified above after repairs, adjustments, or replacements are made.
5. Report results in writing.

D. Sports lighting will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION 265668

SECTION 270526 - GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Grounding conductors.
2. Grounding connectors.
3. Grounding busbars.
4. Grounding rods.
5. Grounding labeling.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

1.3 INFORMATIONAL SUBMITTALS

A. As-Built Data: Plans showing as-built locations of grounding and bonding infrastructure, including the following:

1. Ground rods.
2. Ground and roof rings.
3. BCT, TMGB, TGBs, and routing of their bonding conductors.

B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Installation Supervision: Installation shall be under the direct supervision of ITS Technician or Level 2 Installer as directed, who shall be present at all times when Work of this Section is performed at Project site.
2. Field Inspector: Currently registered by BICSI as a designer RCDD or Technician to perform the on-site inspection as directed.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with UL 467 for grounding and bonding materials and equipment.

C. Comply with TIA-607-B.

2.2 CONDUCTORS

A. Comply with UL 486A-486B.

B. Insulated Conductors: Stranded copper wire, green or green with yellow stripe insulation, insulated for 600 V, and complying with UL 83.

1. Ground wire for custom-length equipment ground jumpers shall be No. 6 AWG, 19-strand, UL-listed, Type THHN wire.
2. Cable Tray Equipment Grounding Wire: No. 8 or No. 6 AWG as directed.

C. Bare Copper Conductors:

1. Solid Conductors: ASTM B3.
2. Stranded Conductors: ASTM B8.
3. Tinned Conductors: ASTM B33.
4. Bonding Cable: 28 kcmils (14.2 sq. mm), 14 strands of No. 17 AWG conductor, and 1/4 inch (6.3 mm) in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Tinned-copper tape, braided conductors terminated with two-hole copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

2.3 CONNECTORS

A. Irreversible connectors listed for the purpose. Listed by an NRTL as complying with NFPA 70 for specific types, sizes, and combinations of conductors and other items connected. Comply with UL 486A-486B.

B. Compression Wire Connectors: Crimp-and-compress connectors that bond to the conductor when the connector is compressed around the conductor. Comply with UL 467.

1. Electroplated tinned copper, C and H shaped.

C. Busbar Connectors: Cast silicon bronze, solderless compression or exothermic-type, mechanical connector; with a long barrel and two holes spaced on 5/8- or 1-inch (15.8- or 25.4-mm) centers for a two-bolt connection to the busbar.

D. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.4 GROUNDING BUSBARS

A. TMGB: Predrilled, wall-mounted, rectangular bars of hard-drawn solid copper, 1/4 by 4 inches (6.3 by 100 mm) in cross section, length as indicated on Drawings. The busbar shall be NRTL listed for use as TMGB and shall comply with TIA-607-B.

1. Predrilling shall be with holes for use with lugs specified in this Section.
2. Mounting Hardware: Stand-off brackets that provide a 4-inch (100-mm) clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.
3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.

B. TGB: Predrilled rectangular bars of hard-drawn solid copper, 1/4 by 2 inches (6.3 by 50 mm) in cross section, length as indicated on Drawings. The busbar shall be for wall mounting, shall be NRTL listed as complying with UL 467, and shall comply with TIA-607-B.

1. Predrilling shall be with holes for use with lugs specified in this Section.
2. Mounting Hardware: Stand-off brackets that provide at least a 2-inch (50-mm) clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.
3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.

C. Rack and Cabinet Grounding Busbars: Rectangular bars of hard-drawn solid copper, accepting conductors ranging from No. 14 to No. 2/0 AWG, NRTL listed as complying with UL 467, and complying with TIA-607-B. Predrilling shall be with holes for use with lugs specified in this Section.

1. Cabinet-Mounted Busbar: Terminal block, with stainless-steel or copper-plated hardware for attachment to the cabinet.
2. Rack-Mounted Horizontal Busbar: Designed for mounting in 19- or 23-inch (483- or 584-mm) equipment racks. Include a copper splice bar for transitioning to an adjoining rack, and stainless-steel or copper-plated hardware for attachment to the rack.
3. Rack-Mounted Vertical Busbar: 72 or 36 inches (1827 or 914 mm) long, with stainless-steel or copper-plated hardware for attachment to the rack.

2.5 GROUND RODS

A. Ground Rods: Steel as directed, sectional type; Diameter as directed.

2.6 IDENTIFICATION

A. Comply with requirements for identification products in Section 270553 "Identification for Communications Systems."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the ac grounding electrode system and equipment grounding for compliance with requirements for maximum ground-resistance level and other conditions affecting performance of grounding and bonding of the electrical system.

B. Inspect the test results of the ac grounding system measured at the point of BCT connection.

C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

D. Proceed with connection of the BCT only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Bonding shall include the ac utility power service entrance, the communications cable entrance, and the grounding electrode system. The bonding of these elements shall form a loop so that each element is connected to at least two others.

B. Comply with NECA 1.

C. Comply with TIA-607-B.

3.3 APPLICATION

A. Conductors: Install solid conductor for No. 8 AWG and smaller and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

1. The bonding conductors between the TGB and structural steel of steel-frame buildings shall not be smaller than No. 6 AWG.
2. The bonding conductors between the TMGB and structural steel of steel-frame buildings shall not be smaller than No. 6 AWG.

B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 2 AWG minimum.

C. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

D. Conductor Support:

1. Secure grounding and bonding conductors at intervals of not less than 36 inches (900 mm).

E. Grounding and Bonding Conductors:

1. Install in the straightest and shortest route between the origination and termination point, and no longer than required. The bend radius shall not be smaller than eight times the diameter of the conductor. No one bend may exceed 90 degrees.
2. Install without splices.
3. Support at not more than 36-inch (900-mm) intervals.
4. Install grounding and bonding conductors in 3/4-inch (21-mm) PVC conduit until conduit enters a telecommunications room. The grounding and bonding conductor pathway through a plenum shall be in EMT. Conductors shall not be installed in EMT unless otherwise indicated.

    a. If a grounding and bonding conductor is installed in ferrous metallic conduit, bond the conductor to the conduit using a grounding bushing that complies with requirements in Section 270528 "Pathways for Communications Systems," and bond both ends of the conduit to a TGB.

3.4 GROUNDING ELECTRODE SYSTEM

A. The BCT between the TMGB and the ac service equipment ground shall not be smaller than No. 1/0 or No. 3/0 AWG as directed.

3.5 GROUNDING BUSBARS

A. Indicate locations of grounding busbars on Drawings. Install busbars horizontally, on insulated spacers 2 inches (50 mm) minimum from wall, 12 inches (300 mm) above finished floor unless otherwise indicated.

B. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.

3.6 CONNECTIONS

A. Bond metallic equipment in a telecommunications equipment room to the grounding busbar in that room, using equipment grounding conductors not smaller than No. 6 AWG.

B. Stacking of conductors under a single bolt is not permitted when connecting to busbars.

C. Assemble the wire connector to the conductor, complying with manufacturer's written instructions and as follows:

1. Use crimping tool and the die specific to the connector.
2. Pretwist the conductor.
3. Apply an antioxidant compound to all bolted and compression connections.

D. Primary Protector: Bond to the TMGB with insulated bonding conductor.

E. Interconnections: Interconnect all TGBs with the TMGB with the telecommunications backbone conductor. If more than one TMGB is installed, interconnect TMGBs using the grounding equalizer conductor. The telecommunications backbone conductor and grounding equalizer conductor size shall not be less than 2 kcmils/linear foot (1 sq. mm/linear meter) of conductor length, up to a maximum size of No. 3/0 AWG unless otherwise indicated.

F. Telecommunications Enclosures and Equipment Racks: Bond metallic components of enclosures to the telecommunications bonding and grounding system. Install top-mounted or vertically mounted rack grounding busbar unless the enclosure and rack are manufactured with the busbar as directed. Bond the equipment grounding busbar to the TGB No. 2 AWG bonding conductors.

G. Structural Steel: Where the structural steel of a steel frame building is readily accessible within the room or space, bond each TGB and TMGB to the vertical steel of the building frame.

H. Electrical Power Panelboards: Where an electrical panelboard for telecommunications equipment is located in the same room or space, bond each TGB to the ground bar of the panelboard.

I. Shielded Cable: Bond the shield of shielded cable to the TGB in communications rooms and spaces. Comply with TIA-568-C.1 and TIA-568-C.2 when grounding shielded balanced twisted-pair cables.

J. Rack- and Cabinet-Mounted Equipment: Bond powered equipment chassis to the cabinet or rack grounding bar. Power connection shall comply with NFPA 70; the equipment grounding conductor in the power cord of cord- and plug-connected equipment shall be considered as a supplement to bonding requirements in this Section.

K. Access Floors: Bond all metal parts of access floors to the TGB.

3.7 IDENTIFICATION

A. Labels shall be preprinted or computer-printed type.

1. Label TMGB(s) with "fs-TMGB," where "fs" is the telecommunications space identifier for the space containing the TMGB.
2. Label TGB(s) with "fs-TGB," where "fs" is the telecommunications space identifier for the space containing the TGB.
3. Label the BCT and each telecommunications backbone conductor at its attachment point: "WARNING! TELECOMMUNICATIONS BONDING CONDUCTOR. DO NOT REMOVE OR DISCONNECT!"

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
2. Test the bonding connections of the system using an ac earth ground-resistance tester, taking two-point bonding measurements in each telecommunications equipment room containing a TMGB and a TGB and using the process recommended by BICSI TDMM. Conduct tests with the facility in operation.

    a. Measure the resistance between the busbar and the nearest available grounding electrode. The maximum acceptable value of this bonding resistance is 100 milliohms.

3. Test for ground loop currents using a digital clamp-on ammeter, with a full-scale of not more than 10 A, displaying current in increments of 0.01 A at an accuracy of plus/minus 2.0 percent.

    a. With the grounding infrastructure completed and the communications system electronics operating, measure the current in every conductor connected to the TMGB and in each TGB. Maximum acceptable ac current level is 1 A.

C. Excessive Ground Resistance: If resistance to ground at the BCT exceeds 5 ohms, notify Architect promptly and include recommendations to reduce ground resistance.

D. Grounding system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION 270526

SECTION 270528 - PATHWAYS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal conduits and fittings.
2. Nonmetallic conduits and fittings.
3. Optical-fiber-cable pathways and fittings.
4. Metal wireways and auxiliary gutters.
5. Nonmetallic wireways and auxiliary gutters.
6. Metallic surface pathways.
7. Nonmetallic surface pathways.
8. Hooks.
9. Boxes, enclosures, and cabinets.
10. Polymer-concrete handholes and boxes for exterior underground cabling.

1.2 ACTION SUBMITTALS

A. Product data for each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: For custom enclosures and cabinets and custom underground handholes and boxes. Include plans, elevations, sections, and attachment details.

D. Samples: For wireways, nonmetallic wireways, surface pathways and tele-power poles and for each color and texture specified as directed.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Pathway routing plans, drawn to scale and coordinated with each other, using input from installers of items involved.

B. Qualification Data: For professional engineer.

C. Seismic Qualification Data: As directed, Seismic rating or Provide seismic bracing for all pathway racks, enclosures, cabinets, equipment racks, and their mounting provisions, including those for internal components, from manufacturer.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

A. Description: Metal raceway of circular cross section with manufacturer-fabricated fittings.

B. General Requirements for Metal Conduits and Fittings:

1. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.
2. Comply with TIA-569-D.

C. GRC: Comply with ANSI C80.1 and UL 6.

D. ARC: Comply with ANSI C80.5 and UL 6A.

E. IMC: Comply with ANSI C80.6 and UL 1242.

F. PVC-Coated Steel Conduit: PVC-coated GRC or IMC as directed.

1. Comply with NEMA RN 1.
2. Coating Thickness: 0.040 inch (1 mm), minimum.

G. EMT: Comply with ANSI C80.3 and UL 797.

H. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.

1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
2. Fittings for EMT:

a. Material: Steel or die cast as directed.
b. Type: Setscrew or compression as directed.

3. Expansion Fittings: PVC or steel to match conduit type, complying with UL-467, rated for environmental conditions where installed, and including flexible external bonding jumper.
4. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.

I. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS AND FITTINGS

A. Description: Nonmetallic raceway of circular section with manufacturer-fabricated fittings.

B. General Requirements for Nonmetallic Conduits and Fittings:

1. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
2. Comply with TIA-569-D.

C. RNC: Type EPC-40-PVC or Type EPC-80-PVC as directed, complying with NEMA TC 2 and UL 651 unless otherwise indicated.

D. Rigid HDPE: Comply with UL 651A.

E. Continuous HDPE: Comply with UL 651A.

F. RTRC: Comply with UL 2515A and NEMA TC 14.

1. Fittings: Comply with NEMA TC 3; match to conduit or tubing type and material.

G. Solvents and Adhesives: As recommended by conduit manufacturer.

2.3 OPTICAL-FIBER-CABLE PATHWAYS AND FITTINGS

A. Description: Comply with UL 2024; flexible-type pathway with a circular cross section, approved for plenum, riser or general-use installation unless otherwise indicated.

1. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
2. Comply with TIA-569-D.

2.4 METAL WIREWAYS AND AUXILIARY GUTTERS

A. Description: Sheet metal trough of rectangular cross section fabricated to required size and shape, without holes or knockouts, and with hinged or removable covers.

B. General Requirements for Metal Wireways and Auxiliary Gutters:

1. Comply with UL 870 and NEMA 250, unless otherwise indicated, and sized according to NFPA 70 as directed.
2. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
3. Comply with TIA-569-D.

C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

2.5 NONMETALLIC WIREWAYS AND AUXILIARY GUTTERS

A. Description: Fiberglass polyester, extruded and fabricated to required size and shape, without holes or knockouts. Cover shall be gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections shall be flanged and have stainless-steel screws and oil-resistant gaskets.

B. Description: PVC, extruded and fabricated to required size and shape, and having snap-on cover, mechanically coupled connections, and plastic fasteners.

C. General Requirements for Nonmetallic Wireways and Auxiliary Gutters:

1. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
2. Comply with TIA-569-D.

D. Fittings and Accessories: Couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings shall match and mate with wireways as required for complete system.

E. Solvents and Adhesives: As recommended by conduit manufacturer.

2.6 SURFACE METAL PATHWAYS

A. Description: Galvanized steel with snap-on covers, complying with UL 5.

B. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

C. Comply with TIA-569-D.

2.7 SURFACE NONMETALLIC PATHWAYS:

A. Description: Two- or three-piece construction, complying with UL 5A, and manufactured of rigid PVC.

B. Finish: Texture and color selected by Architect from manufacturer's standard or custom colors as directed.

C. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

D. Comply with TIA-569-D.

2.8 HOOKS

A. Description: Prefabricated sheet metal cable supports for telecommunications cable.

B. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

C. Comply with TIA-569-D.

D. Galvanized or stainless steel as directed.

E. J or U shape as directed.

2.9 BOXES, ENCLOSURES, AND CABINETS

A. Description: Enclosures for communications.

B. General Requirements for Boxes, Enclosures, and Cabinets:

1. Comply with TIA-569-D.
2. Boxes, enclosures, and cabinets installed in wet locations shall be listed and labeled as defined in NFPA 70, by an NRTL, and marked for use in wet locations.
3. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
4. Device Box Dimensions: 4 inches square by 2-1/8 inches deep (100 mm square by 60 mm deep) or 4 inches by 2-1/8 inches by 2-1/8 inches deep (100 mm by 60 mm by 60 mm deep) as directed
5. Gangable boxes are allowed or prohibited as directed.

C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy or aluminum as directed, Type FD, with gasketed cover.

E. Metal Floor Boxes:

1. Material: Cast metal or sheet metal as directed.
2. Type: Fully adjustable or Semi-adjustable as directed.
3. Shape: Rectangular.
4. Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

F. Nonmetallic Floor Boxes: Nonadjustable, round or rectangular as directed.

1. Nonmetallic floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

H. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum or galvanized, cast iron with gasketed cover as directed.

I. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.

J. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, as directed, with continuous-hinge cover with flush latch unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
2. Nonmetallic Enclosures:

    a. Material: Plastic or Fiberglass as directed.
    b. Finished inside with radio-frequency-resistant paint.

3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

K. Cabinets:

1. NEMA 250, Galvanized-steel box with removable interior panel and removable front as directed, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.
6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.10 POLYMER-CONCRETE HANDHOLES

A. Description: Molded of sand and aggregate; bound together with polymer resin; and reinforced with steel, fiberglass, or a combination of the two.

B. General Requirements for Polymer Concrete Handholes:

1. Boxes and handholes for use in underground systems shall be listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
3. Comply with TIA-569-D and SCTE 77.

C. Configuration: Designed for flush burial with open, closed or integral closed bottom unless otherwise indicated.

D. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.

1. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
2. Cover Legend: Molded lettering, "COMMUNICATIONS".

PART 3 - EXECUTION

3.1 PATHWAY APPLICATION

A. Minimum Pathway Size: 3/4-inch (21-mm) trade size for copper and aluminum cables, and 1 inch (25 mm) for optical-fiber cables.

B. Pathway Fittings: Compatible with pathways and suitable for use and location.

C. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

D. Install surface pathways only where indicated on Drawings.

E. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F (49 deg C).

3.2 INSTALLATION

A. Comply with the following standards for installation requirements except where requirements on Drawings or in this Section are stricter:

1. NECA 1.
2. NECA/BICSI 568.
3. TIA-569-D.
4. NECA 101
5. NECA 102.
6. NECA 105.
7. NECA 111.

B. Comply with NFPA 70 limitations for types of pathways allowed in specific occupancies and number of floors.

C. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

D. Comply with requirements in Section 270529 "Hangers and Supports for Communications Systems" for hangers and supports.

E. Comply with requirements in Section 270544 "Sleeves and Sleeve Seals for Communications Pathways and Cabling" for sleeves and sleeve seals for communications.

F. Keep pathways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal pathway runs above water and steam piping.

G. Complete pathway installation before starting conductor installation.

H. Install no more than the equivalent of two 90-degree bends in any pathway run. Support within 12 inches (300 mm) of changes in direction. Utilize long radius ells for all optical-fiber cables.

I. Conceal rigid conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

J. Support conduit within 12 inches (300 mm) of enclosures to which attached.

K. Pathways Embedded in Slabs:

1. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure pathways to reinforcement at maximum 10-foot (3-m) intervals.
2. Arrange pathways to cross building expansion joints at right angles with expansion fittings. Comply with requirements for expansion joints specified in this article.
3. Arrange pathways to keep a minimum of 1 inch (25 mm) or 2 inches (50 mm) of concrete cover in all directions as directed.
4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
5. Change from nonmetallic conduit and fittings to RNC, Type EPC-40-PVC, GRC or IMC and fittings before rising above floor as directed.

L. Stub-ups to Above Recessed Ceilings:

1. Use EMT, IMC, or RMC for pathways.
2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

M. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of pathway and fittings before making up joints. Follow compound manufacturer's written instructions.

N. Coat field-cut threads on PVC-coated pathway with a corrosion-preventing conductive compound prior to assembly.

O. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure, to assure a continuous ground path.

P. Cut conduit perpendicular to the length. For conduits of 2-inch (50-mm) trade size and larger, use roll cutter or a guide to ensure cut is straight and perpendicular to the length.

Q. Install pull wires in empty pathways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire. Secure pull wire, so it cannot fall into conduit. Cap pathways designated as spare alongside pathways in use.

R. Surface Pathways:

1. Install surface pathway for surface telecommunications outlet boxes only where indicated on Drawings.
2. Install surface pathway with a minimum 2-inch (50-mm) radius control at bend points.
3. Secure surface pathway with screws or other anchor-type devices at intervals not exceeding 48 inches (1200 mm) and with no less than two supports per straight pathway section. Support surface pathway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

S. Pathways for Optical-Fiber and Communications Cable: Install pathways, metal and nonmetallic, rigid and flexible, as follows:

1. 3/4-Inch (21-mm) Trade Size and Smaller: Install pathways in maximum lengths of 50 feet (15 m).
2. 1-Inch (25-mm) Trade Size and Larger: Install pathways in maximum lengths of 75 feet (23 m).
3. Install with a maximum of two 90-degree bends or equivalent for each length of pathway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.

T. Install pathway-sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed pathways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install pathway-sealing fittings according to NFPA 70.

U. Install devices to seal pathway interiors at accessible locations. Locate seals, so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all pathways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service pathway enters a building or structure.
3. Where otherwise required by NFPA 70.

V. Comply with manufacturer's written instructions for solvent welding PVC conduit and fittings.

W. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F (17 deg C), and that has straight-run length that exceeds 25 feet (7.6 m). Install in each run of aboveground RMC and EMT that is located where environmental temperature change may exceed 100 deg F (55 deg C), and that has straight-run length that exceeds 100 feet (30 m).
2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:

    a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) temperature change.
    b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
    c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.
    d. Attics: 135 deg F (75 deg C) temperature change.

3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F (0.06 mm per meter of length of straight run per deg C) of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F (0.0115 mm per meter of length of straight run per deg C) of temperature change for metal conduits.
4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

X. Hooks:

1. Size to allow a minimum of 25 percent future capacity without exceeding design capacity limits.
2. Shall be supported by dedicated support wires. Do not use ceiling grid support wire or support rods.
3. Hook spacing shall allow no more than 6 inches (150 mm) of slack. The lowest point of the cables shall be no less than 6 inches (150 mm) adjacent to ceilings, mechanical ductwork and fittings, luminaires, power conduits, power and telecommunications outlets, and other electrical and communications equipment.

4. Space hooks no more than 5 feet (1.5 m) o.c.
5. Provide a hook at each change in direction.

Y. Mount boxes at heights indicated on Drawings. Install boxes with height measured to center, top or bottom of box unless otherwise indicated.

Z. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block and install box flush with surface of wall. Prepare block surface to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

AA. Horizontally separate boxes mounted on opposite sides of walls, so they are not in the same vertical channel.

BB. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

CC. Set metal floor boxes level and flush with finished floor surface.

DD. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Install backfill.
2. After installing conduit, backfill and compact.
3. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through floor unless otherwise indicated. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.

    a. Couple steel conduits to ducts with adapters designed for this purpose and encase coupling with 3 inches (75 mm) of concrete around conduit for a minimum of 12 inches (300 mm) on each side of the coupling.
    b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.

4. Underground Warning Tape: Comply with requirements in Section 270553 "Identification for Communications Systems."

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch (25 mm) above finished grade.

D. Field cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR COMMUNICATIONS PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 270544 "Sleeves and Sleeve Seals for Communications Pathways and Cabling."

3.6 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.7 PROTECTION

A. Protect coatings, finishes, and cabinets from damage or deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 270528

SECTION 270529 - HANGERS AND SUPPORTS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Steel slotted support systems for communication raceways.
2. Conduit and cable support devices.
3. Support for conductors in vertical conduit.
4. Structural steel for fabricated supports and restraints.
5. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
6. Fabricated metal equipment support assemblies.

B. Related Requirements:

1. Section 270548 "Seismic Controls for Communications Systems" for products and installation requirements necessary for compliance with seismic criteria.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. For fabrication and installation details for communications hangers and support systems.

1. Trapeze hangers. Include product data for components.
2. Steel slotted-channel systems.
3. Aluminum slotted-channel systems.
4. Nonmetallic slotted-channel systems.
5. Equipment supports.
6. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated-Design Submittal: For hangers and supports for communications systems.

1. Include design calculations and details of trapeze hangers.
2. Include design calculations for seismic restraints.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, shown and coordinated with each other, using input from installers of the items involved.

B. Seismic Qualification Data: Certificates, for hangers and supports for communications equipment and systems, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Welding certificates.

1.4 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M or AWS D1.2/D1.2M as directed.

B. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M.
2. AWS D1.2/D1.2M.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design hanger and support system.

B. Seismic Performance: Hangers and supports shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the supported equipment and systems will remain in place without separation of any parts when subjected to the seismic forces specified and the system will be fully operational after the seismic event."
2. Component Importance Factor: 1.5 or 1.0 as directed.

C. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame Rating: Class 1.
2. Self-extinguishing according to ASTM D635.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Preformed steel channels and angles, with minimum 13/32-inch (10-mm) diameter holes at a maximum of 8 inches (200 mm) o.c. in at least one surface.

1. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
2. Material for Channel, Fittings, and Accessories: As directed.
3. Channel Width: As directed.
4. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
5. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
6. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
7. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
8. Channel Dimensions: Selected for applicable load criteria.

B. Conduit and Cable Support Devices: Clamps, hangers, and associated fittings, designed for types and sizes of raceway or cable to be supported as directed.

C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored communications conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.

D. Structural Steel for Fabricated Supports and Restraints: ASTM A36/A36M steel plates, shapes, and bars; black and galvanized.

E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

2. Mechanical-Expansion Anchors: Insert-wedge-type zinc-coated steel or stainless steel for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used as directed.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM F3125/F3125M, Grade A325 (Grade A325M).
6. Toggle Bolts: All-steel or Stainless-steel springhead type as directed.
7. Hanger Rods: Threaded steel.

2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with the following standards for application and installation requirements of hangers and supports, except where requirements on Drawings or in this Section are stricter:

1. NECA 1.
2. NECA/BICSI 568.
3. TIA-569-C.
4. NECA 101.
5. NECA 102.
6. NECA 105.
7. NECA 111.

B. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

C. Comply with requirements for pathways specified in Section 270528 "Pathways for Communications Systems."

D. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMTs, IMCs, and RMCs as required by or scheduled in NECA 1, where its Table 1 lists maximum spacings that are less than those stated in NFPA 70 as directed. Minimum rod size shall be 1/4 inch (6 mm) in diameter.

E. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports as directed.

F. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

A. Raceway Support Methods: As directed, in addition to methods described in NECA 1, EMT, IMC and RMC may be supported by openings through structure members, according to NFPA 70.

B. Strength of Support Assemblies: Where not indicated, select sizes of components, so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).

C. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten communications items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Use approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Use expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated-driven threaded studs, provided with lock washers and nuts, may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
6. To Steel: As directed.
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that comply with seismic-restraint strength and anchorage requirements.

D. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor communications materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).

B. Touchup: Comply with requirements in Section 099113 "Exterior Painting", Section 099123 "Interior Painting" and Section 099600 "High-Performance Coatings" for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal as directed.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas, and apply galvanizing-repair paint to comply with ASTM A780.

END OF SECTION 270529

SECTION 270536 - CABLE TRAYS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Ladder cable tray.
2. Wire-mesh cable tray.
3. Single-rail cable tray.
4. Trough cable tray.
5. Fiberglass cable tray.
6. Cable tray accessories.
7. Warning signs.

B. Related Requirements:

1. Section 260536 "Cable Trays for Electrical Systems" for cable trays and accessories serving electrical systems.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For each type of cable tray.

C. Delegated-Design Submittal: For seismic restraints.

1. Seismic-Restraint Details: Signed and sealed by a qualified professional engineer, licensed in the state where Project is located, who is responsible for their preparation.
2. Design Calculations: Calculate requirements for selecting seismic restraints.
3. Detail fabrication, including anchorages and attachments to structure and to supported cable trays.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for cable trays, accessories, and components, from manufacturer.

B. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design cable tray supports and seismic bracing.

B. Seismic Performance: Cable trays and supports shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. Component Importance Factor: 1.5 or 1.0 as directed.

2.2 GENERAL REQUIREMENTS FOR CABLE TRAYS

A. Cable Trays and Accessories: Identified as defined in NFPA 70 and marked for intended location, application, and grounding.

B. Sizes and Configurations: See the Cable Tray Schedule on Drawings for specific requirements for types, materials, sizes, and configurations.

C. Structural Performance: See articles on individual cable tray types for specific values for uniform load distribution, concentrated load, and load and safety factor parameters.

2.3 LADDER CABLE TRAY

A. Description:

1. Configuration: Two longitudinal side rails with transverse rungs swaged or welded to side rails, complying with NEMA VE 1.
2. Width: As directed.
3. Minimum Usable Load Depth: As directed.
4. Straight Section Lengths: As directed, except where shorter lengths are required to facilitate tray assembly.
5. Rung Spacing: As directed, o.c.
6. Radius-Fitting Rung Spacing: 9 inches (225 mm) at center of tray's width.
7. Minimum Cable-Bearing Surface for Rungs: 7/8-inch (22-mm) width with radius edges.
8. No portion of the rungs shall protrude below the bottom plane of side rails.
9. Structural Performance of Each Rung: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200-lb (90-kg) concentrated load, when tested according to NEMA VE 1.
10. Fitting Minimum Radius: As directed.
11. Class Designation: Comply with NEMA VE 1, As directed.
12. Splicing Assemblies: Bolted type using serrated flange locknuts.
13. Splice-Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.
14. Covers: As directed, type made of same materials and with same finishes as cable tray.

B. Materials and Finishes:

1. Steel:

   a. Straight Section and Fitting Side Rails and Rungs: Steel complies with the minimum mechanical properties of ASTM A1011/A1011M, SS, Grade 33 or ASTM A1008/A1008M, Grade 33, Type 2 as directed.
   b. Steel Tray Splice Plates: ASTM A1011/A1011M, HSLAS, Grade 50, Class 1.
   c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A510/A510M, Grade 1008.
   d. Finish: Hot-dip galvanized after fabrication, complying with ASTM A123/A123M, Class B2.

      1) Hardware: As directed.

   e. Finish: Hot-dip galvanized after fabrication, complying with ASTM A653/A653M, G90 (Z275).

      1) Hardware: Galvanized, ASTM B633, Chromium-zinc plated, ASTM F1136 as directed.

   f. Finish: Electrogalvanized after fabrication, complying with ASTM B633.

      1) Hardware: Galvanized, ASTM B633.

   g. Finish: Epoxy-resin or Powder-coat enamel paint as directed.

      1) Powder-Coat Enamel: Cable tray manufacturer's recommended primer and corrosion-inhibiting treatment, with factory-applied powder-coat paint.
      2) Epoxy-Resin Prime Coat: Cold-curing epoxy primer, MPI# 101.
      3) Epoxy-Resin Topcoat: Epoxy, cold-cured gloss, MPI# 77.
      4) Hardware: Chromium-zinc plated, ASTM F1136 or Stainless steel, Type 316, ASTM F593 and ASTM F594 as directed.

   h. Finish: Factory-standard primer, ready for field painting, with chromium-zinc-plated hardware according to ASTM F1136.
   i. Finish: Black oxide finish for support accessories and miscellaneous hardware according to ASTM D769.

2. Aluminum:

   a. Materials: Alloy 6063-T6 according to ANSI H35.1/H 35.1M for extruded components, and Alloy 5052-H32 or Alloy 6061-T6 according to ANSI H35.1/H 35.1M for fabricated parts as directed.
   b. Hardware: Chromium-zinc-plated steel, ASTM F1136 or Stainless steel, Type 316, ASTM F593 and ASTM F594 as directed.
   c. Hardware for Aluminum Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F593 and ASTM F594.

3. Stainless Steel:

   a. Materials: Low-carbon, passivated stainless steel, Type 304L or Type 316L, ASTM F593 and ASTM F594 as directed.

b. Hardware for Stainless-Steel Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F593 and ASTM F594.

2.4 WIRE-MESH CABLE TRAY

A. Description:

1. Configuration: Galvanized-steel wire mesh, complying with NEMA VE 1.
2. Width: As directed.
3. Minimum Usable Load Depth: As directed.
4. Straight Section Lengths: 10 feet (3.0 m) or 12 feet (3.7 m) as directed, except where shorter lengths are required to facilitate tray assembly.
5. Structural Performance: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200-lb (90-kg) concentrated load, when tested according to NEMA VE 1.
6. Class Designation: Comply with NEMA VE 1, As directed.
7. Splicing Assemblies: Bolted type using serrated flange locknuts.
8. Splice-Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.

B. Materials and Finishes:

1. Steel:

a. Straight Sections and Fittings: Steel complies with the minimum mechanical properties of ASTM A1011/A1011M, SS, Grade 33 or ASTM A1008/A1008M, Grade 33, Type 2 as directed.
b. Steel Tray Splice Plates: ASTM A1011/A1011M, HSLAS, Grade 50, Class 1.
c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A510/A510M, Grade 1008.
d. Finish: Hot-dip galvanized after fabrication, complying with ASTM A123/A123M, Class B2.

1) Hardware: As directed.

e. Finish: Hot-dip galvanized after fabrication, complying with ASTM A653/A653M, G90 (Z275).

1) Hardware: Galvanized, ASTM B633 or Chromium-zinc plated, ASTM F1136 as directed.

f. Finish: Electrogalvanized after fabrication, complying with ASTM B633.

1) Hardware: Galvanized, ASTM B633.

g. Finish: Epoxy-resin or Powder-coat enamel paint as directed.

1) Powder-Coat Enamel: Cable tray manufacturer's recommended primer and corrosion-inhibiting treatment, with factory-applied powder-coat paint.
2) Epoxy-Resin Prime Coat: Cold-curing epoxy primer, MPI# 101.

3) Epoxy-Resin Topcoat: Epoxy, cold-cured gloss, MPI# 77.
4) Hardware: Chromium-zinc plated, ASTM F1136 or Stainless steel, Type 316, ASTM F593 and ASTM F594 as directed.

h. Finish: Factory-standard primer, ready for field painting, with chromium-zinc-plated hardware according to ASTM F1136.
i. Finish: Black oxide finish for support accessories and miscellaneous hardware according to ASTM D769.

2.5 SINGLE-RAIL CABLE TRAY

A. Description:

1. Configuration: An extruded-aluminum assembly, consisting of a single longitudinal center rail with transverse rungs arranged symmetrically about the center rail complying with NEMA VE 1.
2. Construction: Aluminum rungs mechanically connected to aluminum center rail in at least two places, with ends finished to protect installers and cables.
3. Width: As directed.
4. Minimum Usable Load Depth: As directed.
5. Straight Section Lengths: 10 feet (3.0 m) or 12 feet (3.7 m) as directed, except where shorter lengths are required to facilitate tray assembly.
6. Rung Spacing: As directed, o.c.
7. Radius-Fitting Rung Spacing: 9 inches (225 mm) at center of tray's width.
8. Support Point: Splice fittings shall be hanger support point.
9. Support Spacing: Support each section at midpoint. Support wall-mounted sections a maximum of one-sixth of the section length from each end.
10. Class Designation: Comply with NEMA VE 1, As directed.
11. Unbalanced Loads: Maintain cable tray rungs within six degrees of horizontal under all loading conditions.
12. Splicing Assemblies: Bolted type using serrated flange locknuts.
13. Splicing Assembly Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.
14. Splices and Connectors: Protect cables from edges of center rail and do not intrude into cable fill area.
15. Covers: As directed, type made of same materials and with same finishes as cable tray.

B. Materials: Aluminum alloy 6063-T6 according to ANSI H35.1/H 35.1M for extruded components, and Alloy 5052-H32 or Alloy 6061-T6 according to ANSI H35.1/H 35.1M for fabricated parts as directed.

C. Hardware: Chromium-zinc-plated steel, ASTM F1136, Stainless steel, Type 316, ASTM F593 and ASTM F594 as directed.

D. Hardware for Aluminum Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F593 and ASTM F594.

2.6 TROUGH CABLE TRAY

A. Description:

1. Configuration:

   a. A flat or corrugated bearing surface with a solid or ventilated bottom contained within two longitudinal side rails, with both edges welded to the side rails complying with NEMA VE 1 as directed.
   b. Single, formed sheet with a solid or ventilated bottom as directed, complying with NEMA VE 1.

2. Covers: As directed, type made of same materials and with same finishes as cable tray.
3. Width: As directed.
4. Minimum Usable Load Depth: As directed.
5. Straight Section Lengths: As directed, except where shorter lengths are required to facilitate tray assembly.
6. Fitting Minimum Radius: As directed.
7. Class Designation: Comply with NEMA VE 1, As directed.
8. Splicing Assemblies: Bolted type using serrated flange locknuts.
9. Splicing Assembly Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.
10. Covers: As directed, type made of same materials and with same finishes as cable tray.

B. Materials and Finishes:

1. Steel:

   a. Straight Section and Fitting Side Rails and Rungs: Steel complies with the minimum mechanical properties of ASTM A1011/A1011M, SS, Grade 33 or ASTM A1008/A1008M, Grade 33, Type 2 as directed.
   b. Steel Tray Splice Plates: ASTM A1011/A1011M, HSLAS, Grade 50, Class 1.
   c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A510/A510M, Grade 1008.
   d. Finish: Hot-dip galvanized after fabrication complying with ASTM A123/A123M, Class B2.

      1) Hardware: As directed.

   e. Finish: Hot-dip mill galvanized before fabrication complying with ASTM A653/A653M, G90 (Z275).

      1) Hardware: Galvanized, ASTM B633 or Chromium-zinc plated, ASTM F1136 as directed.

   f. Finish: Electrogalvanized after fabrication, complying with ASTM B633.

      1) Hardware: Galvanized, ASTM B633.

   g. Finish: Epoxy-resin or Powder-coat enamel paint as directed.

1) Powder-Coat Enamel: Cable tray manufacturer's recommended primer and corrosion-inhibiting treatment, with factory-applied powder-coat paint.
2) Epoxy-Resin Prime Coat: Cold-curing epoxy primer, MPI# 101.
3) Epoxy-Resin Topcoat: Epoxy, cold-cured gloss, MPI# 77.
4) Hardware: Chromium-zinc plated, ASTM F1136 or Stainless steel, Type 316, ASTM F593 and ASTM F594 as directed.

h. Finish: Factory-standard primer, ready for field painting, with chromium-zinc-plated hardware according to ASTM F1136.
i. Finish: Black oxide finish for support accessories and miscellaneous hardware according to ASTM D769.

2. Aluminum:

a. Materials: Alloy 6063-T6 according to ANSI H35.1/H 35.1M for extruded components, and Alloy 5052-H32 or Alloy 6061-T6 according to ANSI H35.1/H 35.1M for fabricated parts as directed.
b. Hardware: Chromium-zinc-plated steel, ASTM F1136 or Stainless steel, Type 316, ASTM F593 and ASTM F594 as directed.
c. Hardware for Aluminum Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F593 and ASTM F594.

3. Stainless Steel:

a. Materials: Low-carbon, passivated stainless steel, Type 304L or Type 316L, ASTM F593 and ASTM F594 as directed.
b. Hardware for Stainless-Steel Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F593 and ASTM F594.

2.7 FIBERGLASS CABLE TRAY

A. Description:

1. Configuration: Two longitudinal members with rounded edges and smooth surfaces, supporting a bearing surface, complying with NEMA FG 1.
2. Materials: Straight section structural elements; side rails, rungs, and splice plates shall be pultruded from glass-fiber-reinforced polyester or vinyl ester resin as directed, complying with NEMA FG 1 and UL 568.
3. Width: As directed.
4. Minimum Usable Load Depth: As directed, according to NEMA FG 1.
5. Straight Section Lengths: 10 feet (3.0 m) or 20 feet (6.0 m).
6. Class Designation: Comply with NEMA VE 1, as directed.
7. Temperature Rating: Reduce the load rating of trays exposed to temperatures above 75 deg F (24 deg C) according to Table 4-3, "Working Loads," in NEMA FG 1.
8. Fitting Minimum Radius: 12 inches (300 mm) or 24 inches (600 mm) as directed.
9. Splicing Assemblies: Minimum four nuts and bolts per plate. Splice plates shall be furnished with straight sections and fittings.
10. Splicing Assembly Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.

11. Fasteners: Fiberglass-encapsulated, ASTM F593 and ASTM F594 stainless steel, Type 316. Design fasteners so that no metal is visible when fully assembled and tightened. Fastener encapsulation shall not be damaged when torqued to manufacturer's recommended value.
12. Covers: As directed, type made of same materials and with same finishes as cable tray.

2.8 CABLE TRAY ACCESSORIES

A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.

B. Barrier Strips: Same materials and finishes as for cable tray.

C. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

2.9 WARNING SIGNS

A. Comply with requirements for identification in Section 270553 "Identification for Communications Systems."

B. Lettering: 1-1/2-inch- (40-mm-) high, black letters on yellow background with legend "Warning! Not To Be Used as Walkway, Ladder, or Support for Ladders or Personnel."

2.10 SOURCE QUALITY CONTROL

A. Testing: Test and inspect cable trays according to NEMA FG 1 or NEMA VE 1 as directed.

PART 3 - EXECUTION

3.1 CABLE TRAY INSTALLATION

A. Install cable trays according to NEMA FG 1 or NEMA VE 2 as directed.

B. Install cable trays as a complete system, including fasteners, hold-down clips, support systems, barrier strips, adjustable horizontal and vertical splice plates, elbows, reducers, tees, crosses, cable dropouts, adapters, covers, and bonding.

C. Fasten cable tray supports to building structure and install seismic restraints.

D. Design fasteners and supports to carry cable tray, the cables, and a concentrated load of 200 lb. (90 kg). Comply with requirements in Section 270529 "Hangers and Supports for Communications Systems." Comply with seismic-restraint details according to Section 270548.16 "Seismic Controls for Communications Systems."

E. Install center-hung supports for single-rail trays designed for 60 versus 40 percent eccentric loading condition, with a safety factor of 3.

F. Support wire-basket cable trays as directed

G. Support center support hangers or trapeze hangers for wire-basket trays with 1/4-inch- (6-mm-) or 3/8-inch- (10-mm-) diameter rods as directed.

H. Make connections to equipment with flanged fittings fastened to cable trays and to equipment. Support cable trays independent of fittings. Do not carry weight of cable trays on equipment enclosure.

I. Install expansion connectors where cable trays cross building expansion joints and in cable tray runs that exceed dimensions recommended in NEMA FG 1 or NEMA VE 2 as directed. Space connectors and set gaps according to applicable standard.

J. Seal penetrations through fire and smoke barriers. Comply with requirements in Section 078413 "Penetration Firestopping."

K. Install capped metal sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.

L. Install barriers to separate cables of different systems, such as power, communications, and data processing; or of different insulation levels, such as 600, 5000, and 15 000 V.

M. Install permanent covers, if used, after installing cable. Install cover clamps according to NEMA VE 2.

N. Install warning signs in visible locations on or near cable trays after cable tray installation.

3.2 CABLE TRAY GROUNDING

A. Ground cable trays according to NFPA 70 unless additional grounding is specified. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems."

B. Cable trays with shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.

C. Bond cable trays to power source for cables contained within with bonding conductors sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors."

3.3 CABLE INSTALLATION

A. Install cables only when each cable tray run has been completed and inspected.

B. Fasten cables on horizontal runs with cable clamps or cable ties according to NEMA VE 2. Tighten clamps only enough to secure the cable, without indenting the cable jacket.

C. Fasten cables on vertical runs to cable trays every 18 inches (450 mm).

D. Fasten and support cables that pass from one cable tray to another or drop from cable trays to equipment enclosures. Fasten cables to the cable tray at the point of exit and support cables

independent of the enclosure. The cable length between cable trays or between cable tray and enclosure shall be no more than 72 inches (1800 mm).

E. Tie MI cables down every 36 inches (900 mm) where required to provide a 2-hour fire rating and every 72 inches (1800 mm) elsewhere.

F. In existing construction, remove inactive or dead cables from cable trays.

3.4 CONNECTIONS

A. Connect raceways to cable trays according to requirements in NEMA VE 2 and NEMA FG 1.

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements.
2. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable trays, vibrations, and thermal expansion and contraction conditions, which may cause or have caused damage.
3. Verify that the number, size, and voltage of cables in cable trays do not exceed that permitted by NFPA 70. Verify that communications or data-processing circuits are separated from power circuits by barriers or are installed in separate cable trays.
4. Verify that there are no intruding items such as pipes, hangers, or other equipment in the cable tray.
5. Remove dust deposits, industrial process materials, trash of any description, and any blockage of tray ventilation.
6. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.
7. Check for missing, incorrect, or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
8. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable trays. Test entire cable tray system for continuity. Maximum allowable resistance is 1 ohm.

B. Prepare test and inspection reports.

3.6 PROTECTION

A. Protect installed cable trays and cables.

END OF SECTION 270536

SECTION 270543 - UNDERGROUND PATHWAYS AND STRUCTURES FOR COMMUNICATION SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal conduit and fittings, including GRC and PVC-coated GRC.
2. Rigid nonmetallic duct.
3. Flexible nonmetallic duct.
4. Duct accessories, including rigid innerduct and fabric innerduct.
5. Precast concrete handholes.
6. Polymer concrete handholes and boxes with polymer concrete cover.
7. Fiberglass handholes and boxes with polymer concrete cover.
8. Fiberglass handholes and boxes.
9. High density plastic boxes.
10. Utility structure accessories.

1.2 DEFINITIONS

A. Direct-Buried: Duct or a duct bank that is buried in the ground, without any additional casing materials, such as concrete.

B. Duct: A single duct or multiple ducts. Duct may be either installed singly or as component of a duct bank.

C. Duct Bank:

1. Two or more ducts installed in parallel, with or without additional casing materials.
2. Multiple duct banks.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Precast or Factory-Fabricated Underground Utility Structures:

a. Include plans, elevations, sections, details, attachments to other work, and accessories.
b. Include duct entry provisions, including location and duct size.
c. Include reinforcement details.
d. Include frame and cover design and manhole chimneys.
e. Include ladder or step details as directed.

f. Include grounding details.
g. Include dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
h. Include joint details.

2. Factory-Fabricated Handholes and Boxes Other Than Precast Concrete:

a. Include dimensioned plans, sections, and elevations, and fabrication and installation details.
b. Include duct entry provisions, including location and duct size.
c. Include cover design.
d. Include grounding details.
e. Include dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

C. Sustainable Design Submittals:

1.4 INFORMATIONAL SUBMITTALS

A. Duct and Duct-Bank Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures.

1. Drawings shall be signed and sealed by a qualified professional engineer.

B. Product Certificates: For concrete and steel used in precast concrete manholes and handholes as required by ASTM C858 as directed.

C. Qualification Data: For professional engineer and testing agency responsible for testing nonconcrete handholes and boxes.

D. Source quality-control reports.

E. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM E329 for testing indicated.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

A. GRC: Comply with ANSI C80.1 and UL 6.

B. PVC-Coated Steel Conduit: PVC-coated GRC or IMC as directed.

1. Comply with NEMA RN 1.
2. Coating Thickness: 0.040 inch (1 mm), minimum.

C. General Requirements for Metal Conduits and Fittings:

1. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.
2. Comply with TIA-569-C and TIA-758-C.

2.2 RIGID NONMETALLIC DUCT

A. Underground Plastic Utilities Duct: Type EPC-80-PVC and Type EPC-40-PVC RNC as directed, complying with NEMA TC 2 and UL 651, with matching fittings complying with NEMA TC 3 by same manufacturer as duct.

B. General Requirements for Nonmetallic Ducts and Fittings:

1. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.
2. Comply with TIA-569-C and TIA-758-C.

C. Solvents and Adhesives: As recommended by duct manufacturer.

2.3 FLEXIBLE NONMETALLIC DUCT

A. HDPE Duct: Type EPEC 40-HDPE or Type EPEC 80-HDPE complying with NEMA TC 7 and UL 651A as directed.

B. General Requirements for HDPE Duct

1. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.
2. Comply with TIA-569-C and TIA-758-C.

2.4 DUCT ACCESSORIES

A. Rigid Innderduct: Smooth or Corrugated HDPE duct as directed, orange in color, designed for installation within a duct or pathway.

B. Fabric Innerduct: Continuous, polyester, single or multi-pocket fabric innerduct as directed, with internal pull tape and tracer wire.

C. Duct Spacers: Factory-fabricated rigid PVC interlocking spacers, sized for type and size of duct with which used, and selected to provide minimum duct spacing indicated while supporting duct during concreting or backfilling.

D. Underground-Line Warning Tape: Underground-line warning tape specified in Section 270553 "Identification for Communications Systems."

2.5 PRECAST CONCRETE HANDHOLES AND BOXES

A. Description: Monolithically poured, factory-fabricated, reinforced-concrete walls and bottom unless open-bottom enclosures are indicated. Frame and cover shall form top of enclosure and shall have load rating consistent with that of handhole or box.

B. Comply with ASTM C858 for design and manufacturing processes.

C. Frame and Cover: Weatherproof cast-iron frame, with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.

D. Frame and Cover: Weatherproof steel frame, with steel cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.

E. Frame and Cover: Weatherproof steel frame, with hinged steel access door assembly with tamper-resistant, captive, cover-securing bolts.

1. Cover Hinges: Concealed, with hold-open ratchet assembly.
2. Cover Handle: Recessed.

F. Frame and Cover: Weatherproof aluminum frame, with hinged aluminum access door assembly with tamper-resistant, captive, cover-securing bolts.

1. Cover Hinges: Concealed, with hold-open ratchet assembly.
2. Cover Handle: Recessed.

G. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

H. Cover Legend: Molded lettering, "COMMUNICATIONS or COMM" as directed.

I. Configuration: Units shall be designed for flush burial and have open, closed or integral closed bottom unless otherwise indicated.

J. Extensions and Slabs: Designed to mate with bottom of enclosure and made of same material as enclosure.

1. Extension shall provide increased depth of 12 inches (300 mm).
2. Slab: Same dimensions as bottom of enclosure and arranged to provide closure.

K. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

L. Knockout Panels: Precast openings in walls, arranged to match dimensions and elevations of approaching duct and duct banks, plus an additional 6 inches (150 mm) or 12 inches (300 mm) vertically and horizontally to accommodate alignment variations as directed.

1. Knockout panels shall be located no less than 6 inches (150 mm) from interior surfaces of walls, floors, or frames and covers of handholes, but close enough to corners to facilitate racking of cables on walls.
2. Knockout panel opening shall have cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.

3. Knockout panel openings shall be framed with at least two additional No. 3 steel reinforcing bars in concrete around each opening.
4. Knockout panels shall be 1-1/2 to 2 inches (38 to 50 mm) thick.

M. Duct Entrances in Handhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.

1. Type and size shall match fittings to duct or conduit to be terminated.
2. Fittings shall align with elevations of approaching duct and be located near interior corners of handholes to facilitate racking of cable.

N. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.6 POLYMER CONCRETE HANDHOLES AND BOXES WITH POLYMER CONCRETE COVER

A. Description: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.

B. Standard: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.

C. Color: Gray or Green as directed.

D. Configuration: Units shall be designed for flush burial and have open, closed or integral closed bottom unless otherwise indicated.

E. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.

F. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

G. Cover Legend: Molded lettering, "COMMUNICATIONS or "COMM" as directed.

H. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.

I. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering duct for secure, fixed installation in enclosure wall.

J. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have factory-installed inserts for cable racks and pulling-in irons.

2.7 FIBERGLASS HANDHOLES AND BOXES WITH POLYMER CONCRETE FRAME AND COVER

A. Description: Sheet-molded, fiberglass-reinforced, polyester resin enclosure joined to polymer concrete top ring or frame.

B. Standard: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.

C. Color: Gray or Green as directed.

D. Configuration: Units shall be designed for flush burial and have open, closed or integral closed bottom unless otherwise indicated.

E. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.

F. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

G. Cover Legend: Molded lettering, "COMMUNICATIONS or "COMM" as directed

H. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.

I. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering duct for secure, fixed installation in enclosure wall.

J. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have factory-installed inserts for cable racks and pulling-in irons.

2.8 FIBERGLASS HANDHOLES AND BOXES

A. Description: Molded of fiberglass-reinforced polyester resin, with covers made as directed.

B. Standard: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.

C. Color: Gray or Green as directed.

D. Configuration: Units shall be designed for flush burial and have open, closed, integral closed bottom unless otherwise indicated.

E. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.

F. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

G. Cover Legend: Molded lettering, "COMMUNICATIONS or "COMM" as directed.

H. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.

I. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering duct for secure, fixed installation in enclosure wall.

J. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have factory-installed inserts for cable racks and pulling-in irons.

2.9 HIGH-DENSITY PLASTIC BOXES

A. Description: Injection molded of high-density polyethylene or copolymer-polypropylene. Cover shall be made as directed.

B. Standard: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.

C. Color: Gray or Green as directed.

D. Configuration: Units shall be designed for flush burial and have open, closed, integral closed bottom unless otherwise indicated.

E. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.

F. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

G. Cover Legend: Molded lettering, "COMMUNICATIONS or "COMM" as directed.

H. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.

I. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering duct for secure, fixed installation in enclosure wall.

J. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have factory-installed inserts for cable racks and pulling-in irons.

2.10 PRECAST MANHOLES

A. Description: One-piece units and units with interlocking mating sections, complete with accessories, hardware, and features.

B. Standard: Comply with ASTM C858.

C. Structural Design Loading: Comply with requirements in "Underground Enclosure Application" Article.

D. Knockout Panels: Precast openings in walls, arranged to match dimensions and elevations of approaching duct and duct banks, plus an additional 6 inches (150 mm) or 12 inches (300 mm) vertically and horizontally to accommodate alignment variations as directed.

1. Splayed or Center window location as directed.

2. Knockout panels shall be located no less than 6 inches (150 mm) from interior surfaces of walls, floors, or roofs of manholes, but close enough to corners to facilitate racking of cables on walls.
3. Knockout panel opening shall have cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie into concrete envelopes of duct banks.
4. Knockout panel openings shall be framed with at least two additional No. 3 steel reinforcing bars in concrete around each opening.
5. Knockout panels shall be 1-1/2 to 2 inches (38 to 50 mm) thick.

E. Duct Entrances in Manhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.

1. Type and size shall match fittings to duct or conduit to be terminated.
2. Fittings shall align with elevations of approaching duct and be located near interior corners of manholes to facilitate racking of cable.

F. Ground Rod Sleeve: Provide a 3-inch (75-mm) PVC sleeve in manhole floors 2 inches (50 mm) from the wall adjacent to, but not underneath, the duct routed from the facility.

G. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

2.11 UTILITY STRUCTURE ACCESSORIES

A. Accessories for Utility Structures: Utility equipment and accessory items used for utility structure access and utility support, listed and labeled for intended use and application.

B. Manhole Frames, Covers, and Chimney Components: Comply with structural design loading specified for manhole.

1. Frame and Cover: Weatherproof, gray cast iron complying with ASTM A48/A48M, Class 30B or cast aluminum as directed, with milled cover-to-frame bearing surfaces; 26-inch (660-mm) or 29-inch (725-mm) diameter as directed.

   a. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
   b. Special Covers: Recess in face of cover designed to accept finish material in paved areas.

2. Cover Legend: Cast in. Selected to suit system.
3. Manhole Chimney Components: Precast concrete rings, with dimensions matched to those of roof opening.

   a. Mortar for Chimney Ring and Frame and Cover Joints: Comply with ASTM C270, Type M, except for quantities of less than 2.0 cu. ft. (60 L), where packaged mix complying with ASTM C387, Type M, may be used.
   b. Seal joints watertight using preformed plastic or rubber conforming to ASTM C990. Install sealing material according to the sealant manufacturers' printed instructions.

C. Manhole Sump Frame and Grate: ASTM A48/A48M, Class 30B, gray cast iron.

D. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2-inch (50-mm) diameter eye, and 1-by-4-inch (25-by-100-mm) bolt.

1. Working Load Embedded in 6-Inch (150-mm), 4000-psi (27.6-MPa) Concrete: 13,000-lbf (58-kN) minimum tension.

E. Pulling Eyes in Nonconcrete Walls: Eyebolt with reinforced fastening, 1-1/4-inch (31-mm) diameter eye, rated 2500-lbf (11-kN) minimum tension.

F. Pulling-In and Lifting Irons in Concrete Floors: 7/8-inch- (22-mm-) diameter, hot-dip galvanized, bent steel rod; stress relieved after forming; and fastened to reinforcing rod. Exposed triangular opening.

1. Ultimate Yield Strength: 40,000-lbf (180-kN) shear and 60,000-lbf (270-kN) tension.

G. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2-inch (13-mm) ID by 2-3/4 inches (69 mm) deep, flared to a minimum of 1-1/4 inches (31 mm) at base.

1. Tested Ultimate Pullout Strength: 12,000 lbf (53 kN) minimum.

H. Ground Rod Sleeve: 3-inch (75-mm), PVC duct sleeve in manhole floors 2 inches (50 mm) from the wall adjacent to, but not underneath, the duct entering the structure.

I. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel-wedge type with stainless-steel expander clip, with 1/2-inch (13-mm) bolt, 5300-lbf (24-kN) rated pullout strength, and minimum 6800-lbf (30-kN) rated shear strength.

J. Cable Rack Assembly: Nonmetallic. Components fabricated from nonconductive, fiberglass-reinforced polymer.

1. Stanchions: Nominal 36 inches (900 mm) high by 4 inches (100 mm) wide, with minimum of nine holes for arm attachment.
2. Arms: Arranged for secure, drop-in attachment in horizontal position at any location on cable stanchions, and capable of being locked in position. Arms shall be available in lengths ranging from 3 inches (75 mm) with 450-lb (204-kg) minimum capacity to 20 inches (500 mm) with 250-lb (114-kg) minimum capacity. Top of arm shall be nominally 4 inches (100 mm) wide, and arm shall have slots along full length for cable ties.

K. Duct-Sealing Compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F (2 deg C). Capable of withstanding temperature of 300 deg F (150 deg C) without slump and adhering to clean surfaces of plastic duct, metallic duct, duct coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.

L. Fixed Manhole Ladders: Arranged for attachment to roof or wall and floor of manhole as directed. Ladder, mounting brackets, and braces shall be fabricated from nonconductive, structural-grade, fiberglass-reinforced resin or hot-dip galvanized steel as directed.

M. Portable Manhole Ladders: UL-listed, heavy-duty wood or fiberglass specifically designed for portable use for access to electrical manholes as directed. Minimum length equal to distance from deepest manhole floor to grade plus 36 inches (900 mm). One required.

N. Cover Hooks: Heavy duty, designed for lifts 60 lbf (270 N) and greater or Light duty, designed for lifts less than 60 lbf (270 N) as directed. Two required.

2.12 SOURCE QUALITY CONTROL

A. Test and inspect precast concrete utility structures according to ASTM C1037.

B. Nonconcrete Handhole and Pull-Box Prototype Test: Test prototypes of manholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.

1. Tests of materials shall be performed by an independent testing agency.
2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
3. Testing machine pressure gages shall have current calibration certification, complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

PART 3 - EXECUTION

3.1 PREPARATION

A. Coordinate layout and installation of duct, duct bank, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field. Notify Architect if there is a conflict between areas of excavation and existing structures or archaeological sites to remain.

B. Coordinate elevations of duct and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of duct and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by Architect.

3.2 UNDERGROUND DUCT APPLICATION

A. Duct for Communications: Type EPC-80-PVC or Type EPC-40-PVC RNC, in concrete-encased duct bank unless otherwise indicated.

B. Duct for Communications: Type EPC-80-PVC or Type EPC-40-PVC RNC, in direct-buried duct bank unless otherwise indicated as directed.

C. Duct for Communications: Type EPEC-40-HDPE or Type EPEC-80-HDPE duct in direct-bored duct bank unless otherwise indicated as directed.

D. Underground Duct Crossing Paved Paths, Walks and Driveways Roadways and Railroads as directed: Type EPC-40-PVC RNC, encased in reinforced concrete.

E. Stub-Ups for Communications: Concrete-encased as directed.

3.3 UNDERGROUND ENCLOSURE APPLICATION

A. Handholes and Boxes for Communications:

1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete. AASHTO HB 17, H-10 or H-20 structural load rating as directed.
2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Structural load rating as directed.
3. Units in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Structural load rating as directed.
4. Units Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin or High-density plastic as directed, structurally tested according to SCTE 77 with 3000-lbf (13 345-N) vertical loading.
5. Cover design load shall not exceed the design load of the handhole or box.

B. Manholes: Precast concrete.

1. Units Located in Roadways and Other Deliberate Traffic Paths by Heavy or Medium Vehicles: H-20 structural load rating according to AASHTO HB 17.
2. Units Not Located in Deliberate Traffic Paths by Heavy or Medium Vehicles: H-10 load rating according to AASHTO HB 17.

3.4 EARTHWORK

A. Excavation and Backfill: Comply with Section 312000 "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.

B. Restoration: Replace area immediately after backfilling is completed or after construction in immediate area is complete as directed.

C. Restore surface features at areas disturbed by excavation and re-establish original grades unless otherwise indicated.

D. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Section 329200 "Turf and Grasses" and Section 329300 "Plants."

E. Cut and patch existing pavement in the path of underground duct, duct bank, and utility structures according to the "Cutting and Patching" Article in Section 017300 "Execution."

3.5 DUCT AND DUCT-BANK INSTALLATION

A. Where indicated on Drawings, install duct, spacers, and accessories into the duct configuration shown. Duct installation requirements in this Section also apply to duct bank.

B. Install duct and duct bank according to NEMA TCB 2 and TIA-758-C.

C. Slope: Pitch duct and duct bank a minimum slope of 1:100 down toward manholes and handholes and away from buildings and equipment. Slope duct and duct bank from a high point in runs between two manholes, to drain in both directions.

D. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius as directed, both horizontally and vertically, at other locations unless otherwise indicated.

1. Duct and duct banks shall have maximum of two 90-degree bends, or the total of all bends shall be no more 180 degrees between pull points.

E. Joints: Use solvent-cemented joints in duct and fittings and make watertight according to manufacturer's written instructions. Stagger couplings, so those of adjacent ducts do not lie in same plane.

F. Installation Adjacent to High-Temperature Steam Lines: Where duct or duct banks are installed parallel to underground steam lines, perform calculations showing the duct or duct bank will not be subject to environmental temperatures above 40 deg C. Where environmental temperatures are calculated to rise above 40 deg C, and anywhere the duct or duct bank crosses above an underground steam line, install insulation blankets listed for direct burial to isolate the duct bank from the steam line.

G. End-Bell Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 6 inches (150 mm) o.c. for 4-inch (100-mm) duct, and vary proportionately for other duct sizes.

H. Terminator Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use manufactured, cast-in-place duct terminators, with entrances into structure spaced approximately 6 inches (150 mm) o.c. for 4-inch (100-mm) duct and vary proportionately for other duct sizes.

I. Building Wall Penetrations: Make a transition from underground duct to GRC at least 10 feet (3 m) outside the building wall, without reducing duct slope away from the building or forming a trap in the duct. Use fittings manufactured for RNC duct-to-GRC conduit transition. Install GRC penetrations of building walls as specified in Section 270544 "Sleeves and Sleeve Seals for Communications Pathways and Cabling."

J. Sealing: Provide temporary closure at terminations of duct that has cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig (1.03-MPa) hydrostatic pressure.

K. Innerduct: Install immediately after mandreling duct. Size and type as indicated on Drawings. Provide three innerducts per duct.

L. Pulling Cord: Install 200-lbf- (1000-N-m) test nylon cord in empty duct and innerduct.

M. Concrete-Encased Duct and Duct Bank:

1. Excavate trench bottom to provide firm and uniform support for duct or duct bank. Prepare trench bottoms as specified in Section 312000 "Earth Moving" for pipes less than 6 inches (150 mm) in nominal diameter.
2. Width: Excavate trench 12 inches (300 mm) wider than duct or duct bank on each side.
3. Width: Excavate trench 3 inches (75 mm) wider than duct or duct bank on each side.
4. Depth: Install top of duct and duct bank at least 24 inches (600 mm) below finished grade in areas not subject to deliberate traffic, and at least 30 inches (750 mm) below finished grade in deliberate traffic paths for vehicles unless otherwise indicated.
5. Support duct and duct bank on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
6. Minimum Space Between Duct: 3 inches (75 mm) between edge of duct and exterior envelope wall, 2 inches (50 mm) between ducts for like services, and 4 inches (100 mm) between power and communications ducts.
7. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than four or five spacers per 20 feet (6 m) of duct as directed. Place spacers within 24 inches (600 mm) of duct ends. Stagger spacers approximately 6 inches (150 mm) between tiers. Secure spacers to earth and duct to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around duct or duct bank.
8. Elbows: Use manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct run unless otherwise indicated. Extend concrete encasement throughout length of elbow.
9. Elbows: Use manufactured GRC elbows for stub-ups, at building entrances, and at changes of direction in duct run.
10. Reinforcement: Reinforce concrete-encased duct and duct bank where they cross disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
11. Forms: Use trench walls to form side walls of duct and duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
12. Concrete Cover: Install a minimum of 3 inches (75 mm) of concrete cover between edge of duct to exterior envelope wall, 2 inches (50 mm) between ducts, and 4 inches (100 mm) between power and communications duct.
13. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
14. Pouring Concrete: Comply with requirements in "Concrete Placement" Article in Section 033000 "Cast-in-Place Concrete." Place concrete carefully during pours to prevent voids under and between ducts and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto duct. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application.

N. Direct-Buried Duct and Duct Banks:

1. Excavate trench bottom to provide firm and uniform support for duct and duct bank. Comply with requirements in Section 312000 "Earth Moving" for preparation of trench bottoms for duct less than 6 inches (150 mm) in nominal diameter.
2. Install duct with a minimum of 3 inches (75 mm) between duct for like services and 6 inches (150 mm) between power and signal duct.
3. Width: Excavate trench 12 inches (300 mm) wider than duct or duct bank on each side.
4. Width: Excavate trench 3 inches (75 mm) wider than duct or duct bank on each side.

5. Depth: Install top of duct or duct bank at least 36 inches (900 mm) below finished grade unless otherwise indicated.
6. Set elevation of bottom of duct or duct bank below frost line.
7. Support duct on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
8. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than four or five spacers per 20 feet (6 m) of duct as directed. Place spacers within 24 inches (600 mm) of duct ends. Stagger spacers approximately 6 inches (150 mm) between tiers. Secure spacers to earth and duct to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around duct or duct bank.
9. Elbows: Install manufactured duct elbows for stub-ups, at building entrances through floor, and at changes of direction in duct unless otherwise indicated. Encase elbows for stub-ups throughout length of elbow. Extend encasement minimum of 36 inches (900 mm) beyond elbow joints.
10. After installing first tier of duct, backfill and compact. Start at tie-in point and work toward end of duct run, leaving duct at end of run free to move with expansion and contraction, as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand place backfill to 4 inches (100 mm) over duct and hand tamp. Firmly tamp backfill around duct to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction. Comply with requirements in Section 312000 "Earth Moving" for installation of backfill materials.

O. Underground-Line Warning Tape: Bury nonconducting or conducting underground-line warning tape specified in Section 270553 "Identification for Communication Systems" no less than 12 inches (300 mm) above all concrete-encased duct and duct bank and approximately 12 inches (300 mm) below grade as directed. Align tape parallel to and within 3 inches (75 mm) of centerline of duct bank. Provide an additional warning tape for each 12-inch (300-mm) increment of duct-bank width over a nominal 18 inches (450 mm). Space additional tapes 12 inches (300 mm) apart, horizontally.

3.6 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES, AND BOXES

A. Precast Concrete Handhole and Manhole Installation:

1. Comply with ASTM C891 unless otherwise indicated.
2. Install units level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for proper entrances.
3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch (25-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

B. Elevations:

1. Manhole Roof: Install with rooftop at least 15 inches (380 mm) below finished grade.
2. Manhole Frame: In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames 1 inch (25 mm) above finished grade.
3. Install handholes with bottom below frost line, as directed.

4. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch (25 mm) above finished grade.
5. Where indicated, cast handhole cover frame integrally with handhole structure.

C. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.

D. Manhole Access: Circular opening in manhole roof; sized to match cover size.

1. Manholes with Fixed Ladders: Offset access opening from manhole centerlines to align with ladder.
2. Install chimney, constructed of precast concrete collars and rings, to support cast-iron frame to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for frame to chimney.

E. Waterproofing: Apply waterproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. Waterproofing materials and installation are specified in Section 071353 "Elastomeric Sheet Waterproofing." Section 071354 "Thermoplastic Sheet Waterproofing.". After duct has been connected and grouted, and before backfilling, waterproof joints and connections, and touch up abrasions and scars. Waterproof exterior of manhole chimneys after mortar has cured at least three days.

F. Dampproofing: Apply dampproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. Dampproofing materials and installation are specified in Section 071113 "Bituminous Dampproofing." After duct has been connected and grouted, and before backfilling, dampproof joints and connections, and touch up abrasions and scars. Dampproof exterior of manhole chimneys after mortar has cured at least three days.

G. Hardware: Install removable hardware, including pulling eyes, cable stanchions, and cable arms, and insulators, as required for installation and support of cables and conductors and as indicated.

H. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.

I. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches (97 mm) for manholes and 2 inches (50 mm) for handholes, for field-installed anchor bolts installed. Use a minimum of two anchors for each cable stanchion.

3.7 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of duct and duct bank, and seal joint between box and extension as recommended by manufacturer.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas and trafficways, set cover flush with finished grade. Set covers of other handholes 1 inch (25 mm) above finished grade.

D. Install handholes and boxes with bottom below frost line, as directed.

E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.

F. Field cut openings for duct according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

G. For enclosures installed in asphalt paving and subject to occasional, nondeliberate, heavy-vehicle loading, form and pour a concrete ring, encircling, and in contact with, enclosure, and with top surface screeded to top of box cover frame as directed. Bottom of ring shall rest on compacted earth.

1. Concrete: 3000 psi (20 kPa), 28-day strength, complying with Section 033000 "Cast-in-Place Concrete," with a troweled finish.
2. Dimensions: 10 inches wide by 12 inches deep (250 mm wide by 300 mm deep).

3.8 GROUNDING

A. Ground underground duct, duct bank, and utility structures according to Section 270526 "Grounding and Bonding for Communications Systems."

3.9 FIELD QUALITY CONTROL

A. Perform the following tests and inspections and prepare test reports:

1. Demonstrate capability and compliance with requirements on completion of installation of underground duct, duct bank, and utility structures.
2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide a minimum 12-inch- (300-mm-) long mandrel equal to duct size minus 1/4 inch (6 mm). If obstructions are indicated, remove obstructions and retest.
3. Test manhole and handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 270526 "Grounding and Bonding for Communications Systems."

B. Correct deficiencies and retest as specified above to demonstrate compliance.

3.10 CLEANING

A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of duct until duct cleaner indicates that duct is clear of dirt and debris.

B. Clean internal surfaces of manholes, including sump.

1. Sweep floor, removing dirt and debris.
2. Remove foreign material.

END OF SECTION 270543

SECTION 270544 - SLEEVES AND SLEEVE SEALS FOR COMMUNICATIONS PATHWAYS AND CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Sleeves for pathway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

B. Related Requirements:

1. Section 078413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

PART 2 - PRODUCTS

2.1 SLEEVES

A. Wall Sleeves:

1. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. Sleeves for Rectangular Openings:

1. Material: Galvanized-steel sheet.
2. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and with no side larger than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
b. For sleeve cross-section rectangle perimeter 50 inches (1270 mm) or more and one or more sides larger than 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

2.2 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and pathway or cable.
1. Sealing Elements: EPDM or Nitrile (Buna N) rubber interlocking links shaped to fit surface of pipe as directed. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: As directed.
3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, or Stainless steel of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.

2.4 GROUT

A. Description: Non-shrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

B. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.

B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, non-shrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

A. Comply with NECA 1.

B. Comply with NEMA VE 2 for cable tray and cable penetrations.

C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:

1. Interior Penetrations of Non-Fire-Rated Walls and Floors:

    a. Seal annular space between sleeve and pathway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."
    b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.

2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
3. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pathway or cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.
4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level. Install sleeves during erection of floors.

D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:

1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.

E. Roof-Penetration Sleeves: Seal penetration of individual pathways and cables with flexible boot-type flashing units applied in coordination with roofing work.

F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel or cast-iron pipe sleeves and mechanical sleeve seals as directed. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between pathway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at pathway entries into building.

B. Install type and number of sealing elements recommended by manufacturer for pathway or cable material and size. Position pathway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pathway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION 270544

SECTION 270548.16 - SEISMIC CONTROLS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Restraint channel bracings.
2. Restraint cables.
3. Seismic-restraint accessories.
4. Mechanical anchor bolts.
5. Adhesive anchor bolts.

B. Related Requirements:

1. Section 270528.29 "Hangers and Supports for Communications Systems" for commonly used supports and installation requirements.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.

    a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service member of ICC-ES or OSHPD or an agency acceptable to authorities having jurisdiction as directed.
    b. Annotate to indicate application of each product submitted and compliance with requirements.

B. Delegated-Design Submittal: For each seismic-restraint device.

1. Include design calculations and details for selecting seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Design Calculations: Calculate static and dynamic loading caused by equipment weight, operation, and seismic and wind forces required to select seismic and wind restraints and for designing vibration isolation bases.

    a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.

3. Seismic- and Wind-Restraint Details:

a. Design Analysis: To support selection and arrangement of seismic and wind restraints. Include calculations of combined tensile and shear loads.
b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
d. Preapproval and Evaluation Documentation: By an evaluation service member of ICC-ES, OSHPD or an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations) as directed.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

B. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Seismic-restraint devices shall have horizontal and vertical load testing and analysis. They shall bear anchorage preapproval from OSHPD in addition to preapproval, showing maximum seismic-restraint ratings, by ICC-ES or another agency acceptable to authorities having jurisdiction. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) that support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

D. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Wind-Restraint Loading:

1. Basic Wind Speed: As directed.
2. Building Classification Category: As directed.

3. Minimum 10 lb/sq. ft. (48.8 kg/sq. m) multiplied by maximum area of component projected on vertical plane normal to wind direction and 45 degrees either side of normal.

B. Seismic-Restraint Loading:

1. Site Class as Defined in the IBC: As directed.
2. Assigned Seismic Use Group or Building Category as Defined in the IBC: As directed.

   a. Component Importance Factor: 1.0 or 1.5 as directed.
   b. Component Response Modification Factor: As directed.
   c. Component Amplification Factor: 1.0 or 2.5 as directed.

3. Design Spectral Response Acceleration at Short Periods (0.2 Second): As directed.
4. Design Spectral Response Acceleration at 1.0-Second Period: As directed.

2.2 RESTRAINT CHANNEL BRACINGS

A. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end, with other matching components, and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.3 RESTRAINT CABLES

A. Restraint Cables: ASTM A603 galvanized or ASTM A492 stainless-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.4 SEISMIC-RESTRAINT ACCESSORIES

A. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or Reinforcing steel angle clamped to hanger rod as directed.

B. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables as directed.

C. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings and matched to type and size of anchor bolts and studs.

D. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings and matched to type and size of attachment devices used.

E. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.5 MECHANICAL ANCHOR BOLTS

A. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488.

2.6 ADHESIVE ANCHOR BOLTS

A. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an evaluation service member of ICC-ES, OSHPD or an agency acceptable to authorities having jurisdiction as directed.

B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods caused by seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.2 SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Equipment and Hanger Restraints:

1. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
2. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES, OSHPD or an agency acceptable to authorities having jurisdiction providing required submittals for component as directed.

B. Install cables so they do not bend across edges of adjacent equipment or building structure.

C. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

D. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

E. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.3 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where connection is terminated to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
2. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
3. Test to 90 percent of rated proof load of device.

B. Seismic controls will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 270548.16

SECTION 270553 - IDENTIFICATION FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Color and legend requirements for labels and signs.
2. Labels.
3. Bands and tubes.
4. Tapes.
5. Signs.
6. Cable ties.
7. Fasteners for labels and signs.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Identification Schedule:

1. Outlets: Scaled drawings indicating location and proposed designation.
2. Backbone Cabling: Riser diagram showing each communications room, backbone cable, and proposed backbone cable designation.
3. Racks: Scaled drawings indicating location and proposed designation.
4. Patch Panels: Enlarged scaled drawings showing rack row, number, and proposed designations.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with NFPA 70 and TIA 606-B.

B. Comply with ANSI Z535.4 for safety signs and labels.

C. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.2 COLOR AND LEGEND REQUIREMENTS

A. Equipment Identification Labels:

1. Black letters on a white field.

2.3 LABELS

A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.

B. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters of raceway or cable they identify, that stay in place by gripping action.

C. Self-Adhesive Wraparound Labels: Preprinted or Write-on as directed, 3-mil- (0.08-mm-) thick, polyester or vinyl flexible labels with acrylic pressure-sensitive adhesive as directed.
1. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating protective shields over the legend. Labels sized such that the clear shield overlaps the entire printed legend.
2. Marker for Labels: Permanent, waterproof black ink marker recommended by tag manufacturer.
3. Marker for Labels: Machine-printed, permanent, waterproof black ink recommended by printer manufacturer.

D. Self-Adhesive Labels: Polyester or Vinyl as directed, thermal, transfer-printed, 3-mil- (0.08-mm-) thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
1. Minimum Nominal Size:

a. 1-1/2 by 6 inches (37 by 150 mm) for raceway and conductors.
b. 3-1/2 by 5 inches (76 by 127 mm) for equipment.
c. As required by authorities having jurisdiction.

2.4 SIGNS

A. Baked-Enamel Signs:
1. Preprinted aluminum signs, high-intensity reflective, punched or drilled for fasteners, with colors, legend, and size required for application.
2. 1/4-inch (6.4-mm) grommets in corners for mounting.
3. Nominal Size: 7 by 10 inches (180 by 250 mm).

B. Laminated-Acrylic or Melamine-Plastic Signs:
1. Engraved legend.
2. Thickness:

a. For signs up to 20 sq. in. (129 sq. cm), minimum 1/16 inch (1.6 mm) thick.
b. For signs larger than 20 sq. in. (129 sq. cm), 1/8 inch (3.2 mm) thick.

c. Engraved legend with black letters on white face or white letters on a dark gray background as directed.
d. Punched or drilled for mechanical fasteners with 1/4-inch (6.4-mm) grommets in corners for mounting or Self-adhesive as directed.
e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.5 CABLE TIES

A. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength at 73 deg F (23 deg C) according to ASTM D638: 12,000 psi (82.7 MPa).
3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
4. Color: Black, except where used for color-coding.

B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength at 73 deg F (23 deg C) according to ASTM D638: 12,000 psi (82.7 MPa).
3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
4. Color: Black.

C. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.

1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength at 73 deg F (23 deg C) according to ASTM D638: 7000 psi (48.2 MPa).
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F (Minus 46 to plus 140 deg C).
5. Color: Black.

2.6 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

B. Verify identity of each item before installing identification products.

C. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

D. Apply identification devices to surfaces that require finish after completing finish work.

E. Install signs with approved legend to facilitate proper identification, operation, and maintenance of communications systems and connected items.

F. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.

G. Vinyl Wraparound Labels:

1. Secure tight to surface of raceway or cable at a location with high visibility and accessibility.
2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.
3. Provide label 6 inches (150 mm) from cable end.

H. Snap-Around Labels:

1. Secure tight to surface at a location with high visibility and accessibility.
2. Provide label 6 inches (150 mm) from cable end.

I. Self-Adhesive Wraparound Labels:

1. Secure tight to surface at a location with high visibility and accessibility.
2. Provide label 6 inches (150 mm) from cable end.

J. Self-Adhesive Labels:

1. On each item, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.

K. Cable Ties: General purpose, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

3.2 IDENTIFICATION SCHEDULE

A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations with high visibility. Identify by system and circuit designation.

C. Accessible Fittings for Raceways and Cables within Buildings: Identify covers of each junction and pull box with self-adhesive labels containing wiring system legend.

1. System legends shall be as follows:

a. Telecommunications.

D. Faceplates: Label individual faceplates with self-adhesive labels. Place label at top of faceplate. Each faceplate shall be labeled with its individual, sequential designation, numbered clockwise when entering room from primary egress, composed of the following, in the order listed:

1. Wiring closet designation.
2. Colon.
3. Faceplate number.

E. Equipment Room Labeling:

1. Racks, Frames, and Enclosures: Identify front and rear of each with self-adhesive labels containing equipment designation.
2. Patch Panels: Label individual rows in each rack, starting at top and working down, with self-adhesive labels. Label individual rows and outlets, starting at to left and working down, with self-adhesive labels.
3. Data Outlets: Label each outlet with a self-adhesive label indicating the following, in the order listed:

a. Room number being served.
b. Colon.
c. Faceplate number.

F. Backbone Cables: Label each cable indicating the location of the far or other end of the backbone cable as directed. Patch panel or punch down block where cable is terminated should be labeled identically.

G. Horizontal Cables: As directed, label each cable indicating the following, in the order listed:

1. Room number.
2. Colon.
3. Faceplate number.

H. Instructional Signs: Self-adhesive labels.

I. Warning Labels for Indoor Cabinets, Boxes, and Enclosures: Self-adhesive labels or Baked-enamel warning signs as directed.

1. Apply to exterior of door, cover, or other access.

J. Equipment Identification Labels:

1. Indoor Equipment: As directed.
2. Outdoor Equipment: Laminated-acrylic or melamine-plastic sign.
3. Equipment to Be Labeled:

    a. Communications cabinets.
    b. Uninterruptible power supplies.
    c. Computer room air conditioners.
    d. Fire-alarm and suppression equipment.
    e. Egress points.
    f. Power distribution components.

END OF SECTION 270553

SECTION 271100 - COMMUNICATIONS EQUIPMENT ROOM FITTINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Backboards.
2. Boxes, enclosures, and cabinets.
3. Power strips.

B. Related Requirements:

1. Section 270536 "Cable Trays for Communications Systems" for cable trays and accessories.
2. Section 271313 "Communications Copper Backbone Cabling" for copper data cabling associated with system panels and devices.
3. Section 271323 "Communications Optical Fiber Backbone Cabling" for optical-fiber data cabling associated with system panels and devices.
4. Section 271333 "Communications Coaxial Backbone Cabling" for coaxial data cabling associated with system panels and devices.
5. Section 271513 "Communications Copper Horizontal Cabling" for copper data cabling associated with system panels and devices.
6. Section 271523 "Communications Optical Fiber Horizontal Cabling" for coaxial data cabling associated with system panels and devices.
7. Section 271533 "Communications Coaxial Horizontal Cabling" for coaxial data cabling associated with system panels and devices.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For communications equipment room fittings. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Equipment Racks and Cabinets: Include workspace requirements and access for cable connections.
3. Grounding: Indicate location of grounding bus bar and its mounting detail showing standoff insulators and wall mounting brackets.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, from manufacturer.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Equipment shall withstand the effects of earthquake motions determined according to ASCE/SEI 7 or Telcordia GR-63-CORE requirements for Zone 4 Seismic Earthquake Environments as directed.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.2 BACKBOARDS

A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm).

B. Backboard Paint: As directed.

2.3 BOXES, ENCLOSURES, AND CABINETS

A. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets shall be listed and labeled for intended location and use.

B. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

C. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, Type FD, ferrous alloy or aluminum, with gasketed cover.

D. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.

E. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

F. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum or galvanized cast iron with gasketed cover as directed.

G. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

H. Device Box Dimensions: 4 inches square by 2-1/8 inches deep (100 mm square by 60 mm deep) or 4 inches by 2-1/8 inches by 2-1/8 inches deep (100 mm by 60 mm by 60 mm deep).

I. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, with continuous-hinge cover with flush latch unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
2. Nonmetallic Enclosures: Plastic or Fiberglass as directed.
3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

2.4 POWER STRIPS

A. Comply with requirements in Section 271116 "Communications Racks, Frames, and Enclosures."

B. Power Strips: Comply with UL 1363.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Rack mounting, with detachable or integral flanges as directed.
3. Height: 1 RU.
4. Housing: Metal.
5. Six, 15-A, 120-V ac, NEMA WD 6, Configuration 5-15R or 20-A, 120-V ac, NEMA WD 6, Configuration 5-20R receptacles as directed.
6. Front or Rear-facing receptacles as directed.
7. LED indicator lights for power and protection status.
8. LED indicator lights for reverse polarity and open outlet ground.
9. Circuit Breaker and Thermal Fusing: When protection is lost, circuit opens and cannot be reset.
10. Circuit Breaker and Thermal Fusing: Unit continues to supply power if protection is lost.
11. Close-coupled, direct plug-in or Cord connected with 15-foot (4.5-m) line cord as directed.
12. Rocker-type on-off switch, illuminated when in on position.
13. Surge Protection: UL 1449, Type 3.

    a. Maximum Surge Current, Line to Neutral: 27 kA or 72 kA as directed.
    b. Protection modes shall be line to neutral, line to ground, and neutral to ground.
    c. UL 1449 Voltage Protection Rating for line to neutral and line to ground shall be 600 V and 500 V for neutral to ground.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Comply with BICSI's "Telecommunications Distribution Methods Manual" for layout of communications equipment spaces.

C. Comply with BICSI's "Information Technology Systems Installation Methods Manual" for installation of equipment in communications equipment spaces.

D. Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

E. Coordinate layout and installation of communications equipment in tracks and in room. Coordinate service entrance configuration with service provider.

F. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

G. Backboards:

1. Install from 6 inches (150 mm) to 8 feet, 6 inches (2588 mm) above finished floor. If plywood is fire rated, ensure that fire-rating stamp is visible after installation.
2. Paint all sides of backboard with two coats of paint, leaving fire rating stamp visible.
3. Comply with requirements for backboard installation in BICSI's "Information Technology Systems Installation Methods Manual" and TIA-569-D.

3.2 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-D, Annex A, "Firestopping."

C. Comply with BICSI's "Information Technology Systems Installation Methods Manual", "Firestopping Practices" Ch.

END OF SECTION 271100

SECTION 271116 - COMMUNICATIONS RACKS, FRAMES, AND ENCLOSURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. 19-inch equipment racks.
2. 19-inch freestanding, wall-mounted, freestanding and wall-mounted equipment cabinets or as directed.
3. Power strips.
4. Grounding.
5. Labeling.

1.2 DEFINITIONS

A. Access Provider: An operator that provides a circuit path or facility between the service provider and user. An access provider can also be a service provider.

B. Service Provider: The operator of a telecommunications transmission service delivered through access provider facilities.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For communications racks, frames, and enclosures. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Equipment Racks and Cabinets: Include workspace requirements and access for cable connections.
3. Grounding: Indicate location of TGB and its mounting detail showing standoff insulators and wall-mounting brackets.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.

B. Seismic Qualification Data: Certificates, from manufacturer.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Cabling installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings shall be under direct supervision of RCDD or Technician as directed.
2. Installation Supervision: Installation shall be under direct supervision of Technician or Installer 2, Copper or Fiber as directed, who shall be present at all times when Work of this Section is performed at Project site.
3. Field Inspector: Currently registered by BICSI as RCDD or Technician to perform on-site inspection as directed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Equipment shall withstand the effects of earthquake motions determined according to ASCE/SEI 7 or Telcordia GR-63-CORE requirements for Zone 4 Seismic Earthquake Environments as directed.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

B. UL listed.

C. RoHS compliant.

D. Compliant with requirements of the Payment Card Industry Data Security Standard.

2.2 19-INCH EQUIPMENT RACKS

A. Description: Two and four-post racks with threaded rails designed for mounting telecommunications equipment or as directed. Width is compatible with EIA/ECIA 310-E, 19-inch (482.6-mm) equipment mounting with an opening of 17.72-inches (450-mm) between rails.

B. General Requirements:

1. Frames: Modular units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
2. Material: As directed.
3. Finish: Manufacturer's standard, baked-polyester powder coat.
4. Color: Black.

C. Floor-Mounted Racks:

1. Overall Height: 72 inches (1828.8 mm) or 84 inches (2133.6 mm) as directed.
2. Overall Depth: 23 inches (584.2 mm) or 29 inches (736.6 mm) as directed.

3. Upright Depth: 3 inches (76.2 mm) or 6 inches (152.4 mm) as directed.
4. Two-Post Load Rating: 200 lb (91 kg) or 400 lb (181 kg) as directed.
5. Four-Post Load Rating: 1000 lb (454 kg) or 2000 lb (907 kg) as directed.
6. Number of Rack Units per Rack: As directed.

    a. Numbering: Every or Every five rack units as directed, on interior of rack.

7. Threads: As directed.
8. Vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug, and a power strip.
9. Base shall have a minimum of four mounting holes for permanent attachment to floor.
10. Top shall have provisions for attaching to cable tray or ceiling.
11. Self-leveling.

D. Wall-Mounted Racks:

1. Height: 18 inches (457.2 mm) or 22 inches (558.8 mm) as directed.
2. Depth: 23 inches (584.2 mm) or 29 inches (736.6 mm) as directed.
3. Load Rating: 150 lb (65 kg) or 200 lb (91 kg) as directed.
4. Number of Rack Units per Rack: As directed.
5. Threads: As directed.
6. Wall Attachment: Four mounting holes.
7. Equipment Access: Integral swing.

E. Cable Management:

1. Metal, with integral wire retaining fingers.
2. Baked-polyester powder coat finish.
3. Vertical cable management panels shall have front and rear channels, with covers.
4. Provide horizontal crossover cable manager at the top of each relay rack, with a minimum height of two rack units each.

2.3 19-INCH EQUIPMENT CABINETS

A. Description: Manufacturer-assembled four-post frame enclosed by side and top panels and front and rear doors, designed for mounting telecommunications equipment. Width is compatible with EIA/ECIA 310-E, 19-inch (482.6-mm) equipment mounting with an opening of 17.72 inches (450 mm) between rails.

B. General Cabinet Requirements:

1. Modular units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
2. Material: As directed, Extruded steel, Extruded aluminum, Sheet steel or Sheet aluminum.
3. Finish: Manufacturer's standard, baked-polyester powder coat.
4. Color: Black.

C. Modular Freestanding Cabinets:

1. Overall Height: 72 inches (1828.8 mm) or 84 inches (2133.6 mm) as directed.
2. Overall Depth: 23 inches (584.2 mm) or 29 inches (736.6 mm) as directed.
3. Load Rating: 3000 lb (1362 kg).
4. Number of Rack Units: As directed.

    a. Numbering: Every or Every five rack units, on interior of rack as directed.

5. Threads: As directed.
6. Removable and lockable side and top panels.
7. Hinged and lockable front and rear doors.
8. Adjustable feet for leveling.
9. Screened ventilation openings in roof and rear door.
10. Cable access provisions in roof and base.
11. TGB.
12. Rack or Roof-mounted, 550-cfm (260-L/s) fan with filter as directed.
13. Power strip.
14. All cabinets keyed alike.

D. Modular Wall Cabinets:

1. Height: 18 inches (457.2 mm) or 22 inches (558.8 mm) as directed.
2. Depth: 23 inches (584.2 mm) or 29 inches (736.6 mm) as directed.
3. Load Rating: 150 lb (65 kg) or 200 lb (91 kg) as directed.
4. Number of Rack Units: As directed.
5. Threads: As directed.
6. Lockable front and rear doors.
7. Louvered side panels.
8. Cable access provisions top and bottom.
9. Grounding lug.
10. Rack or Roof-mounted, 250-cfm (118-L/s) fan as directed.
11. Power strip.
12. All cabinets keyed alike.

E. Cable Management:

1. Metal, with integral wire retaining fingers.
2. Baked-polyester powder coat finish.
3. Vertical cable management panels shall have front and rear channels, with covers.
4. Provide horizontal crossover cable manager at top of each relay rack, with a minimum height of two rack units each.

2.4 POWER STRIPS

A. Power Strips: Comply with UL 1363.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Rack mounting, with detachable or integral flanges as directed.
3. Height: 1 RU.

4. Housing: Metal.
5. Six, 15-A, 120-V ac, NEMA WD 6, Configuration 5-15R or 20-A, 120-V ac, NEMA WD 6, Configuration 5-20R receptacles as directed.
6. Front or Rear-facing receptacles as directed.
7. LED indicator lights for power and protection status.
8. LED indicator lights for reverse polarity and open outlet ground.
9. Circuit Breaker and Thermal Fusing: When protection is lost, circuit opens and cannot be reset.
10. Circuit Breaker and Thermal Fusing: Unit continues to supply power if protection is lost.
11. Close-coupled, direct plug-in or Cord connected with 15-foot (4.5-m) line cord as directed.
12. Rocker-type on-off switch, illuminated when in on position.
13. Surge Protection: UL 1449, Type 3.

    a. Maximum Surge Current, Line to Neutral: 27 kA or 72 kA as directed.
    b. Protection modes shall be line to neutral, line to ground, and neutral to ground.
    c. UL 1449 Voltage Protection Rating for line to neutral and line to ground shall be 600 V and 500 V for neutral to ground.

2.5 GROUNDING

A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.

B. Rack and Cabinet TGBs: Rectangular bars of hard-drawn solid copper, accepting conductors ranging from No. 14 to No. 2/0 AWG, NRTL listed as complying with UL 467, and complying with TIA-606-B. Predrilling shall be with holes for use with lugs specified in this Section.

1. Cabinet-Mounted TGB: Terminal block, with stainless-steel or copper-plated hardware for attachment to cabinet.
2. Rack-Mounted Horizontal TGB: Designed for mounting in 19- or 23-inch (482.6- or 584.2-mm) equipment racks. Include a copper splice bar for transitioning to an adjoining rack, and stainless-steel or copper-plated hardware for attachment to the rack.
3. Rack-Mounted Vertical TGB: 72 or 36 inches (1828.8 or 914.4 mm) long, with stainless-steel or copper-plated hardware for attachment to rack.

2.6 LABELING

A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Comply with BICSI TDMM for layout of communications equipment spaces.

C. Comply with BICSI ITSIMM for installation of communications equipment spaces.

D. Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

E. Coordinate layout and installation of communications equipment in racks and room. Coordinate service entrance configuration with service provider.

1. Meet jointly with system providers, equipment suppliers, and Owner to exchange information and agree on details of equipment configurations and installation interfaces.
2. Record agreements reached in meetings and distribute them to other participants.
3. Adjust configurations and locations of distribution frames, cross-connects, and patch panels in equipment spaces to accommodate and optimize configuration and space requirements of telecommunications equipment.
4. Adjust configurations and locations of equipment with distribution frames, cross-connects, and patch panels of cabling systems of other communications, electronic safety and security, and related systems that share space in equipment room.

F. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

3.2 GROUNDING

A. Comply with NECA/BICSI 607.

B. Install grounding according to BICSI ITSIMM, "Bonding, Grounding (Earthing) and Electrical Protection" Ch.

C. Locate TGB to minimize length of bonding conductors. Fasten to wall, allowing at least 2 inches (50 mm) of clearance behind TGB. Connect TGB with a minimum No. 4 AWG grounding electrode conductor from TGB to suitable electrical building ground. Connect rack TGB to near TGB or the TMGB.

1. Bond the shield of shielded cable to patch panel, and bond patch panel to TGB or TMGB.

3.3 IDENTIFICATION

A. Coordinate system components, wiring, and cabling complying with TIA-606-B. Comply with requirements in Section 270553 "Identification for Electrical Systems."

B. Comply with requirements in Section 099123 "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.

C. Paint and label colors for equipment identification shall comply with TIA-606-B for Class 2, Class 3 or Class 4 level of administration as directed, including optional identification requirements of this standard.

D. Labels shall be machine printed. Type height as directed.

END OF SECTION 271116

SECTION 271313 - COMMUNICATIONS COPPER BACKBONE CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Category 6 twisted pair cable.
2. Category 6a twisted pair cable.
3. Twisted pair cable hardware, including plugs, jacks, patch panels, and cross-connects.
4. Grounding provisions for twisted pair cable.
5. Cabling identification products.
6. Source quality control requirements for twisted pair cable.

B. Related Requirements:

1. Section 270513 "Conductors and Cables for Communications Systems" for data cabling associated with system panels and devices.

1.2 COPPER BACKBONE CABLING DESCRIPTION

A. Copper backbone cabling system shall provide interconnections between communications equipment rooms, main terminal space, and entrance facilities in the telecommunications cabling system structure. Cabling system consists of backbone cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection.

B. Backbone cabling cross-connects may be located in communications equipment rooms or at entrance facilities. Bridged taps and splitters shall not be used as part of backbone cabling.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Reviewed and stamped by RCDD.

1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
2. Cabling administration Drawings and printouts.
3. Wiring diagrams to show typical wiring schematics, including the following:

    a. Telecommunications rooms plans and elevations.
    b. Telecommunications pathways.
    c. Telecommunications system access points.
    d. Telecommunications grounding system
    e. Cross-connects.

f. Patch panels.
g. Patch cords.

4. Cross-Connects and Patch Panels: Detail mounting assemblies and show elevations and physical relationship between the installed components.

C. Twisted pair cable testing plan.

D. Sustainable Design Submittals:

1.4 INFORMATIONAL SUBMITTALS

A. Source quality-control reports.

B. Field quality-control reports.

C. Product Certificates: For each type of product.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings and cabling administration Drawings, cabling administration Drawings, and field testing program development by an RCDD or a Technician as directed.
2. Installation Supervision: Installation shall be under the direct supervision of Technician or Level 2 Installer as directed, who shall be present at all times when Work of this Section is performed at Project site.
3. Testing Supervisor: Currently certified by BICSI as an RCDD or a Technician to supervise on-site testing as directed.

B. Testing Agency Qualifications: Testing agency must have personnel certified by BICSI on staff.

1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD.

1.7 COORDINATION

A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. General Performance: Backbone cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard.

B. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or 450 or less as directed.

C. Telecommunications Pathways and Spaces: Comply with TIA-569-D.

D. Grounding: Comply with TIA-607-B.

2.2 GENERAL CABLE CHARACTERISTICS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with the applicable standard and NFPA 70 for the following types:

1. Communications, Plenum Rated: Type CMP complying with UL 1685 or Type CMP in listed plenum communications raceway or Type CMP in listed cable routing assembly as directed.
2. Communications, Plenum Rated: Type CM, Type CMG, Type CMP, Type CMR, or Type CMX in metallic conduit installed according to NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
3. Communications, Riser Rated: Type CMR complying with UL 1666 and ICEA S-103-701.
4. Communications, Riser Rated: Type CMP or Type CMR in listed plenum or riser communications raceway.
5. Communications, Riser Rated: Type CMP or Type CMR in metallic conduit installed according to NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."

B. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or 450 or less as directed.

C. RoHS compliant.

2.3 CATEGORY 6 TWISTED PAIR CABLE

A. Description: 100-ohm, 23 AWG, four unshielded twisted pairs (UTP), overall foil shield with unshielded twisted pairs (F/UTP), riser or plenum-rated cable as directed, with internal spline, covered with a color thermoplastic jacket and overall metallic shield as directed.

B. Standard: Comply with NEMA WC 66/ICEA S-116-732 and TIA-568-C.2 for Category 6 cables.

2.4 CATEGORY 6a TWISTED PAIR CABLE

A. Description: 100-ohm, 23 AWG, four unshielded twisted pairs (UTP), overall foil shield with unshielded twisted pairs (F/UTP), riser, plenum-rated, with internal spline as directed, covered with a color thermoplastic jacket and overall metallic shield as directed.

B. Standard: Comply with TIA-568-C.2 for Category 6a cables.

2.5 TWISTED PAIR CABLE HARDWARE

A. General Requirements for Cable Connecting Hardware:

1. Twisted pair cable hardware shall meet the performance requirements as directed.
2. Comply with TIA-568-C.2, IDC type, with modules designed for punch-down caps or tools.
3. Cables shall be terminated with connecting hardware of same category or higher.
4. Source Limitations: Obtain twisted pair cable hardware from single source from single manufacturer or Obtain twisted pair cable hardware from same manufacturer as twisted pair cable, from single source as directed.

B. Connecting Blocks: 110-style IDC for Category 5e, 110-style IDC for Category 6 or 66-style IDC for Category 5e as directed. Provide blocks for the number of cables terminated on the block, plus 25 percent spare, integral with connector bodies, including plugs and jacks where indicated.

C. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.

1. Number of Terminals per Field: One for each conductor in assigned cables.

D. Patch Panel: Modular panels housing numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.

1. Features:

a. Universal T568A and T568B wiring labels.
b. Labeling areas adjacent to conductors.
c. Replaceable connectors.
d. 24 or 48 ports.

2. Construction: 16-gauge steel and mountable on 19-inch (483 mm) equipment racks.

3. Number of Jacks per Field: One for each four-pair cable indicated or conductor group of indicated cables, plus spares and blank positions adequate to suit specified expansion criteria as directed.

E. Plugs and Plug Assemblies:

1. Male; eight position (8P8C); color coded modular telecommunications connector designed for termination of a single four-pair 100 ohm unshielded or shielded twisted pair cable.
2. Standard: Comply with TIA-568-C.2.
3. Marked to indicate transmission performance.

F. Jacks and Jack Assemblies:

1. Female; eight position; modular; fixed telecommunications connector designed for termination of a single four-pair 100-ohm unshielded or shielded twisted pair cable.
2. Designed to snap-in to a patch panel or faceplate.
3. Standard: Comply with TIA-568-C.2.
4. Marked to indicate transmission performance.

G. Patch Cords: Factory-made, four-pair cables in 36-inch (900-mm) or 48-inch (1200-mm) lengths as directed; terminated with an eight-position modular plug at each end.

1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6 performance. Patch cords shall have latch guards to protect against snagging.
2. Patch cords shall have color-coded boots for circuit identification.

H. Faceplates:

1. Two, Four or Six port as directed, vertical single gang faceplates designed to mount to single gang wall boxes.
2. Eight, Ten or Twelve port as directed, vertical double gang faceplates designed to mount to double gang wall boxes.
3. Plastic Faceplate: High-impact plastic. Coordinate color with Section 262726 "Wiring Devices."
4. Metal Faceplate: Stainless steel or Brass as directed, complying with requirements in Section 262726 "Wiring Devices."
5. For use with snap-in jacks accommodating any combination of twisted pair, optical-fiber, and coaxial work-area cords.

    a. Flush-mount jacks, positioning the cord at a 45-degree angle.

I. Legend:

1. Factory labeled by silk-screening or engraving for stainless steel brass faceplates.
2. Machine printed, in the field, using adhesive-tape label.
3. Snap-in, clear-label covers and machine-printed paper inserts.

2.6 GROUNDING

A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.

B. Comply with TIA-607-B.

2.7 SOURCE QUALITY CONTROL

A. Factory test cables on reels according to TIA-568-C.1.

B. Factory test cables according to TIA-568-C.2.

C. Cable will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 ENTRANCE FACILITIES

A. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.

3.2 WIRING METHODS

A. Wiring Method: Install cables in raceways and cable trays, except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces, attics, and gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables, except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for raceways and boxes specified in Section 270528 "Pathways for Communications Systems."

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools. Install cables parallel with or at right angles to sides and back of enclosure.

3.3 INSTALLATION OF PATHWAYS

A. Comply with requirements for demarcation point, cabinets, and racks specified in Section 271100 "Communications Equipment Room Fittings."

B. Comply with Section 270528 "Pathways for Communications Systems."

C. Comply with Section 270529 "Hangers and Supports for Communications Systems."

D. Comply with Section 270536 "Cable Trays for Communications Systems."

E. Drawings indicate general arrangement of pathways and fittings.

3.4 INSTALLATION OF COPPER BACKBONE CABLES

A. Comply with NECA 1 and NECA/BICSI 568.

B. General Requirements for Cabling:

1. Comply with TIA-568-C.0, TIA-568-C.1, and TIA-568-C.2.
2. Comply with BICSI's "Information Transport Systems Installation Manual," Ch. 6, "Cable Termination Practices."
3. Install 110-style IDC termination hardware unless otherwise indicated.
4. Do not untwist twisted pair cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.
5. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
6. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
7. Install lacing bars to restrain cables, prevent straining connections, and prevent bending cables to smaller radii than minimums recommended by manufacturer.
8. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI's "Information Transport Systems Installation Manual," Ch. 6, "Cable Termination Practices." Use lacing bars and distribution spools.
9. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
10. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
11. In the communications equipment room, install a 10-foot- (3-m-) long service loop on each end of cable.
12. Pulling Cable: Comply with BICSI's "Information Transport Systems Installation Manual," Ch. 4, "Pulling Cable." Monitor cable pull tensions.

C. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend twisted pair cabling, not in a wireway or pathway, a minimum of 8 inches (200 mm) above ceilings by cable supports not more than 60 inches (1524 mm) apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

D. Installation of Cable Routed Exposed under Raised Floors:

1. Install plenum-rated cable only.
2. Install cabling after the flooring system has been installed in raised floor areas.
3. Coil cable 6 feet (1800 mm) long not less than 12 inches (300 mm) in diameter below each feed point.

E. Group connecting hardware for cables into separate logical fields.

F. Separation from EMI Sources:

1. Comply with recommendations from BICSI's "Telecommunications Distribution Methods Manual" and TIA-569-D for separating unshielded copper communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (600 mm).

3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).

4. Separation between communications cables in grounded metallic raceways, power lines, and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (76 mm).
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).

5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.5 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-D, Annex A, "Firestopping."

C. Comply with "Firestopping Systems" Article in BISCI's "Telecommunications Distribution Methods Manual."

3.6 GROUNDING

A. Install grounding according to the "Grounding, Bonding, and Electrical Protection" chapter in BICSI's "Telecommunications Distribution Methods Manual."

B. Comply with TIA-607-B and NECA/BICSI-607.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall, allowing at least a 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding bus bar to suitable electrical building ground, using a minimum No. 4 AWG grounding electrode conductor.

D. Bond metallic equipment to the grounding bus bar, using not smaller than a No. 6 AWG equipment grounding conductor.

3.7 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."

1. Administration Class: As directed.
2. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.

B. Cable and Wire Identification:

1. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. Each wire connected to building-mounted devices is not required to be numbered at the device if wire color is consistent with associated wire connected and numbered within panel or cabinet.
3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet (4.5 m).
4. Label each terminal strip, and screw terminal in each cabinet, rack, or panel.

    a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group, extended from a panel or cabinet to a building-mounted device, with the name and number of a particular device.
    b. Label each unit and field within distribution racks and frames.

5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and -connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.

C. Labels shall be preprinted or computer-printed type, with a printing area and font color that contrast with cable jacket color but still comply with TIA-606-B requirements for the following:

1. Cables use flexible vinyl or polyester that flexes as cables are bent.

3.8 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections with the assistance of a factory-authorized service representative.

E. Tests and Inspections:

1. Visually inspect jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments and inspect cabling connections for compliance with TIA-568-C.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Test copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.

    a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

F. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similarly to Table 10.1 in BICSI's "Telecommunications Distribution Methods Manual," or shall be transferred from the instrument to the computer, saved as text files, printed, and submitted.

G. Remove and replace cabling where test results indicate that they do not comply with specified requirements.

H. End-to-end cabling will be considered defective if it does not pass tests and inspections.

I. Prepare test and inspection reports.

END OF SECTION 271313

SECTION 271323 - COMMUNICATIONS OPTICAL FIBER BACKBONE CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. 62.5/125-micrometer, multimode, optical fiber cable (OM1).
2. 50/125 micrometer, multimode, optical fiber cable (OM2).
3. 850 nanometer laser-optimized 50/125 micrometer multimode optical fiber cable (OM3).
4. 850 nanometer laser-optimized 50/125 micrometer multimode optical fiber cable (OM4).
5. 9/125 micrometer single-mode, indoor-outdoor optical fiber cable (OS1).
6. 9/125 micrometer single-mode, indoor-outdoor optical fiber cable (OS2).
7. Optical fiber cable connecting hardware, patch panels, and cross-connects.
8. Cabling identification products.

1.2 OPTICAL FIBER BACKBONE CABLING DESCRIPTION

A. Optical fiber backbone cabling system shall provide interconnections between communications equipment rooms, main terminal space, and entrance facilities in the telecommunications cabling system structure. Cabling system consists of backbone cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection.

B. Backbone cabling cross-connects may be located in communications equipment rooms or at entrance facilities. Bridged taps and splitters shall not be used as part of backbone cabling.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Reviewed and stamped by RCDD.

1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
2. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
3. Cabling administration drawings and printouts.
4. Wiring diagrams to show typical wiring schematics including the following:

    a. Telecommunications rooms plans and elevations.

b. Telecommunications pathways.
c. Telecommunications system access points.
d. Telecommunications grounding system
e. Cross-connects.
f. Patch panels.
g. Patch cords.

5. Cross-connects and patch panels.

C. Optical fiber cable testing plan.

D. Sustainable Design Submittals: As directed.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For RCDD Installer, installation supervisor, and field inspector.

B. Source quality-control reports.

C. Field quality-control reports.

D. Product Certificates: For each type of product.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings and Cabling Administration Drawings, Cabling Administration Drawings, and field testing program development by an RCDD.
2. Installation Supervision: Installation shall be under the direct supervision of Technician Level 2 Installer, who shall be present at all times when Work of this Section is performed at Project site.
3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

B. Testing Agency Qualifications: Testing agency must have personnel certified by BICSI on staff.

1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD, a Technician.

C. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or 450 or less as directed.

1.7 COORDINATION

A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. General Performance: Backbone cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard.

B. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or 450 or less as directed.

C. Telecommunications Pathways and Spaces: Comply with TIA-569-D.

D. Grounding: Comply with TIA-607-B.

2.2 62.5/125-MICROMETER, MULTIMODE, OPTICAL FIBER CABLE (OM1)

A. Description: Multimode, 62.5/125-micrometer, fiber number, nonconductive, conductive tight buffer, optical fiber cable as directed.

B. Standards:

1. Comply with ICEA S-83-596 for mechanical properties.
2. Comply with TIA-568-C.3 for performance specifications.
3. Comply with TIA-492AAAA for detailed specifications.

C. Conductive cable shall be steel or aluminum armored type as directed.

D. Maximum Attenuation: 3.50 dB/km at 850 nm; 1.5 dB/km at 1300 nm.

E. Minimum Overfilled Modal Bandwidth-length Product: 200 MHz-km at 850 nm; 500 MHz-km at 1300 nm.

F. Jacket:

1. Jacket Color: Orange.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

G. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:

1. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
2. Plenum Rated, Nonconductive: Type OFNP in listed plenum communications raceway.
3. Plenum Rated, Nonconductive: Type OFNP, or Type OFNR in metallic conduit.
4. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262; Type OFNP in listed plenum communications raceway; or Type OFNP, or Type OFNR in metallic conduit.
5. Riser Rated, Nonconductive: Type OFNR or Type OFNP, complying with UL 1666 as directed.
6. Riser Rated, Nonconductive: Type OFNP or Type OFNR in listed riser or plenum communications raceway.
7. Riser Rated, Nonconductive: Type OFNP or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
8. Plenum Rated, Conductive: Type OFCP complying with NFPA 262.
9. Plenum Rated, Conductive: Type OFCP or Type OFNP in listed plenum communications raceway.
10. Plenum Rated, Conductive: Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
11. Riser Rated, Conductive: Type OFCR; or Type OFCP; complying with UL 1666 and ICEA S-103-701.
12. Riser Rated, Conductive: Type OFCP, Type OFNP, or Type OFCR or Type OFNP in listed riser or plenum communications raceway.
13. Riser Rated, Conductive: Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit.

2.3 50/125 MICROMETER, MULTIMODE, OPTICAL FIBER CABLE (OM2)

A. Description: Multimode, 50/125-micrometer, fiber number as directed, nonconductive, conductive tight buffer, optical fiber cable.

B. Standards:

1. Comply with ICEA S-83-596 for mechanical properties.
2. Comply with TIA-568-C.3 for performance specifications.
3. Comply with TIA-492AAAB for detailed specifications.

C. Conductive cable shall be steel or aluminum armored type as directed.

D. Maximum Attenuation: 3.50 dB/km at 850 nm; 1.5 dB/km at 1300 nm.

E. Minimum Overfilled Modal Bandwidth-length Product: 500 MHz-km at 850 nm; 500 MHz-km at 1300 nm.

F. Jacket:

1. Jacket Color: Orange.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

G. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:

1. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
2. Plenum Rated, Nonconductive: Type OFNP in listed plenum communications raceway.
3. Plenum Rated, Nonconductive: Type OFNP, or Type OFNR in metallic conduit.
4. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262; Type OFNP in listed plenum communications raceway; or Type OFNP, or Type OFNR in metallic conduit.
5. Riser Rated, Nonconductive: Type OFNR or Type OFNP, complying with UL 1666 as directed.
6. Riser Rated, Nonconductive: Type OFNP or Type OFNR in listed riser or plenum communications raceway.
7. Riser Rated, Nonconductive: Type OFN, Type OFNG, Type OFNP, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
8. Plenum Rated, Conductive: Type OFCP or Type OFNP, complying with NFPA 262.
9. Plenum Rated, Conductive: Type OFCP or Type OFNP in listed plenum communications raceway.
10. Plenum Rated, Conductive: Type OFC, Type OFN, Type OFCG, Type OFNG, Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
11. Riser Rated, Conductive: Type OFCR; or Type OFCP; complying with UL 1666 and ICEA S-103-701.
12. Riser Rated, Conductive: Type OFCP, Type OFNP, or Type OFCR or Type OFNP in listed riser or plenum communications raceway.
13. Riser Rated, Conductive: Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit.

2.4 850 NANOMETER LASER-OPTIMIZED, 50/125 MICROMETER, MULTIMODE OPTICAL FIBER CABLE (OM3)

A. Description: Multimode, 50/125-micrometer, fiber number as directed, nonconductive, conductive tight buffer, optical fiber cable.

B. Standards:

1. Comply with ICEA S-83-596 for mechanical properties.
2. Comply with TIA-568-C.3 for performance specifications.
3. Comply with TIA-492AAAC for detailed specifications.

C. Conductive cable shall be steel or aluminum armored type as directed.

D. Maximum Attenuation: 3.50 dB/km at 850 nm; 1.5 dB/km at 1300 nm.

E. Minimum Overfilled Modal Bandwidth-length Product: 1500 MHz-km at 850 nm; 500 MHz-km at 1300 nm.

F. Minimum Effective Modal Bandwidth-length Product: 2000 MHz-km at 850 nm.

G. Jacket:

1. Jacket Color: Aqua.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

H. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:

1. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
2. Plenum Rated, Nonconductive: Type OFNP in listed plenum communications raceway.
3. Plenum Rated, Nonconductive: Type OFNP, or Type OFNR in metallic conduit.
4. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262; Type OFNP in listed plenum communications raceway; or Type OFNP, or Type OFNR in metallic conduit.
5. Riser Rated, Nonconductive: Type OFNR or Type OFNP, complying with UL 1666.
6. Riser Rated, Nonconductive: Type OFNP or Type OFNR in listed riser or plenum communications raceway.
7. Riser Rated, Nonconductive: Type OFNP, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
8. Plenum Rated, Conductive: Type OFCP or Type OFNP, complying with NFPA 262.
9. Plenum Rated, Conductive: Type OFCP or Type OFNP in listed plenum communications raceway.
10. Plenum Rated, Conductive: Type OFNG, Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
11. Riser Rated, Conductive: Type OFCR or Type OFCP; complying with UL 1666 and ICEA S-103-701.
12. Riser Rated, Conductive: Type OFCP, Type OFNP, or Type OFCR or Type OFNP in listed riser or plenum communications raceway.
13. Riser Rated, Conductive: Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit.

2.5 850 NANOMETER LASER-OPTIMIZED, 50/125 MICROMETER, MULTIMODE OPTICAL FIBER CABLE (OM4)

A. Description: Multimode, 50/125-micrometer, fiber number as directed, nonconductive, conductive tight buffer, optical fiber cable as directed.

B. Standards:

1. Comply with ICEA S-83-596 for mechanical properties.
2. Comply with TIA-568-C.3 for performance specifications.
3. Comply with TIA-492AAAD for detailed specifications.

C. Conductive cable shall be steel or aluminum armored type.

D. Maximum Attenuation: 3.50 dB/km at 850 nm; 1.5 dB/km at 1300 nm.

E. Minimum Overfilled Modal Bandwidth-length Product: 3500 MHz-km at 850 nm; 500 MHz-km at 1300 nm.

F. Minimum Effective Modal Bandwidth-length Product: 4700 MHz-km at 850 nm.

G. Jacket:

1. Jacket Color: Aqua.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

H. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:

1. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
2. Plenum Rated, Nonconductive: Type OFNP in listed plenum communications raceway.
3. Plenum Rated, Nonconductive: Type OFNP, or Type OFNR in metallic conduit.
4. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262; Type OFNP in listed plenum communications raceway; or Type OFN, Type OFNG, Type OFNP, or Type OFNR in metallic conduit.
5. Riser Rated, Nonconductive: Type OFNR or Type OFNP, complying with UL 1666.
6. Riser Rated, Nonconductive: Type OFNP or Type OFNR in listed riser or plenum communications raceway.
7. Riser Rated, Nonconductive: Type OFNP, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
8. Plenum Rated, Conductive: Type OFCP, complying with NFPA 262.
9. Plenum Rated, Conductive: Type OFCP or Type OFNP in listed plenum communications raceway.
10. Plenum Rated, Conductive: Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
11. Riser Rated, Conductive: Type OFCR or Type OFCP; complying with UL 1666 and ICEA S-103-701.

12. Riser Rated, Conductive: Type OFCP, Type OFNP, or Type OFCR or Type OFNP in listed riser or plenum communications raceway.
13. Riser Rated, Conductive: Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit.

2.6 9/125 MICROMETER SINGLE-MODE, INDOOR-OUTDOOR OPTICAL FIBER CABLE (OS1)

A. Description: Single mode, 9/125-micrometer, fibers as directed, single loose tube, armored optical fiber cable.

B. Description: Single mode, 9/125-micrometer, fibers as directed, stranded loose tube, armored optical fiber cable.

C. Standards:

1. Comply with TIA-492CAAA for detailed specifications.
2. Comply with TIA-568-C.3 for performance specifications.
3. Comply with ICEA S-104-696 for mechanical properties.

D. Armored cable shall be steel or aluminum armored type as directed.

E. Maximum Attenuation: 0.5 dB/km at 1310 nm; 0.5 dB/km at 1550 nm.

F. Jacket:

1. Jacket Color: Yellow.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

G. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:

1. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
2. Plenum Rated, Nonconductive: Type OFNP in listed plenum communications raceway.
3. Plenum Rated, Nonconductive: Type OFNP, or Type OFNR in metallic conduit.
4. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262; Type OFNP in listed plenum communications raceway; or Type OFN, Type OFNG, Type OFNP, or Type OFNR in metallic conduit.
5. Riser Rated, Nonconductive: Type OFNR or Type OFNP, complying with UL 1666 as directed.
6. Riser Rated, Nonconductive: Type OFNP or Type OFNR in listed riser or plenum communications raceway.
7. Riser Rated, Nonconductive: Type OFNP, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
8. Plenum Rated, Armored (Conductive): Type OFCP, complying with NFPA 262.
9. Plenum Rated, Armored (Conductive): Type OFCP or Type OFNP in listed plenum communications raceway.

10. Plenum Rated, Armored (Conductive): Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
11. Riser Rated, Armored (Conductive): Type OFCR or Type OFCP; complying with UL 1666 and ICEA S-103-701.
12. Riser Rated, Armored (Conductive): Type OFCP, Type OFNP, or Type OFCR or Type OFNP in listed riser or plenum communications raceway.
13. Riser Rated, Armored (Conductive): Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit.

2.7 9/125 MICROMETER, SINGLE-MODE, INDOOR-OUTDOOR OPTICAL FIBER CABLE (OS2)

A. Description: Single mode, 9/125-micrometer, fibers as directed, single loose tube, unarmored or armored optical fiber cable.

B. Description: Single mode, 9/125-micrometer, fibers, stranded loose tube, armored optical fiber cable.

C. Standards:

1. Comply with TIA-492CAAB for detailed specifications.
2. Comply with TIA-568-C.3 for performance specifications.
3. Comply with ICEA S-104-696 for mechanical properties.

D. Armored cable shall be steel or aluminum armored type as directed.

E. Maximum Attenuation: 0.5 dB/km at 1310 nm; 0.5 dB/km at 1550 nm.

F. Jacket:

1. Jacket Color: Yellow.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

G. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:

1. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
2. Plenum Rated, Nonconductive: Type OFNP in listed plenum communications raceway.
3. Plenum Rated, Nonconductive: Type OFNP, or Type OFNR in metallic conduit.
4. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262; Type OFNP in listed plenum communications raceway; or Type OFN, Type OFNG, Type OFNP, or Type OFNR in metallic conduit.
5. Riser Rated, Nonconductive: Type OFNR or Type OFNP, complying with UL 1666.
6. Riser Rated, Nonconductive: Type OFNP or Type OFNR in listed riser or plenum communications raceway.

7. Riser Rated, Nonconductive: Type OFNP, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
8. Plenum Rated, Armored (Conductive): Type OFCP, complying with NFPA 262.
9. Plenum Rated, Armored (Conductive): Type OFCP or Type OFNP in listed plenum communications raceway.
10. Plenum Rated, Armored (Conductive): Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
11. Riser Rated, Armored (Conductive): Type OFCR or Type OFCP; complying with UL 1666 and ICEA S-103-701.
12. Riser Rated, Armored (Conductive): Type OFCP, Type OFNP, or Type OFCR or Type OFNP in listed riser or plenum communications raceway.
13. Riser Rated, Armored (Conductive): Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit.

2.8 OPTICAL FIBER CABLE HARDWARE

A. Standards:

1. Comply with Optical Fiber Connector Intermateability Standard specifications of the TIA-604 series.
2. Comply with TIA-568-C.3.

B. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.

1. Number of Connectors per Field: One for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.

C. Patch Cords: Factory-made, dual-fiber cables in 36-inch (900-mm) lengths.

D. Connector Type: As directed.

E. Plugs and Plug Assemblies:

1. Male; color-coded modular telecommunications connector designed for termination of a single optical fiber cable.
2. Insertion loss not more than 0.25 or 0.75 dB as directed.
3. Marked to indicate transmission performance.

F. Jacks and Jack Assemblies:

1. Female; quick-connect, simplex and duplex; fixed telecommunications connector designed for termination of a single optical fiber cable.
2. Insertion loss not more than 0.25 or 0.75 dB as directed.
3. Marked to indicate transmission performance.
4. Designed to snap-in to a patch panel or faceplate.

2.9 GROUNDING

A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.

B. Comply with TIA-607-B.

2.10 IDENTIFICATION PRODUCTS

A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.11 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Factory test multimode optical fiber cables according to TIA-526-14-B and TIA-568-C.3.

C. Factory test pre-terminated optical fiber cable assemblies according to TIA-526-14-B and TIA-568-C.3.

D. Cable will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 ENTRANCE FACILITIES

A. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.

3.2 WIRING METHODS

A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces, in attics, and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for pathways specified in Section 270528 "Pathways for Communications Systems."

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.3 INSTALLATION OF OPTICAL FIBER BACKBONE CABLES

A. Comply with NECA 1, NECA 301, and NECA/BICSI 568.

B. General Requirements for Optical Fiber Cabling Installation:

1. Comply with TIA-568-C.1 and TIA-568-C.3.
2. Comply with BICSI ITSIMM, Ch. 6, "Cable Termination Practices."
3. Terminate all cables; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
4. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
5. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
6. Bundle, lace, and train cable to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, "Cabling Termination Practices" Chapter. Use lacing bars and distribution spools.
7. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
8. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
9. In the communications equipment room, provide a 10-foot- (3-m-) long service loop on each end of cable.
10. Pulling Cable: Comply with BICSI ITSIMM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
11. Cable may be terminated on connecting hardware that is rack or cabinet mounted.

C. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

D. Installation of Cable Routed Exposed under Raised Floors:

1. Install plenum-rated cable only.
2. Install cabling after the flooring system has been installed in raised floor areas.
3. Coil cable 6 feet (1800 mm) long not less than 12 inches (300 mm) in diameter below each feed point.

E. Group connecting hardware for cables into separate logical fields.

3.4 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-D, Annex A, "Firestopping."

C. Comply with BICSI ITSIMM, "Firestopping" Chapter.

3.5 GROUNDING

A. Install grounding according to BICSI ITSIMM, "Grounding (Earthing), Bonding, and Electrical Protection" Chapter.

B. Comply with TIA-607-B and NECA/BICSI-607.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.6 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."

1. Administration Class: As directed.
2. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.

B. Paint and label colors for equipment identification shall comply with TIA-606-B for Class 2, Class 3 or Class 4 level of administration including optional identification requirements of this standard as directed.

C. Comply with requirements in Section 271523 "Communications Optical Fiber Horizontal Cabling" for cable and asset management software.

D. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

E. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, entrance pathways and cables as directed, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.

F. Cable and Wire Identification:

1. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet (4.5 m).
4. Label each unit and field within distribution racks and frames.
5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.

G. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA 606-B, for the following:

1. Flexible vinyl or polyester that flexes as cables are bent.

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections with the assistance of a factory-authorized service representative.

C. Tests and Inspections:

1. Visually inspect optical fiber jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA-568-C.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Optical Fiber Cable Tests:

   a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
   b. Link End-to-End Attenuation Tests:

      1) Horizontal and multimode backbone link measurements: Test at 850 or 1300 nm in one direction according to TIA-526-14-B, Method B, One Reference Jumper.
      2) Attenuation test results for backbone links shall be less than 2.0 dB. Attenuation test results shall be less than those calculated according to equation in TIA-568-C.1.

D. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.

E. Remove and replace cabling where test results indicate that it does not comply with specified requirements.

F. End-to-end cabling will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

END OF SECTION 271323

SECTION 271333 - COMMUNICATIONS COAXIAL BACKBONE CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Communications coaxial cable.
2. CATV coaxial cable.
3. Coaxial cable hardware.
4. Identification products.

1.2 COAXIAL BACKBONE CABLING DESCRIPTION

A. Coaxial cabling system shall provide interconnections between communications equipment rooms, main terminal space, and entrance facilities in the telecommunications cabling system structure. Cabling system consists of backbone cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection.

B. Backbone cabling cross-connects may be located in communications equipment rooms or at entrance facilities.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Nominal OD.
2. Minimum bending radius.
3. Maximum pulling tension.

B. Shop Drawings:

1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
2. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.

C. Sustainable Design Submittals:

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For RCDD, Installer, installation supervisor, and field inspector.

B. Source quality-control reports.

C. Field quality-control reports.

D. Maintenance data.

1.5 CLOSEOUT SUBMITTALS

A. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On USB media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings and Cabling Administration Drawings, Cabling Administration Drawings, and field testing program development by an RCDD, a Technician as directed.
2. Installation Supervision: Installation shall be under the direct supervision of Technician or Level 2 Installer as directed, who shall be present at all times when Work of this Section is performed at Project site.

B. Testing Agency Qualifications: Testing agency must have personnel certified by BICSI on staff.

1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard, and the requirements of TIA-568-C.4.

B. Telecommunications Pathways and Spaces: Comply with TIA-569-D.

C. Grounding: Comply with TIA-607-B.

2.2 GENERAL CABLE CHARACTERISTICS

A. Communications Cable: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with the applicable standard and NFPA 70 for the following types:

1. Communications, Plenum Rated: Type CMP complying with UL 1685 or Type CMP in listed plenum communications raceway or Type CMP in listed cable routing assembly as directed.
2. Communications, Plenum Rated: Type CM, Type CMG, Type CMP, Type CMR, or Type CMX in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
3. Communications, Riser Rated: Type CMR complying with UL 1666 and ICEA S-103-701.
4. Communications, Riser Rated: Type CMP complying with UL 1685, or Type CMR complying with UL 1666 and ICEA S-103-701 in listed plenum or riser communications raceway.
5. Communications, Riser Rated: Type CMP or Type CMR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."

B. CATV Cable: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with the applicable standard and NFPA 70 for the following types:

1. CATV Plenum Rated: Type CATVP installed in riser raceways or cable routing assemblies, complying with NFPA 262.
2. CATV Riser Rated: Type CATVR complying with UL 1666; or CATVP complying with NFPA 262 or installed in riser raceways or cable routing assemblies as directed.
3. CATV Cable: Type CATV, or CATVP or CATVR or installed in general purpose, riser, or plenum communications raceways or cable routing assemblies in fireproof riser shafts with firestops at each penetration as directed.

2.3 COMMUNICATIONS COAXIAL CABLE

A. Description: Coaxial cable with a 75-ohm characteristic impedance designed for broadband data transmission.

B. NFPA and UL compliant, listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 13, and with NFPA 70, "Class 1, Class 2, and Class 3 Remote-Control, Signaling, and Power-Limited Circuits" and "Communications Circuits" articles. Types are as follows:

1. RG-6/U: UL Type CMR and CL2R as directed.

    a. No. 16 or 18 AWG as directed, solid, copper-covered steel conductor.
    b. Riser rated.
    c. Gas-injected, foam-PE insulation.
    d. Shielded with 100 percent aluminum tape and 40 or 60 percent aluminum braid as directed.
    e. Double shielded with 100 percent aluminum foil shield, 60 percent aluminum braided inner shield, and 40 percent aluminum braided outer shield.
    f. Jacketed with black or white PVC or PE as directed.
    g. Suitable for indoor installations.

2. RG-6/U: UL Type CMP and CL2P as directed.

    a. No. 16 or 18 AWG as directed, solid, copper-covered steel conductor.

b. Plenum rated.
c. Gas-injected, foam-PE insulation.
d. Shielded with 100 percent aluminum tape and 40 or 60 percent aluminum braid as directed.
e. Double shielded with 100 percent aluminum foil shield, 60 percent aluminum braided inner shield, and 40 percent aluminum braided outer shield.
f. Jacketed with black or white PVC or PE as directed.
g. Suitable for indoor installations.

3. RG-11/U: UL Type CMP and CL2P as directed.

a. No. 14 AWG, solid, copper-covered steel conductor.
b. Plenum rated. Suitable for outdoor installations in ambient temperatures ranging from minus 40 to plus 85 deg C.
c. Gas-injected, foam-PE insulation.
d. Shielded with 100 percent aluminum tape and 40 or 60 percent aluminum braid as directed.
e. Double shielded with 100 percent aluminum foil shield, 60 percent aluminum braided inner shield, and 40 percent aluminum braided outer shield.
f. Jacketed with sunlight-resistant, black or white PVC or PE as directed.

2.4 CATV COAXIAL CABLE

A. Description: Coaxial cable with a 75-ohm characteristic impedance designed for CATV transmission.

B. NFPA and UL compliant, listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1655 and with NFPA 70, "Community Antenna Television and Radio Distribution" Article. Types are as follows:

1. RG-6/U: UL Type CATVR.

a. No. 18 AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation.
b. Riser rated.
c. Gas-injected, foam-PE insulation.
d. Shielded with 100 percent aluminum tape and 40 or 60 percent aluminum braid as directed.
e. Double shielded with 100 percent aluminum foil shield, 60 percent aluminum braided inner shield, and 40 percent aluminum braided outer shield.
f. Jacketed with black or white PVC or PE as directed.
g. Suitable for indoor installations.

2. RG-6/U: UL Type CATVP.

a. No. 18 AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation.
b. Plenum rated.
c. Gas-injected, foam-PE insulation.

d. Shielded with 100 percent aluminum tape and 40 or 60 percent aluminum braid as directed.
e. Double shielded with 100 percent aluminum foil shield, 60 percent aluminum braided inner shield, and 40 percent aluminum braided outer shield.
f. Jacketed with black or white PVC or PE as directed.
g. Suitable for indoor installations.

2.5 COAXIAL CABLE HARDWARE

A. Description: Hardware designed to connect, splice, and terminate coaxial cable with a 75-ohm characteristic impedance.

B. Coaxial-Cable Connectors: Type BNC, 75 ohms.

C. Patch Cords: Factory-made cables in 36-inch (900-mm) or 48-inch (1200-mm) lengths; terminated with modular Type BNC connector at each end.

D. Faceplates:

1. Plastic Faceplate: High-impact plastic. Coordinate color with Section 262726 "Wiring Devices."
2. Metal Faceplate: Stainless steel or Brass as directed, complying with requirements in Section 262726 "Wiring Devices."
3. For use with snap-in jacks accommodating any combination of twisted pair, optical-fiber, and coaxial work area cords.

    a. Flush-mounted jacks, positioning the cord at a 90-degree angle.

E. Legend:

1. Factory labeled by silk-screening or engraving for stainless steel brass faceplates.
2. Machine printed, in the field, using self-adhesive labels.
3. Snap-in, clear-label covers and machine-printed paper inserts.

2.6 GROUNDING

A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.

B. Comply with TIA-607-B.

2.7 IDENTIFICATION PRODUCTS

A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

PART 3 - EXECUTION

3.1 ENTRANCE FACILITIES

A. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.

3.2 WIRING METHODS

A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces, in attics, and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for raceways and boxes specified in Section 270528 "Pathways for Communications Systems."

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.3 INSTALLATION OF PATHWAYS

A. Comply with requirements specified in Section 271100 "Communications Equipment Room Fittings."

B. Comply with requirements in Section 270528 "Pathways for Communications Systems" for installation of conduits and wireways.

C. Comply with Section 270528.29 "Hangers and Supports for Communications Systems."

D. Drawings indicate general arrangement of pathways and fittings.

E. Comply with NFPA 70 for pull-box sizing and length of conduit and number of bends between pull points.

F. Backboards: Install backboards with 96-inch (2440-mm) dimension vertical. Butt adjacent sheets tightly and form smooth gap-free corners and joints.

3.4 INSTALLATION OF COAXIAL BACKBONE CABLES

A. Comply with NECA 1, TIA 568-C.4, and NECA/BICSI 568.

B. General Requirements for Cabling:

1. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section.
2. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and patch panels.
3. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
4. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section. Use lacing bars and distribution spools.
5. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
6. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
7. In the communications equipment room, install a 10-foot (3-m) long service loop on each end of cable.
8. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems," "Pulling and Installing Cable" Section. Monitor cable pull tensions.

C. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend coaxial cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceilings by cable supports not more than 60 inches (1524 mm) apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

D. Installation of Cable Routed Exposed under Raised Floors:

1. Install plenum rated cable only.
2. Install cabling after the flooring system has been installed in raised floor areas.
3. Coil cable 6 feet (1800 mm) long not less than 12 inches (300 mm) in diameter below each feed point.

E. Outdoor Coaxial Cable Installation:

1. Install outdoor connections in enclosures complying with NEMA 250, Type 4X. Install corrosion-resistant connectors with properly designed O-rings to keep out moisture.
2. Attach antenna lead-in cable to support structure at intervals not exceeding 36 inches (915 mm).

F. Group connecting hardware for cables into separate logical fields.

G. Separation from EMI Sources:

1. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:

a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
b. Electrical Equipment Rating Between 2 and 5 kVA: A minimum of 12 inches (300 mm).
c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (610 mm).

2. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
b. Electrical Equipment Rating Between 2 and 5 kVA: A minimum of 6 inches (150 mm).
c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).

3. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
b. Electrical Equipment Rating Between 2 and 5 kVA: A minimum of 3 inches (76 mm).
c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).

4. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
5. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.5 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-D, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.6 GROUNDING

A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. Comply with TIA-607-B and NECA/BICSI-607.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding

bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.7 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."

1. Administration Class: As directed.
2. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.

B. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

C. Cable and Wire Identification:

1. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet (4.5 m).
4. Label each terminal strip and screw terminal in each cabinet, rack, or panel.

    a. Individually number wiring conductors connected to terminal strips and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device with name and number of particular device as shown.
    b. Label each unit and field within distribution racks and frames.

5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.

D. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA 606-B, for the following:

1. Cables use flexible vinyl or polyester that flexes as cables are bent.

3.8 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative.

B. Tests and Inspections:

1. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
2. Test coaxial backbone copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination.

C. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.

D. Remove and replace cabling where test results indicate that they do not comply with specified requirements.

E. End-to-end cabling will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

END OF SECTION 271333

SECTION 271513 - COMMUNICATIONS COPPER HORIZONTAL CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Category 5e twisted pair cable.
2. Category 6 twisted pair cable.
3. Category 6a twisted pair cable.
4. Twisted pair cable hardware, including plugs and jacks.
5. Cable management system.
6. Grounding provisions for twisted pair cable.

1.2 COPPER HORIZONTAL CABLING DESCRIPTION

A. Horizontal cabling system shall provide interconnections between Distributor A, Distributor B, or Distributor C, and the equipment outlet, otherwise known as "Cabling Subsystem 1," in the telecommunications cabling system structure. Cabling system consists of horizontal cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for horizontal-to-horizontal cross-connection.

1. TIA-568-C.1 requires that a minimum of two equipment outlets be installed for each work area.
2. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the telecommunications equipment outlet.
3. Bridged taps and splices shall not be installed in the horizontal cabling.

B. A work area is approximately 100 sq. ft. (9.3 sq. m) and includes the components that extend from the equipment outlets to the station equipment.

C. The maximum allowable horizontal cable length is 295 feet (90 m). This maximum allowable length does not include an allowance for the length of 16 feet (4.9 m) to the workstation equipment or in the horizontal cross-connect.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Reviewed and stamped by RCDD.

1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
2. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
3. Cabling administration Drawings and printouts.

4. Wiring diagrams and installation details of telecommunications equipment, to show location and layout of telecommunications equipment.

C. Twisted pair cable testing plan.

D. Sustainable Design Submittals:

E. Samples: For telecommunications jacks and plugs, in specified finish, one for each type and configuration and faceplates for color selection and evaluation of technical features.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For RCDD, Installer, installation supervisor, and field inspector.

B. Product Certificates: For each type of product.

C. Source quality-control reports.

D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance data.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On USB media.
3. Device address list.
4. Printout of software application and graphic screens.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings and cabling administration Drawings, cabling administration Drawings, and field testing program development by an RCDD.
2. Installation Supervision: Installation shall be under the direct supervision of Technician or Level 2 Installer, who shall be present at all times when Work of this Section is performed at Project site.
3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

B. Testing Agency Qualifications: Testing agency must have personnel certified by BICSI on staff.

1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD.

1.7 COORDINATION

A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

1.8 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, provide software support for two years.

B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard.

B. Telecommunications Pathways and Spaces: Comply with TIA-569-D.

C. Grounding: Comply with TIA-607-B.

2.2 GENERAL CABLE CHARACTERISTICS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with the applicable standard and NFPA 70 for the following types:

1. Communications, Plenum Rated: Type CMP complying with UL 1685 or Type CMP in listed plenum communications raceway or Type CMP in listed cable routing assembly.
2. Communications, Plenum Rated: Type CM, Type CMG, Type CMP, Type CMR, or Type CMX in metallic conduit installed according to NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
3. Communications, Non-plenum: Type CMR complying with UL 1666 and ICEA S-103-701.
4. Communications, Non-plenum: Type CMP or Type CMR in listed plenum or riser communications raceway.
5. Communications, Non-plenum: Type CMP or Type CMR in metallic conduit installed according to NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."

B. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or 450 or less as directed.

C. RoHS compliant.

2.3 CATEGORY 5e TWISTED PAIR CABLE

A. Description: Four-pair, balanced-twisted pair cable, certified to meet transmission characteristics of Category 5e cable at frequencies up to 100 MHz.

B. Standard: Comply with ICEA S-90-661, NEMA WC 63.1, and TIA-568-C.2 for Category 5e cables.

C. Conductors: 100-ohm, 24 AWG solid copper.

D. Shielding/Screening: As directed.

E. Cable Rating: Riser or Plenum as directed.

F. Jacket: White or Gray thermoplastic as directed.

2.4 CATEGORY 6 TWISTED PAIR CABLE

A. Description: Four-pair, balanced-twisted pair cable, with internal spline, certified to meet transmission characteristics of Category 6 cable at frequencies up to 250MHz.

B. Standard: Comply with NEMA WC 66/ICEA S-116-732 and TIA-568-C.2 for Category 6 cables.

C. Conductors: 100-ohm, 23 AWG solid copper.

D. Shielding/Screening: As directed.

E. Cable Rating: Riser or Plenum as directed.

F. Jacket: As directed.

2.5 CATEGORY 6a TWISTED PAIR CABLE

A. Description: Four-pair, balanced-twisted pair cable, with internal spline, certified to meet transmission characteristics of Category 6a cable at frequencies up to 500MHz.

B. Standard: Comply with TIA-568-C.2 for Category 6a cables.

C. Conductors: 100-ohm, 23 AWG solid copper.

D. Shielding/Screening: As directed.

E. Cable Rating: Riser or Plenum as directed.

F. Jacket: As directed.

2.6 TWISTED PAIR CABLE HARDWARE

A. Description: Hardware designed to connect, splice, and terminate twisted pair copper communications cable.

B. General Requirements for Twisted Pair Cable Hardware:

1. Comply with the performance requirements as directed.
2. Comply with TIA-568-C.2, IDC type, with modules designed for punch-down caps or tools.
3. Cables shall be terminated with connecting hardware of same category or higher.

C. Source Limitations: Obtain twisted pair cable hardware from single source from single manufacturer. Or Obtain twisted pair cable hardware from same manufacturer as twisted pair cable, from single source.

D. Connecting Blocks:

1. 110-style IDC for Category 5e.
2. 66-style IDC for Category 5e.
3. 110-style IDC for Category 6.
4. 110-style IDC for Category 6a.
5. Provide blocks for the number of cables terminated on the block, plus 25 percent spare, integral with connector bodies, including plugs and jacks where indicated.

E. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.

1. Number of Terminals per Field: One for each conductor in assigned cables.

F. Patch Panel: Modular panels housing numbered jack units with IDC-type connectors at each jack location for permanent termination of pair groups of installed cables.

1. Features:

a. Universal T568A and T568B wiring labels.
b. Labeling areas adjacent to conductors.
c. Replaceable connectors.
d. 24 or 48 ports.

2. Construction: 16-gauge steel and mountable on 19-inch (483 mm) equipment racks.
3. Number of Jacks per Field: One for each four-pair cable indicated or conductor group of indicated cables, plus spares and blank positions adequate to suit specified expansion criteria as directed.

G. Patch Cords: Factory-made, four-pair cables in 36-inch (900-mm) or 48-inch (1200-mm) lengths as directed; terminated with an eight-position modular plug at each end.

1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure performance. Patch cords shall have latch guards to protect against snagging.
2. Patch cords shall have color-coded boots for circuit identification.

H. Plugs and Plug Assemblies:

1. Male; eight position; color-coded modular telecommunications connector designed for termination of a single four-pair, 100-ohm, unshielded or shielded twisted pair cable.
2. Standard: Comply with TIA-568-C.2.
3. Marked to indicate transmission performance.

I. Jacks and Jack Assemblies:

1. Female; eight position; modular; fixed telecommunications connector designed for termination of a single four-pair, 100-ohm, unshielded or shielded twisted pair cable.
2. Designed to snap-in to a patch panel or faceplate.
3. Standard: Comply with TIA-568-C.2.
4. Marked to indicate transmission performance.

J. Faceplate:

1. Two, Four or Six port as directed, vertical single gang faceplates designed to mount to single gang wall boxes.
2. Eight, Ten or Twelve port as directed, vertical double gang faceplates designed to mount to double gang wall boxes.
3. Plastic Faceplate: High-impact plastic. Coordinate color with Section 262726 "Wiring Devices."
4. Metal Faceplate: Stainless steel or Brass as directed, complying with requirements in Section 262726 "Wiring Devices."
5. For use with snap-in jacks accommodating any combination of twisted pair, optical fiber, and coaxial work area cords.

    a. Flush mounting jacks, positioning the cord at a 45-degree angle.

K. Legend:

1. Machine printed, in the field, using adhesive-tape label.
2. Snap-in, clear-label covers and machine-printed paper inserts.

2.7 CABLE MANAGEMENT SYSTEM

A. Description: Computer-based cable management system, with integrated database and graphic capabilities.

B. Document physical characteristics by recording the network, TIA details, and connections between equipment and cable.

C. Information shall be presented in database view, schematic plans, or technical drawings.

1. Microsoft Visio Professional or Auto CAD drawing software shall be used as drawing and schematic plans software.

D. System shall interface with the following testing and recording devices:

1. Direct upload tests from circuit testing instrument into the personal computer.
2. Direct download circuit labeling into labeling printer.

2.8 GROUNDING

A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.

B. Comply with TIA-607-B.

PART 3 - EXECUTION

3.1 INSTALLATION OF TWISTED-PAIR HORIZONTAL CABLES

A. Comply with NECA 1 and NECA/BICSI 568.

B. Wiring Method: Install cables in raceways and cable trays, except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces, attics, and gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables, except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for raceways and boxes specified in Section 270528 "Pathways for Communications Systems."

C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools. Install conductors parallel with or at right angles to sides and back of enclosure.

D. General Requirements for Cabling:

1. Comply with TIA-568-C.1.
2. Comply with BICSI's Information Transport Systems Installation Methods Manual, Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section.
3. Install 110-style IDC termination hardware unless otherwise indicated.
4. Do not untwist twisted pair cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.
5. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.

6. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
7. Install lacing bars to restrain cables, prevent straining connections, and prevent bending cables to smaller radii than minimums recommended by manufacturer.
8. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI information Transport Systems Installation Methods Manual, Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section. Use lacing bars and distribution spools.
9. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
10. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
11. In the communications equipment room, install a 10-foot- (3-m-) long service loop on each end of cable.
12. Pulling Cable: Comply with BICSI Information Transport Systems Installation Methods Manual, Ch. 5, "Copper Structured Cabling Systems," "Pulling and Installing Cable" Section. Monitor cable pull tensions.

E. Group connecting hardware for cables into separate logical fields.

F. Separation from EMI Sources:

1. Comply with recommendations from BICSI's "Telecommunications Distribution Methods Manual" and TIA-569-D for separating unshielded copper communication cable from potential EMI sources, including electrical power lines and equipment.

3.2 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-D, Annex A, "Firestopping."

C. Comply with "Firestopping Systems" Article in BISCI's "Telecommunications Distribution Methods Manual."

3.3 GROUNDING

A. Install grounding according to the "Grounding, Bonding, and Electrical Protection" chapter in BICSI's "Telecommunications Distribution Methods Manual."

B. Comply with TIA-607-B and NECA/BICSI-607.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall, allowing at least a 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding bus bar to suitable electrical building ground, using a minimum No. 4 AWG grounding electrode conductor.

D. Bond metallic equipment to the grounding bus bar, using not smaller than a No. 6 AWG equipment grounding conductor.

3.4 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."

B. Paint and label colors for equipment identification shall comply with TIA-606-B for Class 2, Class 3 or Class 4 level of administration as directed, including optional identification requirements of this standard.

C. Equipment grounding conductors.

D. Cable and Wire Identification:

1. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. Each wire connected to building-mounted devices is not required to be numbered at the device if wire color is consistent with associated wire connected and numbered within panel or cabinet.
3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet (4.5 m).
4. Label each terminal strip, and screw terminal in each cabinet, rack, or panel.

    a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group, extended from a panel or cabinet to a building-mounted device, with the name and number of a particular device.
    b. Label each unit and field within distribution racks and frames.

5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and -connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.

E. Labels shall be preprinted or computer-printed type, with a printing area and font color that contrast with cable jacket color but still comply with TIA-606-B requirements for the following:

1. Cables use flexible vinyl or polyester that flexes as cables are bent.

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. Tests and Inspections:

1. Visually inspect jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments and inspect cabling connections for compliance with TIA-568-C.1.

2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Test twisted pair cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.

C. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similarly to Table 10.1 in BICSI's "Telecommunications Distribution Methods Manual," or shall be transferred from the instrument to the computer, saved as text files, printed, and submitted.

D. Remove and replace cabling where test results indicate that they do not comply with specified requirements.

E. End-to-end cabling will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

END OF SECTION 271513

SECTION 271523 - COMMUNICATIONS OPTICAL FIBER HORIZONTAL CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. 62.5/125-micrometer, multimode, optical fiber cable (OM1).
2. 50/125 micrometer, multimode, optical fiber cable (OM2).
3. 9/125 micrometer, single mode, optical fiber cable (OS1).
4. 9/125 micrometer, single-mode, indoor-outdoor optical fiber cable (OS2).
5. Optical fiber cable connecting hardware, patch panels, and cross-connects.
6. Grounding.
7. Cabling identification products.

1.2 OPTICAL FIBER HORIZONTAL CABLING DESCRIPTION

A. Optical fiber horizontal cabling system shall provide interconnections between Distributor A, Distributor B, or Distributor C and the equipment outlet, otherwise known as "Cabling Subsystem 1," or Distributor C and the equipment outlet, otherwise known as "Centralized Cabling," in the telecommunications cabling system structure. Cabling system consists of horizontal cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for horizontal-to-horizontal cross-connection.

1. TIA-568-C.1 requires that a minimum of two equipment outlets be installed for each work area.
2. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the equipment outlet.
3. Bridged taps and splices shall not be installed in the horizontal cabling.

B. A work area is approximately 100 sq. ft. (9.3 sq. m) and includes the components that extend from the equipment outlets to the equipment.

C. The maximum allowable horizontal cable length is 295 feet (90 m). This maximum allowable length does not include an allowance for the length of 16 feet (4.9 m) to the workstation equipment or in the horizontal cross-connect.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Reviewed and stamped by RCDD.

1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.

2. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
3. Cabling administration Drawings and printouts.
4. Wiring diagrams and installation details of telecommunications equipment, to show location and layout of telecommunications equipment.

C. Fiber optic cable testing plan.

D. Sustainable Design Submittals:
1. Samples: For telecommunications jacks and plugs.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For RCDD, Installer, installation supervisor, and field inspector.

B. Product Certificates: For each type of product.

C. Source quality-control reports.

D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On USB media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

B. Maintenance data.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings and Cabling Administration Drawings, Cabling Administration Drawings, and field testing program development by an RCDD or Technician as directed.
2. Installation Supervision: Installation shall be under the direct supervision of Technician or Level 2 Installer as directed, who shall be present at all times when Work of this Section is performed at Project site.
3. Testing Supervisor: Currently certified by BICSI as an RCDD or Technician as directed.

B. Testing Agency Qualifications: Testing agency must have personnel certified by BICSI on staff.

1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

1.7 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning with Substantial Completion, provide software support for two years.

B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard.

B. Telecommunications Pathways and Spaces: Comply with TIA-569-D.

C. Grounding: Comply with TIA-607-B.

2.2 62.5/125-MICROMETER, MULTIMODE, OPTICAL FIBER CABLE (OM1)

A. Description: Multimode, 62.5/125-micrometer, 1, 2 or 4-fiber, nonconductive or conductive, tight buffer, optical fiber cable as directed.

B. Standards:

1. Comply with ICEA S-83-596 for mechanical properties.
2. Comply with TIA-568-C.3 for performance specifications.
3. Comply with TIA-492AAAA for detailed specifications.

C. Conductive cable shall be steel or aluminum armored type as directed.

D. Maximum Attenuation: 3.50 dB/km at 850 nm; 1.5 dB/km at 1300 nm.

E. Minimum Overfilled Modal Bandwidth-length Product: 200 MHz-km at 850 nm; 500 MHz-km at 1300 nm.

F. Jacket:

1. Jacket Color: Orange.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

G. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:

1. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
2. Plenum Rated, Nonconductive: Type OFNP in listed plenum communications raceway.
3. Plenum Rated, Nonconductive: Type OFNP or Type OFNR in metallic conduit.
4. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262; Type OFNP in listed plenum communications raceway; or Type OFNP or Type OFNR in metallic conduit.
5. Plenum Rated, Conductive: Type OFCP complying with NFPA 262.
6. Plenum Rated, Conductive: Type OFCP or Type OFNP in listed plenum communications raceway.
7. Plenum Rated, Conductive: Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."

2.3 50/125 MICROMETER, MULTIMODE, OPTICAL FIBER CABLE (OM2)

A. Description: Multimode, 50/125-micrometer, 1, 2 or 4-fiber as directed, nonconductive conductive as directed, tight buffer, optical fiber cable.

B. Standards:

1. Comply with ICEA S-83-596 for mechanical properties.
2. Comply with TIA-568-C.3 for performance specifications.
3. Comply with TIA-492AAAB for detailed specifications.

C. Conductive cable shall be steel or aluminum armored type as directed.

D. Maximum Attenuation: 3.50 dB/km at 850 nm; 1.5 dB/km at 1300 nm.

E. Minimum Overfilled Modal Bandwidth-length Product: 500 MHz-km at 850 nm; 500 MHz-km at 1300 nm.

F. Jacket:

1. Jacket Color: Orange.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

G. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:

1. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
2. Plenum Rated, Nonconductive: Type OFNP in listed plenum communications raceway.
3. Plenum Rated, Nonconductive: Type OFNP or Type OFNR in metallic conduit.
4. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262; Type OFNP in listed plenum communications raceway; or Type OFNP or Type OFNR in metallic conduit.

5. Plenum Rated, Conductive: Type OFCP or Type OFNP, complying with NFPA 262.
6. Plenum Rated, Conductive: Type OFCP or Type OFNP in listed plenum communications raceway.
7. Plenum Rated, Conductive: Type OFC, Type OFN, Type OFCG, Type OFNG, Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."

2.4 9/125 MICROMETER SINGLE-MODE, INDOOR-OUTDOOR OPTICAL FIBER CABLE (OS1)

A. Description: Single mode, 9/125-micrometer, 1 or 2 fibers as directed, tight buffered, nonconductive or conductive optical fiber cable as directed.

B. Conductive cable shall be steel or aluminum armored type as directed.

C. Maximum Attenuation: 0.5 dB/km at 1310 nm; 0.5 dB/km at 1550 nm.

D. Jacket:

1. Jacket Color: Yellow.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

E. Standards:

1. Comply with TIA-492CAAA for detailed specifications.
2. Comply with TIA-568-C.3 for performance specifications.
3. Comply with ICEA S-104-696 for mechanical properties.

F. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:

1. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
2. Plenum Rated, Nonconductive: Type OFNP in listed plenum communications raceway.
3. Plenum Rated, Nonconductive: Type OFNP or Type OFNR in metallic conduit.
4. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262; Type OFNP in listed plenum communications raceway; or Type OFN, Type OFNG, Type OFNP, or Type OFNR in metallic conduit.
5. Plenum Rated, Conductive: Type OFCP, complying with NFPA 262.
6. Plenum Rated, Conductive: Type OFCP or Type OFNP in listed plenum communications raceway.
7. Plenum Rated, Conductive: Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."

2.5 9/125 MICROMETER, SINGLE-MODE, INDOOR-OUTDOOR OPTICAL FIBER CABLE (OS2)

A. Description: Single mode, 9/125-micrometer, 1 or 2 fibers as directed, tight buffered, nonconductive or conductive optical fiber cable as directed.

B. Conductive cable shall be steel or aluminum armored type as directed.

C. Maximum Attenuation: 0.5 dB/km at 1310 nm; 0.5 dB/km at 1550 nm.

D. Jacket:

1. Jacket Color: Yellow.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

E. Standards:

1. Comply with TIA-492CAAB for detailed specifications.
2. Comply with TIA-568-C.3 for performance specifications.
3. Comply with ICEA S-104-696 for mechanical properties.

F. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:

1. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
2. Plenum Rated, Nonconductive: Type OFNP in listed plenum communications raceway.
3. Plenum Rated, Nonconductive: Type OFNP or Type OFNR in metallic conduit.
4. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262; Type OFNP in listed plenum communications raceway; or Type OFN, Type OFNG, Type OFNP, or Type OFNR in metallic conduit.
5. Plenum Rated, Conductive: Type OFCP, complying with NFPA 262.
6. Plenum Rated, Conductive: Type OFCP or Type OFNP in listed plenum communications raceway.
7. Plenum Rated, Conductive: Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."

2.6 OPTICAL FIBER CABLE HARDWARE

A. Standards:

1. Comply with Fiber Optic Connector Intermateability Standard (FOCIS) specifications of the TIA-604 series.
2. Comply with TIA-568-C.3.

B. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.

1. Number of Connectors per Field: One for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.

C. Patch Cords: Factory-made, single-fiber cables in 36-inch (900-mm) lengths.

D. Connector Type: As directed.

E. Plugs and Plug Assemblies:

1. Male; color-coded modular telecommunications connector designed for termination of a single optical fiber cable.
2. Insertion loss not more than 0.25 or 0.75 dB as directed.
3. Marked to indicate transmission performance.

F. Jacks and Jack Assemblies:

1. Female; quick-connect, simplex and duplex; fixed telecommunications connector designed for termination of a single optical fiber cable.
2. Insertion loss not more than 0.25 or 0.75 dB as directed.
3. Marked to indicate transmission performance.
4. Designed to snap-in to a patch panel or faceplate.

G. Faceplate:

1. Two, Four or Six-port as directed, vertical single-gang faceplates designed to mount to single-gang wall boxes.
2. Eight, Ten or Twelve-port as directed, vertical double-gang faceplates designed to mount to double-gang wall boxes.
3. Plastic Faceplate: High-impact plastic. Coordinate color with Section 262726 "Wiring Devices."
4. Metal Faceplate: Stainless steel or Brass as directed, complying with requirements in Section 262726 "Wiring Devices."
5. For use with snap-in jacks accommodating any combination of twisted pair, optical fiber, and coaxial work area cords.

    a. Flush mounting jacks, positioning the cord at a 45-degree angle.

2.7 GROUNDING

A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.

B. Comply with TIA-607-B.

2.8 IDENTIFICATION PRODUCTS

A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.9 SOURCE QUALITY CONTROL

A. Factory test multimode optical fiber cables according to TIA-526-14-B and TIA-568-C.3.

B. Factory test preterminated optical fiber cable assemblies according to TIA-526-14-B and TIA-568-C.3.

C. Cable will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION OF OPTICAL FIBER BACKBONE CABLES

A. Comply with NECA 1, NECA 301 and NECA/BICSI 568.

B. General Requirements for Optical Fiber Cabling Installation:

1. Comply with TIA-568-C.1 and TIA-568-C.3.
2. Comply with BICSI ITSIMM, Ch. 6, "Cable Termination Practices."
3. Terminate all cables; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
4. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
5. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
6. Bundle, lace, and train cable to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, "Cabling Termination Practices" Chapter. Use lacing bars and distribution spools.
7. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
8. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
9. In the communications equipment room, provide a 10-foot- (3-m-) long service loop on each end of cable.
10. Pulling Cable: Comply with BICSI ITSIMM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
11. Cable may be terminated on connecting hardware that is rack or cabinet mounted.

C. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces, in attics, and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.

2. Comply with requirements for pathways specified in Section 270528 "Pathways for Communications Systems."

D. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

E. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

F. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

G. Installation of Cable Routed Exposed under Raised Floors:

1. Install plenum-rated cable only.
2. Install cabling after the flooring system has been installed in raised floor areas.
3. Coil cable 6 feet (1800 mm) long not less than 12 inches (300 mm) in diameter below each feed point.

H. Group connecting hardware for cables into separate logical fields.

3.2 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-D, Annex A, "Firestopping."

C. Comply with BICSI ITSIMM, "Firestopping" Chapter.

3.3 GROUNDING

A. Install grounding according to BICSI ITSIMM, "Grounding (Earthing), Bonding, and Electrical Protection" Chapter.

B. Comply with TIA-607-B and NECA/BICSI-607.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.4 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."

1. Administration Class: As directed.
2. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.

B. Paint and label colors for equipment identification shall comply with TIA-606-B for Class 2, Class 3 or Class 4 level of administration including optional identification requirements of this standard as directed.

C. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

D. Cable and Wire Identification:

1. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet (4.5 m).
4. Label each unit and field within distribution racks and frames.
5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.

E. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA 606-B, for the following:

1. Flexible vinyl or polyester that flexes as cables are bent.

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. Tests and Inspections:

1. Visually inspect optical fiber jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments and inspect cabling connections for compliance with TIA-568-C.1.

2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Optical Fiber Cable Tests:

    a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
    b. Link End-to-End Attenuation Tests:

        1) Horizontal and Multimode Horizontal Link Measurements: Test at 850 or 1300 nm in one direction according to TIA-526-14-B, Method B, One Reference Jumper.
        2) Attenuation test results for horizontal links shall be less than 2.0 dB. Attenuation test results shall be less than those calculated according to equation in TIA-568-C.1.

C. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.

D. Remove and replace cabling where test results indicate that it does not comply with specified requirements.

E. End-to-end cabling will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

END OF SECTION 271523

SECTION 271533 - COMMUNICATIONS COAXIAL HORIZONTAL CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Communications coaxial cable.
2. CATV coaxial cable.
3. Coaxial cable hardware.
4. Grounding.
5. Identification products.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
2. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
3. Cabling administration drawings and printouts.

C. Sustainable Design Submittals:

1. Samples: For telecommunications jacks and plugs, in specified finish, one for each type and configuration and faceplates for color selection and evaluation of technical features.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For RCDD, Installer, installation supervisor, and field inspector.

B. Source quality-control reports.

C. Field quality-control reports.

D. Maintenance Data: For splices and connectors to include in maintenance manuals.

1.4 CLOSEOUT SUBMITTALS

A. Software and Firmware Operational Documentation.

B. Maintenance Data: For coaxial cable, splices, and connectors to include in maintenance manuals.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings and Cabling Administration Drawings, Cabling Administration Drawings, and field testing program development by an RCDD Technician.
2. Installation Supervision: Installation shall be under the direct supervision of Technician Level 2 Installer, who shall be present at all times when Work of this Section is performed at Project site.

B. Testing Agency Qualifications: Testing agency must have personnel certified by BICSI on staff.

1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD.

1.6 COORDINATION

A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard, and the requirements of TIA-568-C.4.

B. Telecommunications Pathways and Spaces: Comply with TIA-569-D.

C. Grounding: Comply with TIA-607-B.

2.2 GENERAL CABLE CHARACTERISTICS

A. Communications Cable: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with the applicable standard and NFPA 70 for the following types:

1. Communications, Plenum Rated: Type CMP complying with UL 1685 or Type CMP in listed plenum communications raceway or Type CMP in listed cable routing assembly as directed.
2. Communications, Plenum Rated: Type CM, Type CMG, Type CMP, Type CMR, or Type CMX in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."

B. CATV Cable: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with the applicable standard and NFPA 70 for the following types:

1. CATV Plenum Rated: Type CATVP installed in riser raceways or cable routing assemblies, complying with NFPA 262.
2. CATV Cable: Type CATV, or CATVP or CATVR, installed in general purpose, riser, or plenum communications raceways or cable routing assemblies in fireproof riser shafts with firestops at each penetration.

2.3 COMMUNICATIONS COAXIAL CABLE

A. Description: Coaxial cable with a 75-ohm characteristic impedance designed for broadband data transmission.

B. NFPA and UL compliance, listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 13, and with NFPA 70, "Class 1, Class 2, and Class 3 Remote-Control, Signaling, and Power-Limited Circuits" and "Communications Circuits" articles. Types are as follows:

1. RG-6/U: UL Type CMP and CL2P as directed.

    a. No. 16 or 18 AWG as directed, solid, copper-covered steel conductor.
    b. Plenum rated.
    c. Gas-injected, foam-PE insulation.
    d. Shielded with 100 percent aluminum tape and 40 or 60 percent aluminum braid as directed.
    e. Double shielded with 100 percent aluminum foil shield, 60 percent aluminum braided inner shield, and 40 percent aluminum braided outer shield.
    f. Jacketed with black or white PVC or PE as directed.
    g. Suitable for indoor installations.

2. RG-11/U: UL Type CMP and CL2P as directed.

    a. No. 14 AWG, solid, copper-covered steel conductor.
    b. Plenum rated. Suitable for outdoor installations in ambient temperatures ranging from minus 40 to plus 85 deg F (minus 40 to plus 30 deg C).
    c. Gas-injected, foam-PE insulation.
    d. Shielded with 100 percent aluminum tape and 40 or 60 percent aluminum braid as directed.
    e. Double shielded with 100 percent aluminum foil shield, 60 percent aluminum braided inner shield, and 40 percent aluminum braided outer shield.
    f. Jacketed with sunlight-resistant, black or white PVC or PE as directed.

2.4 CATV COAXIAL CABLE

A. Description: Coaxial cable with a 75-ohm characteristic impedance designed for CATV transmission.

B. NFPA and UL compliance, listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1655 and with NFPA 70, "Community Antenna Television and Radio Distribution Systems" Article. Types are as follows:

1. RG-6/U: UL Type CATVP.

a. No. 18 AWG, solid, copper-covered steel conductor.
b. Plenum rated.
c. Gas-injected, foam-PE insulation.
d. Shielded with 100 percent aluminum tape and 40 or 60 percent aluminum braid as directed.
e. Double shielded with 100 percent aluminum foil shield, 60 percent aluminum braided inner shield, and 40 percent aluminum braided outer shield.
f. Jacketed with black or white PVC or PE as directed.
g. Suitable for indoor installations.

2.5 COAXIAL CABLE HARDWARE

A. Description: Hardware designed to connect, splice, and terminate coaxial cable with a 75-ohm characteristic impedance.

B. Coaxial-Cable Connectors: Type BNC, 75 ohms.

C. Jacks and Jack Assemblies: Modular, color-coded, with female Type BNC connectors.

D. Patch Cords: Factory-made cables in 36-inch (900-mm) or 48-inch (1200-mm) lengths as directed; terminated with a male Type BNC connector at each end.

E. Faceplates:

1. Plastic Faceplate: High-impact plastic. Coordinate color with Section 262726 "Wiring Devices."
2. Metal Faceplate: Stainless steel or Brass as directed, complying with requirements in Section 262726 "Wiring Devices."
3. For use with snap-in jacks accommodating any combination of twisted pair, optical-fiber, and coaxial work area cords.

a. Flush-mounted jacks, positioning the cord at a 90-degree angle from faceplate surface.

4. Legend:

a. Factory labeled by silk-screening or engraving for stainless steel or brass faceplates as directed.
b. Machine printed, in the field, using adhesive-tape label.
c. Snap-in, clear-label covers and machine-printed paper inserts.

2.6 GROUNDING

A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.

B. Comply with TIA-607-B.

PART 3 - EXECUTION

3.1 ENTRANCE FACILITIES

A. Coordinate horizontal cabling with the protectors and demarcation point provided by communications service provider.

3.2 INSTALLATION OF COAXIAL HORIZONTAL CABLES

A. Comply with NECA 1 and NECA/BICSI 568.

B. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces, in attics, and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for raceways and boxes specified in Section 270528 "Pathways for Communications Systems."

C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

D. General Requirements for Cabling:

1. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section.
2. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and patch panels.
3. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
4. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
5. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section. Use lacing bars and distribution spools.

6. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
7. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
8. In the communications equipment room, install a 10-foot- (3-m-) long service loop on each end of cable.
9. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems," "Pulling Cable" Section. Monitor cable pull tensions.

E. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend coaxial cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceilings by cable supports not more than 60 inches (1524 mm) apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

F. Installation of Cable Routed Exposed under Raised Floors:

1. Install plenum-rated cable only.
2. Install cabling after the flooring system has been installed in raised floor areas.
3. Coil cable 6 feet (1800 mm) long not less than 12 inches (300 mm) in diameter below each feed point.

G. Outdoor Coaxial Cable Installation:

1. Install outdoor connections in enclosures complying with NEMA 250, Type 4X. Install corrosion-resistant connectors with properly designed O-rings to keep out moisture.
2. Attach antenna lead-in cable to support structure at intervals not exceeding 36 inches (915 mm).

H. Group connecting hardware for cables into separate logical fields.

I. Separation from EMI Sources:

1. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
    b. Electrical Equipment Rating Between 2 and 5 kVA: A minimum of 12 inches (300 mm).
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (610 mm).

2. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).

b. Electrical Equipment Rating Between 2 and 5 kVA: A minimum of 6 inches (150 mm).
c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).

3. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
b. Electrical Equipment Rating Between 2 and 5 kVA: A minimum of 3 inches (76 mm).
c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).

4. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
5. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.3 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-C, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.4 GROUNDING

A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. Comply with TIA-607-B and NECA/BICSI-607.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.5 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

C. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, horizontal pathways and cables, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.

D. Cable and Wire Identification:

1. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet (4.5 m).
4. Label each terminal strip and screw terminal in each cabinet, rack, or panel.

    a. Individually number wiring conductors connected to terminal strips and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device with name and number of particular device as shown.
    b. Label each unit and field within distribution racks and frames.

5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communications cabling, use a different color for jacks and plugs of each service.

E. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA 606-B, for the following:

1. Cables use flexible vinyl or polyester that flexes as cables are bent.

3.6 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative.

B. Tests and Inspections:

1. Visually inspect coaxial jacket materials for NRTL certification markings.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.

3. Test coaxial horizontal copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination.

C. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.

D. Remove and replace cabling where test results indicate that they do not comply with specified requirements.

E. End-to-end cabling will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

END OF SECTION 271533

SECTION 271611 - COMMUNICATIONS HYBRID CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Multimode optical fiber and copper hybrid cable for Class 2 circuits.
2. Single-mode optical fiber and copper hybrid cable for Class 2 circuits.
3. Optical fiber cable-connecting hardware.
4. Grounding.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Reviewed and stamped by RCDD.

C. Fiber-optic cable testing plan.

D. Sustainable Design Submittals:

1.3 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of product.

B. Source quality-control reports.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings and cabling administration Drawings, cabling administration Drawings, and field testing program development by a BICSI-certified RCDD Technician as directed.
2. Installation Supervision: Installation shall be under the direct supervision of Technician Level 2 Installer, who shall be present at all times when Work of this Section is performed at Project site.

B. Field Inspector: Currently registered by BICSI as RCDD Technician to perform the on-site inspection.

C. Testing Agency Qualifications: Certified by BICSI.

1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD Technician to supervise on-site testing.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. General Performance:

1. Cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard.
2. Comply with UL 13.

B. Telecommunications Pathways and Spaces: Comply with TIA-569-D.

C. Grounding: Comply with TIA-607-B.

D. RoHS compliant.

2.2 MULTIMODE OPTICAL FIBER AND COPPER HYBRID CABLE

A. "Description" Paragraph below includes common characteristics of common hybrid cables. Verify cable construction with manufacturer.

B. Description: One, Two or Four 62.5/125-micrometer multimode optical fibers and two copper conductors sharing a common jacket.

C. Copper Conductors:

1. Comply with ASTM B3 for stranded conductors.
2. Size: As directed.
3. Insulation: THWN or THHN as directed.

D. Optical Fiber:

1. Type: 62.5/125-micrometer, multimode, optical fiber cable (OM1) or 50/125-micrometer, multimode, optical fiber cable (OM2) as directed.
2. Maximum Attenuation: 0.5 dB/km at 1310 nm; 0.5 dB/km at 1550 nm.

E. Jacket:

1. Jacket Color: As directed.
2. Imprinted with fiber count, fiber type, copper count, copper size, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

F. Shield: Aluminum foil or Aluminum braid as directed.

G. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with NFPA 70, Article 725 for the following types:

1. Plenum Rated: Type CL3P and CL2P, complying with NFPA 262.
2. Riser Rated: Type CL3R and CL2R, complying with UL 1666.
3. Riser Rated: Type CMR, complying with UL 444.
4. Tray Cable: Type PLTC.

2.3 SINGLE-MODE OPTICAL FIBER AND COPPER HYBRID CABLE

A. "Description" Paragraph below includes common characteristics of common hybrid cables. Verify cable construction with manufacturer.

B. Description: One, Two or Four single-mode optical fibers and two copper conductors sharing a common jacket as directed.

C. Copper Conductors:

1. Comply with ASTM B3 for stranded conductors.
2. Size: As directed.
3. Insulation: THWN or THHN as directed.

D. Optical Fiber:

1. Type: As directed.
2. Maximum Attenuation: 0.5 dB/km at 1310 nm; 0.5 dB/km at 1550 nm.

E. Jacket:

1. Jacket Color: As directed.
2. Imprinted with fiber count, fiber type, copper count, copper size, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

F. Shield: Aluminum foil or Aluminum braid as directed.

G. Armor: Steel or Aluminum as directed.

H. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with NFPA 70, Article 725 for the following types:

1. Plenum Rated: Type CL3P and CL2P, complying with NFPA 262.
2. Riser Rated: Type CL3R and CL2R, complying with UL 1666.
3. Riser Rated: Type CMR, complying with UL 444.
4. Tray Cable: Type PLTC.

2.4 OPTICAL FIBER CABLE HARDWARE

A. Standards:

1. Comply with Fiber Optic Connector Intermate ability Standard (FOCIS) specifications of the TIA-604 series.
2. Comply with TIA-568-C.3.

B. Connector Type: As directed.

C. Plugs and Plug Assemblies:

1. Male; color-coded modular telecommunications connector designed for termination of a single-fiber optic cable.
2. Insertion loss not more than 0.25 or 0.75 dB as directed.

D. Jacks and Jack Assemblies:

1. Female; quick-connect, simplex and duplex; fixed telecommunications connector designed for termination of a single-fiber optic cable.
2. Insertion loss not more than 0.25 or 0.75 dB as directed.
3. Designed to snap in to a patch panel or faceplate.

E. Patch Cords: Factory-made, single-fiber cables in 36-inch (900-mm) lengths.

2.5 GROUNDING

A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.

B. Comply with TIA-607-B.

2.6 SOURCE QUALITY CONTROL

A. Factory test multimode optical fiber cables according to TIA-526-14-B and TIA-568-C.3.

B. Factory test pre-terminated optical fiber cable assemblies according to TIA-526-14-B and TIA-568-C.3.

C. Cable will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION OF HYBRID CABLES

A. Comply with NECA 1 and NECA 301.

B. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces, attics, and gypsum board partitions

where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for pathways specified in Section 270528 "Pathways for Communications Systems."

C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

D. General Requirements for Cabling:

1. Comply with TIA-568-C Series of standards.
2. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems" and Ch. 6, "Optical Fiber Structured Cabling Systems" for cable terminations.
3. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
4. Cables may not be spliced.
5. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
6. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
7. Bundle, lace, and train cable to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 6, "Cabling Termination Practices." Use lacing bars and distribution spools.
8. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
9. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
10. In the communications equipment room, provide a 10-foot- (3-m-) long service loop on each end of cable.
11. Pulling Cable: Comply with requirements of BICSI ITSIMM Ch. 5, "Copper Structured Cabling Systems," and Ch. 6, "Optical Fiber Structured Cabling Systems" for pulling cable. Monitor cable pull tensions.
12. Cable may be terminated on connecting hardware that is rack or cabinet mounted.

E. Group connecting hardware for cables into separate logical fields.

3.2 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-D, Annex A, "Firestopping."

C. Comply with BICSI ITSIMM, "Firestopping Practices" chapter.

3.3 GROUNDING

A. Install grounding according to BICSI ITSIMM, "Bonding, Grounding (Earthing) and Electrical Protection" chapter.

B. Comply with TIA-607-B and NECA/BICSI-607.

C. Locate telecommunications grounding bus bar to minimize the length of bonding conductors. Fasten to wall, allowing at least 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground. Connect rack grounding bus bar to the telecommunications ground bus bar or the telecommunications main ground bus bar.

1. Bond the shield of shielded cable to patch panel and bond patch panel to TGB or TMGB.

3.4 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Administration Class: As directed.
2. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.

B. Comply with requirements in Section 099123 "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.

C. Paint and label colors for equipment identification shall comply with TIA-606-B for Class 2, Class 3 or Class 4 level of administration as directed, including optional identification requirements of this standard.

D. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect schedule with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

E. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, horizontal pathways and cables, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.

F. Cable and Wire Identification:

1. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.

3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet (4.5 m).
4. Label each unit and field within distribution racks and frames.
5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.

G. Labels shall be machine printed. Type height as directed.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform tests and inspections with the assistance of a factory-authorized service representative.

E. Tests and Inspections:

1. Visually inspect jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments and inspect cabling connections for compliance with TIA-568-C.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Optical Fiber Cable Tests:

    a. Test instruments shall comply with or exceed applicable requirements in TIA-568-C.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
    b. Link End-to-End Attenuation Tests:

        1) Horizontal and Multimode Horizontal Link Measurements: Test at 850 or 1300 nm in one direction according to TIA-526-14-B, Method B, One Reference Jumper.
        2) Attenuation test results for horizontal links shall be less than 2.0 dB. Attenuation test results shall be less than those calculated according to equation in TIA-568-C.1.

F. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similar to that suggested by BICSI for cable testing, or transferred from the instrument to the computer, saved as text files, and printed and submitted.

G. Remove and replace cabling where test results indicate that it does not comply with specified requirements.

H. End-to-end cabling will be considered defective if it does not pass tests and inspections.

I. Prepare test and inspection reports.

END OF SECTION 271611

SECTION 274133 - MASTER ANTENNA TELEVISION SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. MATV equipment using cable television service, direct broadcast satellite service, an off-air antenna system, CCTV cameras and video recorders as the signal source.
2. Off-air antennas.
3. MATV headend components.
4. Distribution components.

B. Related Sections:

1. Section 271313 "Communications Copper Backbone Cabling" for copper data cabling associated with system panels and devices.
2. Section 271323 "Communications Optical Fiber Backbone Cabling" for optical-fiber data cabling associated with system panels and devices.
3. Section 271333 "Communications Coaxial Backbone Cabling" for riser-rated coaxial data cabling associated with system panels and devices.
4. Section 271513 "Communications Copper Horizontal Cabling" for balanced twisted-pair optical-fiber cables and connectors.
5. Section 271523 "Communications Optical Fiber Horizontal Cabling" for optical-fiber cables and connectors.
6. Section 271533 "Communications Coaxial Horizontal Cabling" for coaxial cables and connectors.
7. Section 282000 "Video Surveillance" for cameras, monitors, computers, and cabling for video surveillance systems.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For headend and distribution system. Include plans, elevations, sections, details, and attachments to other work.

1. Detail fabrication and installation details for television equipment.
2. Functional Block Diagram: Show single-line interconnections between components for headend and distribution system to user-interface points. Show cable types and sizes.

3. Dimensioned Plan and Elevations of Headend Equipment: Show access and workspace requirements.
4. Wiring Diagrams: For power, signal, and control wiring. Balanced twisted-pair or optical-fiber cable include cross connects, patch panels, and patch cords.

C. Samples: Full size for each outlet device plate in required colors and textures.

D. Design Calculations: Calculate signal attenuation budget and show calculated line and equipment losses for the system based on the functional block diagram, to show that proposed system layout can be expected to perform up to specification. Calculate signal strength from sources to headend input points for each antenna, satellite dish, and CATV grouping. Allowable losses between components and user interface shall be used to determine size and type of coaxial cable.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Include dimensioned plan and elevation views of components and enclosures. Show access and workspace requirements.

B. Equipment List: Include each piece of equipment and include model number, manufacturer, serial number, location, and date of original installation. Insert testing record of each piece of adjustable equipment, listing name of person testing, date of test, and description of as-left set points.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For headend and distribution system to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. System shall consist of cable television service, direct broadcast satellite service, an off-air antenna system, CCTV cameras and video recorders and a coaxial cable distribution system as directed.

1. Headend equipment shall consist of receiving antennas, satellites, and associated signal distribution amplification and equalization.
2. Distribution of direct broadcast satellite-service signals, which includes coordinating with Owner's selected service provider for installation of its dish-type antennas and processing the signals as needed to provide specified services combined into a single-feed point ready for connection into the distribution system. Obtain signal levels and noise and distortion characteristics from service provider as the point of departure for system layout and final equipment selection.

3. Distribution of cable television service signals, which includes coordinating with Owner's selected service provider for installation of cable to the service point ready for connection into the distribution system. Obtain signal levels and noise and distortion characteristics from service provider as the point of departure for system layout and final equipment selection.
4. Cable distribution system consisting of coaxial cables, user interfaces, signal taps and splitters, RF amplifiers, signal equalizers, power supplies, and required hardware, complying with EIA/ECA 310-E and CTA-2032-B and resulting in performance parameters specified in this Section. System shall be capable of distributing television channels according to CTA-542-D.

B. Hardware Requirements: Use plug-in, modular, solid-state electronic components. Mount amplifiers and other powered equipment in standard 19-inch (483-mm) cabinet complying with EIA/ECA 310-E.

C. Off-Air Stations: Install antennas for the reception and distribution of selected stations.

2.2 PERFORMANCE REQUIREMENTS

A. Minimum acceptable performance of distribution system at all user-interface points shall be as follows:

1. RF Video-Carrier Level: Between 3 and 12 db mV.
2. Relative Video-Carrier Level: Within 3 db to adjacent channel.
3. Carrier Level Stability, Short Term: Level shall not change more than 0.5 db during a 60-minute period.
4. Carrier Level Stability, Long Term: Level shall not change more than 2 db during a 24-hour period.
5. Channel Frequency Response: Across any 6-MHz channel in the 54- to 220-MHz frequency range, referenced to video; signal amplitude shall be plus or minus 1 db, maximum.
6. Carrier-to-Noise Ratio: 45 db or more.
7. RF Visual Signal-to-Noise Ratio: 43 db or more.
8. Antenna Combiner Insertion Loss: 40 db maximum.
9. Signal Power Splitter and Isolation Tap Return Loss: 17 db maximum.
10. Cable Connectors Attenuation: Less than 0.1 db.
11. Cross Modulation: Less than minus 50 db.
12. Carrier-to-Echo Ratio: More than 40 db.
13. Composite Triple Beat: Less than minus 53 db.
14. Second Order Beat: Less than minus 60 db.
15. Terminal Isolation from Television to Television: 25 db, minimum.
16. Terminal Isolation between Television and FM: 35 db, minimum.
17. Hum Modulation: 2 percent, maximum.
18. RF FM Carrier Level: 13 to 17 db below video-carrier level.
19. FM Frequency Response: More than in the 88- to 108-MHz frequency range; signal amplitude is plus or minus 0.75 db, maximum.
20. FM Carrier-to-Noise Ratio: More than 24 db.

2.3 SYSTEM REQUIREMENTS

A. Components: Plug-in, modular, heavy-duty, industrial- or commercial-grade units.

B. Equipment: Silicon-based, solid-state, integrated circuit devices.

C. Power Supply Characteristics: Devices shall be within specified parameters for ac supply voltages within the range of 105 to 130 V.

D. Protect signal cables and connected components against transient-voltage surges by suppressors and absorbers designed specifically for that purpose. Comply with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."

E. Provide ac-powered equipment with integral surge protection devices complying with UL 1449.

F. RF and Video Impedance Matching: Signal-handling components, including connecting cable, shall have end-to-end impedance-matched signal paths. Match and balance devices used at connections where it is impossible to avoid impedance mismatch or mismatch of balanced circuits to unbalanced circuits.

G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.4 MATV EQUIPMENT

A. Description: Signal-source components, signal-processing and amplifying equipment, distribution components, and interconnecting wiring. System shall receive, amplify, process, and distribute signals to outlets for receiving sets. Equipment shall translate UHF channels to VHF channels before distribution to outlets.

B. Identification of Signal Sources Distributed:

C. MATV System Qualitative and Quantitative Performance Requirements: Reception quality of color-television program transmissions at each system outlet from each service and source shall be equal to or superior than that obtained with performance checks specified in "Field Quality Control" Article, using standard, commercial, cable-ready, multiple A/V input color-television receivers.

2.5 OFF-AIR ANTENNAS

A. Antennas shall be tested, marked, and packaged, according to CTA-774-A, CEA-2028-B, and CEA-2032-B. Antennas shall be labeled according to CEA antenna mapping program.

B. Off-Air, Mast-Mounted Antennas: Weatherproof single-channel or broadband type, constructed of high-strength anodized aluminum and rated to survive in a 100-mph (160-km/h) wind, minimum.
   1. Elements: Internally dampened against mechanical vibration that may occur in service.
   2. Ends of Crossarms and Elements: Sealed.
   3. Mounting and Connecting Hardware: Corrosion proof.

4. Frequency Range: Matched to source frequencies.
5. CEA Reception Patterns: As directed.
6. FM Antenna: Separate from the broadband antenna and the omnidirectional or directional antenna as directed, with 2-db minimum gain.

C. Antenna-Supporting Structures: Prefabricated, hot-dip galvanized-steel units.
1. Strength of Structure and Attachments: Adequate to withstand 100-mph (160-km/h) winds while supporting installed antennas.
2. Comply with 47 CFR 17 and TIA 222-G.
3. Comply with FAA AC 70/7460-1L.

2.6 MATV HEADEND COMPONENTS

A. Headend Equipment.

1. Components:

a. Channel mixers.
b. Processors.
c. Broadband amplifier.
d. Single-channel amplifiers.
e. FM module.
f. Combining networks.

2. Description: For receiving off-air television and FM signals and outputting the signals to cable distribution system. Equip coaxial down-leads of the off-air antennas with preamplifiers to send signals at strength required by headend. Headend component performance specified in this article is minimum acceptable; better performance may be required to comply with minimum acceptable system performance standard in "Performance Requirements" Article.
3. House units in standard 19-inch (483-mm) electronic equipment cabinet complying with EIA/ECA 310-E.

B. Antenna Combiner: Directional coupler design network, combining up to eight antenna signals into a single output. Frequency response of the device shall be 5 to 400 MHz, and the insertion loss between input ports shall be not less than 40 db.

C. Down-Lead Preamplifiers: Antenna mast-mounted preamplifier, designed to boost antenna signal and contained in weatherproof housing; single-channel or broadband type. Install power supplies indoors at headend equipment, connected through power inserters to provide power to preamplifiers through the coaxial down-lead cable.
1. Frequency Response: Plus or minus 0.75 db.
2. Minimum Input: Minus 20 db mV.
3. Return Loss: 14 db.
4. I/O Impedance: 75 ohms.

D. Channel Mixers: Use for nonadjacent channels only.
1. Insertion Loss (Maximum 54 to 216 MHz): 2.5 db.
2. Return Loss: 14 db.
3. Out-of-Band Rejection: 12 db.

4. I/O Impedance: 75 ohms.

E. Broadband Amplifier:
1. Frequency Range: 54 to 108, 174 to 220 or 54 to 220 MHz as directed.
2. Frequency Response: Plus or minus 1.0 db across passband.
3. Maximum Noise: 10 db.
4. Minimum Return Loss: 16 db.
5. I/O Impedance: 75 ohms.

F. Single-Channel Amplifiers:
1. Frequency: 6 MHz for specified channel.
2. Frequency Response: Plus or minus 0.5 db.
3. Maximum Noise: 10 db.
4. Minimum Return Loss: 14 db.
5. Automatic Gain Control: Plus or minus 1-db output variation for rated input level range variation.
6. Skirt Rejection: Minus 26 db at plus or minus 5 MHz from channel center.
7. Sound Trap: Adjustable to 10 Vdb of attenuation of the sound carrier.
8. I/O Impedance: 75 ohms.

G. Combining Network (Mixer): Combines the off-air television FM, CCTV and CATV signals into a single-broadband output as directed. An output test point, a 75-ohm television jack, a mixer output step attenuator dual-pilot insertion network, and a removable mixer-to-trunk jumper are included.

1. Passband: As required by system performance.
2. Distortion: Not more than plus or minus 0.1 db over any 6-MHz segment.
3. Distortion: Not more than plus or minus 0.5 db over the 54- to 216-MHz frequency range.
4. Nominal Insertion Loss:

a. 15 db maximum, channel input to single-system output.
b. 13 db maximum, channel input to mixer output.
c. 20 db maximum at test point (e.g., loss from trunk output).

5. Isolation between Any Two Inputs: 30 db.
6. I/O Impedance: 70 ohms.

2.7 DISTRIBUTION COMPONENTS

A. Signal Power Splitters and Isolation Taps: Metal-enclosed directional couplers with brass connector parts. Where installed in signal circuits used to supply cable-powered amplifiers, power throughput capacity shall exceed load by at least 25 percent.
1. Return Loss: 17 db.
2. RFI Shielding: 100 db.
3. Isolation: 25 db.
4. I/O Impedance: 75 ohms.

B. Distribution System Amplifiers: Powered by coaxial cable system and equipped with surge protection device and external test points to allow convenient signal monitoring.

C. Cable System Power Supplies: Plug-in, modular construction, with surge, short-circuit, and overload protection.

D. Signal Traps: Packaged filters tuned to interference frequencies encountered in Project.

E. Attenuators: Passive, of fixed value, and used to balance signal levels.

F. Terminating Resistors: Enclosed units rated 0.5 W and matched for coaxial impedance.

G. Jack: Flush, female-type outlets, designed to mimic power duplex outlet; for mounting in standard outlet box; with metallic parts of anodized brass, beryllium copper, or phosphor bronze. Cable connector mounting shall be semi-recessed, so its protrusion is flush with the plane of device plate. Feed-through-type cable connection shall not be used, except in area housing a single tenant, except within a single-dwelling unit as directed.
   1. Cable Connector: Female, Type F.
   2. Wall Plates: Match materials and finish of power outlets in same space.
   3. Attenuation: Less than 0.1 db.
   4. Voltage Standing-Wave Ratio: Less than 1.15 to 1.

2.8 ENCLOSURES

A. Enclosures for Interior, Controlled Environments: NEMA 250, Type 1.

B. Enclosures for Interior, Uncontrolled Environments: NEMA 250, or as directed.

C. Enclosures for Exterior Environments: NEMA 250, or as directed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install signal line surge suppressors on coaxial cables entering headend equipment space and at antenna-mounted amplifiers. Comply with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."

B. Install antenna towers, masts, and mountings on concrete bases. Comply with requirements for concrete bases specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.

   1. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   2. Install anchor bolts to elevations required for proper attachment to supported equipment.

3.2 ANTENNA AND HEADEND INSTALLATION

A. Mount headend equipment in electronic equipment cabinets recommended by manufacturer. Group related items in methodical sequence.

B. Arrange equipment to facilitate access for maintenance and to preserve headroom and passage space. Parts that require periodic service or maintenance shall be readily accessible. Headend components that require tuning adjustments shall be accessible from the front of equipment cabinets.

C. Align antenna elements to achieve maximum signal level and quality.

D. Antenna-Supporting Structure: Increase antenna height as required to obtain signal strength needed for specified system performance.

E. Antenna Cable Entrance: Use weatherproof entrance fittings, and seal at penetrations of the building envelope.

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections:

1. Align and adjust system and pretest components, wiring, and functions to verify that they comply with specified requirements.
2. Replace malfunctioning or damaged items.
3. Retest until satisfactory performance and conditions are achieved.
4. Prepare television equipment for acceptance and operational testing.
5. Use an agile receiver and signal strength meter or spectrum analyzer for testing.
6. Test Schedule: Schedule tests after pretesting has successfully been completed and system has been in normal functional operation for at least 14 days. Provide a minimum of 10 days' notice of test schedule.
7. Operational Tests: Perform tests of operational system to verify that system complies with Specifications. Include all modes of system operation. Test equipment for proper operation in all functional modes.
8. Distribution System Acceptance Tests:

    a. Field-Strength Instrument: Rated for minus 40-db mV measuring sensitivity and a frequency range of 54 to 812 MHz, minimum. Provide documentation of recent calibration against recognized standards.
    b. Signal Level and Picture Quality: Use a field-strength meter or spectrum analyzer, and a standard television receiver to measure signal levels and check picture quality at all or 25 percent of user-interface outlets as directed.

        1) Test the signal strength in db mV at 55, 151, 547, and 750 MHz as directed.
        2) Minimum acceptable signal level is 0 db mV (1000 mV).
        3) Maximum acceptable signal level over the entire bandwidth is 15 db mV.
        4) Television receiver shall show no evidence of cross-channel intermodulation, ghost images, or beat interference.

C. Headend and distribution system will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

E. Cap all unused connectors and seal weathertight.

END OF SECTION 274133

SECTION 275116 - PUBLIC ADDRESS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Preamplifiers.
2. Power amplifiers.
3. Microphones.
4. Control console.
5. Equipment cabinet.
6. Equipment rack.
7. Telephone paging adapters.
8. Tone generator.
9. Loudspeakers.
10. Noise-operated gain controllers.
11. Microphone and headphone outlets.
12. Conductors and cables.
13. Pathways.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Power, signal, and control wiring.

C. Delegated-Design Submittal: For supports and seismic restraints for control consoles, equipment cabinets and racks, and components indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of supports and seismic restraints for control consoles, equipment cabinets and racks, and components.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain public address system from single source from single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NFPA 70.

2.2 FUNCTIONAL DESCRIPTION OF SYSTEM

A. System Functions:

1. Selectively connect any zone to any available signal channel.
2. Selectively control sound from microphone outlets and other inputs.
3. "All-call" feature shall connect the all-call sound signal simultaneously to all zones regardless of zone or channel switch settings.
4. Telephone paging adapter shall allow paging by dialing an extension from any local telephone instrument and speaking into the telephone.
5. Produce a program-signal tone that is amplified and sounded over all speakers, overriding signals currently being distributed.
6. Reproduce high-quality sound that is free of noise and distortion at all loudspeakers at all times during equipment operation including standby mode with inputs off; output free of nonuniform coverage of amplified sound.

2.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design supports and seismic restraints for control consoles, equipment cabinets and racks, and components, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Seismic Performance: Supports and seismic restraints for control consoles, equipment cabinets and racks, and components shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.4 SYSTEM DESCRIPTION

A. Compatibility of Components: Coordinate component features to form an integrated system. Match components and interconnections for optimum performance of specified functions.

B. Equipment: Comply with UL 813. Equipment shall be modular, using solid-state components, and fully rated for continuous duty unless otherwise indicated. Select equipment for normal operation on input power usually supplied at 110 to 130 V, 60 Hz.

C. Equipment Mounting: Where rack, cabinet, or console mounting is indicated, equipment shall be designed to mount in a 19-inch (483-mm) housing complying with EIA/ECA-310-E.

D. Weather-Resistant Equipment: Listed and labeled by a qualified testing agency for duty outdoors or in damp locations.

2.5 PREAMPLIFIERS

A. Preamplifier: Separately mounted.

B. Preamplifier: Integral to power amplifier.

C. Output Power: Plus 4 dB above 1 mW at matched power-amplifier load.

D. Total Harmonic Distortion: Less than 1 percent.

E. Frequency Response: Within plus or minus 2 dB from 20 to 20,000 Hz.

F. Input Jacks: Minimum of three. One matched for low-impedance microphone; one USB port; and the other matchable to DVD or CD player, or radio tuner signals without external adapters.

G. Minimum Noise Level: Minus 55 dB below rated output.

H. Controls: On-off, input levels, and master gain.

2.6 POWER AMPLIFIERS

A. Mounting: Console or Rack as directed.

B. Output Power: 70-V balanced line. 80 percent of the sum of wattage settings of connected for each station and speaker connected in all-call mode of operation, plus a percentage allowance for future stations as directed.

C. Total Harmonic Distortion: Less than 3 percent at rated power output from 50 to 12,000 Hz.

D. Minimum Signal-to-Noise Ratio: 80 dB, at rated output.

E. Frequency Response: Within plus or minus 3 dB from 20 to 12,000 Hz.

F. Output Regulation: Less than 2 dB from full to no load.

G. Controls: On-off, input levels, and low-cut filter.

H. Input Sensitivity: Matched to preamplifier and to provide full-rated output with sound-pressure level of less than 10 dynes/sq. cm impinging on speaker microphone or handset transmitter.

2.7 MICROPHONES

A. Paging Microphone:

1. Type: Dynamic, with cardioid or omnidirectional polar characteristic as directed.
2. Impedance: 500 or 250 ohms as directed.
3. Frequency Response: Uniform, 50 to 15,000 Hz.
4. Sensitivity: Minus 70 dB.
5. Output Level: Minus 58 dB, minimum.
6. Cable: Braided shield cable with Amphenol or Neutrik XLR connectors as directed. Coordinate impedance with microphone impedance.
7. Mounting: Desk stand with integral-locking, press-to-talk switch.

2.8 CONTROL CONSOLE

A. Cabinet: Modular, desktop or desk style as directed; complying with EIA/ECA-310-E.

B. Housing: Steel, 0.0478-inch (1.2 mm) minimum, with removable front and rear panels. Side panels are removable for interconnecting side-by-side mounting.

C. Panel for Equipment and Controls: Rack mounted.

D. Controls:

1. Switching devices to select signal sources for distribution channels.
2. Program selector switch to select source for each program channel.
3. Switching devices to select zones for paging.
4. All-call selector switch.

E. Indicators: A visual annunciation for each distribution channel to indicate source being used.

F. Self-Contained Power and Control Unit: A single assembly of basic control, electronics, and power supply necessary to accomplish specified functions.

G. Spare Positions: 20 percent spare zone control and annunciation positions on console.

H. Microphone jack.

2.9 LOUDSPEAKERS

A. Cone-Type Loudspeakers:

1. Minimum Axial Sensitivity: 91 dB at 1 m, with 1-W input.
2. Frequency Response: Within plus or minus 3 dB from 50 to 15,000 Hz.
3. Size: 6 inches (150 mm) or 8 inches (200 mm) with 1-inch (25-mm) voice coil and minimum 5-oz. (140-g) ceramic magnet as directed.
4. Rated Output Level: 8 or 10 W, as directed.
5. Minimum Dispersion Angle: 100 degrees.
6. Matching Transformer: Full-power rated with four taps. Maximum insertion loss of 0.5 dB.

7. Surface-Mounted Units: Ceiling, wall, or pendant mounted, as indicated, in steel back boxes, acoustically dampened. Front face of at least 0.0478-inch (1.2-mm) steel and whole assembly rust proofed and shop primed for field painting.
8. Flush-Ceiling-Mounted Units: In steel back boxes, acoustically dampened. Metal ceiling grille with white baked enamel.

B. Horn-Type Loudspeakers:

1. Type: Single-horn units, double-reentrant design, with minimum full-range power rating of 15 W.
2. Matching Transformer: Full-power rated with four standard taps. Maximum insertion loss of 0.5 dB.
3. Frequency Response: Within plus or minus 3 dB from 250 to 12,000 Hz.
4. Dispersion Angle: 130 by 110 degrees.
5. Mounting: Integral bracket.
6. Units in Damp, Wet, or Outdoor Locations: Listed and labeled for environment in which they are located.
7. Units in Hazardous (Classified) Locations: Listed and labeled for environment in which they are located. Provide any accessories required to maintain listing.

2.10 OUTLETS

A. Microphone Outlet: Three-pole, polarized, locking-type, microphone receptacles in single-gang boxes. Equip wall outlets with brushed stainless-steel device plates. Equip floor outlets with gray tapered rubber or plastic cable nozzles and fixed outlet covers.

2.11 CONDUCTORS AND CABLES

A. Jacketed, twisted pair and twisted multipair, untinned solid copper.

1. Insulation for Wire in Conduit: Thermoplastic, not less than 1/32 inch (0.8 mm) thick.
2. Microphone Cables: Neoprene jacketed, not less than 2/64 inch (0.8 mm) thick, over shield with filled interstices. Shield No. 34 AWG, tinned, soft-copper strands formed into a braid or approved equivalent foil. Shielding coverage on conductors is not less than 60 percent.
3. Plenum Cable: Listed and labeled for plenum installation.

2.12 PATHWAYS

A. Conduit and Boxes: Comply with Section 270528 "Pathways for Communications Systems. "Flexible metal conduit shall not be used.

1. Outlet boxes shall be not less than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.

PART 3 - EXECUTION

3.1 WIRING METHODS

A. Wiring Method: Install cables in pathways and cable trays except within consoles, cabinets, desks, and counters, and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal pathway and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for pathways and boxes specified in Section 270528 "Pathways for Communications Systems."

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.2 INSTALLATION OF PATHWAYS

A. Comply with requirements in Section 270528 "Pathways for Communications Systems." for installation of conduits and wireways.

B. Install manufactured conduit sweeps and long-radius elbows whenever possible.

3.3 INSTALLATION OF CABLES

A. Comply with NECA 1.

B. General Cable Installation Requirements:

1. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at outlets and terminals.
2. Splices, Taps, and Terminations: Arrange on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Cables may not be spliced.
3. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
4. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
5. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
6. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used.

C. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend speaker cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceiling by cable supports not more than 60 inches (1524 mm) apart.
3. Cable shall not be run through structural members or be in contact with pipes, ducts, or other potentially damaging items.

D. Separation of Wires: Separate speaker-microphone, line-level, speaker-level, and power wiring runs. Install in separate pathways or, where exposed or in same enclosure, separate conductors at least 12 inches (300 mm) apart for speaker microphones and adjacent parallel power and telephone wiring. Separate other communication equipment conductors as recommended by equipment manufacturer.

3.4 INSTALLATION

A. Coordinate layout and installation of system components and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

B. Match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.

C. Identification of Conductors and Cables: Color-code conductors and apply wire and cable marking tape to designate wires and cables so they identify media in coordination with system wiring diagrams.

D. Equipment Cabinets and Racks:

1. Group items of same function together, either vertically or side by side, and arrange controls symmetrically. Mount monitor panel above the amplifiers.
2. Arrange all inputs, outputs, interconnections, and test points so they are accessible at rear of rack for maintenance and testing, with each item removable from rack without disturbing other items or connections.
3. Blank Panels: Cover empty space in equipment racks so entire front of rack is occupied by panels.

E. Wall-Mounted Outlets: Flush mounted.

F. Floor-Mounted Outlets: Conceal in floor and install cable nozzles through outlet covers. Secure outlet covers in place. Trim with carpet in carpeted areas.

G. Conductor Sizing: Unless otherwise indicated, size speaker circuit conductors from racks to loudspeaker outlets not smaller than No. 18 AWG and conductors from microphone receptacles to amplifiers not smaller than No. 22 AWG.

H. Weatherproof Equipment: For units that are mounted outdoors, in damp locations, or where exposed to weather, install consistent with requirements of weatherproof rating.

I. Speaker-Line Matching Transformer Connections: Make initial connections using tap settings indicated on Drawings.

J. Connect wiring according to Section 271500 "Communications Horizontal Cabling" and Section 280513 "Conductors and Cables for Electronic Safety and Security."

3.5 GROUNDING

A. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

B. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding.

C. Install grounding electrodes as specified in Section 270526 "Grounding and Bonding for Communications Systems."

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Schedule tests with at least seven days' advance notice of test performance.
2. After installing public address system and after electrical circuitry has been energized, test for compliance with requirements.
3. Operational Test: Perform tests that include originating program and page messages at microphone outlets, preamplifier program inputs, and other inputs. Verify proper routing and volume levels and that system is free of noise and distortion.
4. Acoustic Coverage Test: Feed pink noise into system using octaves centered at 500 and 4000 Hz. Use sound-level meter with octave-band filters to measure level at five locations in each zone. For spaces with seated audiences, maximum permissible variation in level is plus or minus 2 dB. In addition, the levels between locations in same zone and between locations in adjacent zones must not vary more than plus or minus 3 dB.
5. Power Output Test: Measure electrical power output of each power amplifier at normal gain settings of 50, 1000, and 12,000 Hz. Maximum variation in power output at these frequencies must not exceed plus or minus 1 dB.

C. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified. Prepare a list of final tap settings of paging speaker-line matching transformers.

D. Public address system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

1. Include a record of final speaker-line matching transformer-tap settings and signal ground-resistance measurement certified by Installer.

3.7 ADJUSTING

A. On-Site Assistance: Engage a factory-authorized service representative to provide on-site assistance in adjusting sound levels, resetting transformer taps, and adjusting controls to meet occupancy conditions.

END OF SECTION 275116

SECTION 275119.11 - SOUND MASKING SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Zoned sound-masking systems.
2. Local sound-masking systems.
3. Spot sound-masking system.
4. Wire and cable.

1.2 DEFINITIONS

A. Covered Spaces: Spaces above which masking loudspeakers are installed.

B. Spatial Uniformity: A condition where the sound-pressure levels throughout a defined space do not vary significantly from the arithmetic mean sound-pressure level. The amount of allowable variation is specified by others, such as a consultant, designer, or owner.

C. Temporal Uniformity: At a given position, a condition where the average sound-pressure level measured over a short time interval does not differ significantly from the average sound-pressure level measured over a long time interval. The amount of allowable variation is specified by others, such as a consultant, designer, or owner.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For sound-masking systems.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer, manufacturer and testing agency as directed.

B. Seismic Qualification Data: Certificates, for sound-masking equipment, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

B. Software and Firmware Operational Documentation:

1. Inventory of system components, with model and serial numbers for each.
2. Software operating and upgrade manuals.
3. Program Software and System Settings Backup: On digital media complete with data files.
4. Device address list.
5. Printout of software application and graphic screens.

1.6 WARRANTY

A. Manufacturer's Special Warranty: Manufacturer agrees to repair or replace sound-masking loudspeaker control units and loudspeakers that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Sound-masking equipment shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the controller will remain in place without separation of any parts when subjected to the seismic forces specified.
2. Component Importance Factor: 1.0.

B. Comply with UL 813.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Compliance Standard: Fabricate and label electronic components to comply with UL 60065 or UL 1419.

E. Wire, cable, devices, and assemblies installed in air-handling spaces shall be plenum rated, complying with NFPA 70 requirements for rate of heat-release and smoke-release characteristics. Tests for these requirements shall be according to UL 2043.

2.2 ZONED SOUND-MASKING SYSTEM

A. Description: Zoned, sound-masking, paging system, with central digital control of settings for each zone. Each zone consists of one sound-masking loudspeaker control unit with a maximum of three speakers.

B. Standard: Comply with ASTM E1374.

C. Sound-Masking Loudspeaker Control Unit:

1. Plenum mounted, coupled to the sound-masking loudspeaker, as indicated on Drawings.
2. Mounted inside sound-masking loudspeaker enclosure.
3. Power Supply: NFPA 70, Class 2.
4. Masking-Sound Generator: Digital, solid-state, random sequence noise generator, stable in sound spectrum and output level.

    a. Electronic sound and equalizers for shaping the masking-sound spectrum, complying with ASTM E1374.
    b. Masking Sound: 125 Hz to 8 kHz, with equalizers for adjusting the masking-sound spectrum at third-octave resolution.
    c. Masking-Sound Volume Adjustment: At least 10 steps at 1.5 dB each, or a continuous adjustment with that range.
    d. Provision for the connection of three slave loudspeakers.

5. Paging: Volume control and line-matching transformer that is compatible with the paging panel.

D. Sound-Masking Loudspeakers: Connected to a loudspeaker control unit.

1. Cone Type: 8 inches (200 mm) in diameter with 1-inch (25-mm) voice coil and minimum 5-oz. (142-g) ceramic magnet, mounted in an acoustic enclosure.

    a. For plenum mounting, arrange units for upward dispersion, suspended from the building structure above the ceiling; adjustable, not less than 20 inches (510 mm) from finished ceiling.
    b. For flush-with-ceiling mounting, arrange units for downward dispersion and equip with a perforated grill and accessories required for mounting in the suspended ceiling system.

2. Rated Output Level: 10 W.
3. Dispersion Angle: 100 degrees.
4. Sensitivity: 90-dB sound-pressure level (SPL) at 1 W/m on the reference axis.
5. Audio Output: 87 dBA, maximum for both masking sound and paging/music.
6. Frequency Response: Plus or minus 3 dB from 90 to 10,000 Hz.
7. Terminals for sound signal extension to slave loudspeakers.

E. Slave Sound-Masking Loudspeakers: Used to extend the audio broadcast of the sound-masking loudspeaker, meeting the same specification as for the sound-masking loudspeakers, except the connection is to a sound-masking loudspeaker, not to the sound-masking loudspeaker control unit.

F. Paging Panel: To distribute paging messages to sound-masking loudspeakers.

1. Groups: The paging panel shall provide for assigning each zone to a paging group. Controls for a group shall include the following:

a. Volume control.
b. Bass and treble controls.
c. Mute switch.

2. Sources:

a. Telephone:

1) Input Impedance: 600 ohms.
2) Input Level: 10 V maximum.
3) Input Sensitivity: 300 mV for maximum output.
4) Gain, Maximum: 20 dB, adjustable in 20 one-dB steps.
5) Frequency Response: 20 to 10,000 Hz.

b. Auxiliary:

1) Input Impedance: 100 kohms.
2) Input Level: 10 V maximum.
3) Input Sensitivity: 300 mV for maximum output.
4) Gain Maximum: 20 dB, adjustable in 20 one-dB steps.
5) Frequency Response: 20 to 10,000 Hz.

c. Microphone:

1) Input Impedance: 600 ohm.
2) Input Level: 30 mV maximum.
3) Input Sensitivity: 1 mV for maximum output.
4) Gain, Maximum: 70 dB, adjustable in 20 one-dB steps.
5) Frequency Response: 20 to 10,000 Hz.

3. Amplifier:

a. Output Power: 70.7-V balanced line.
b. Size, Minimum: 80 percent of the sum of wattage settings of connected for each loudspeaker, plus an allowance for future expansion of 25 percent.
c. Total Harmonic Distortion: Less than 3 percent at rated power output, from 50 to 12,000 Hz.
d. Minimum Signal-to-Noise Ratio: 80 dB, at rated output.
e. Frequency Response: Within plus or minus 3 dB from 50 to 12,000 Hz.
f. Output Regulation: Less than 2 dB from full to no load.
g. Controls: On-off, input levels, and low-cut filter.

4. Enclosure: Modular wall cabinet; all connections and adjustments shall be within the locked enclosure.

    a. Manufacturer's standard, baked-polyester powder-coat finish.
    b. Lockable piano-hinged doors.

5. Panel Power:

    a. Circuit Breaker and Thermal Fusing: When protection is lost, circuit opens and cannot be reset.
    b. Circuit Breaker and Thermal Fusing: Unit continues to supply power if protection is lost.
    c. Rocker-type on-off switch, illuminated when in on position.
    d. Surge Protection:

        1) Peak Single-Impulse Surge Current Rating: 33, 26 or 13 kA per phase as directed.
        2) Protection modes shall be line to neutral, line to ground, and neutral to ground. UL 1449 clamping voltage for all three modes shall be not more than 330 V.

6. Program Clock: Timer to adjust sound-masking volume of a group of zones according to a programmed schedule, allowing any zone to be assigned to a time channel.

    a. 2 channels.
    b. Unique schedule for each day of the week.
    c. Master Volume Control: 10 dBA for each channel.
    d. Ramp-up program for initial installation, on a user-defined schedule for 15 days in user-selected increments of 0.5 dBA or 1 dBA.

2.3 LOCAL SOUND-MASKING SYSTEM

A. Description: Local, single-zone sound-masking and paging system, consisting of a control unit and loudspeakers.

B. Standard: Comply with ASTM E1374.

C. Control Unit: Includes masking-sound generator, paging equipment, amplifiers, and constant 70.7-V cabling to the loudspeakers.

1. Power Supply: NFPA 70, Class 2.
2. Masking Sound Generator: Digital, solid-state, random sequence noise generator, stable in sound spectrum and output level, and containing the following:

    a. Electronic sound generator and equalizers for shaping the masking-sound spectrum.
    b. Masking Sound: 125 Hz to 8 kHz, with equalizers for adjusting the masking-sound spectrum at third-octave resolution.
    c. Masking-Sound Volume Adjustment: At least 10 steps at 1.5 dB each, or a continuous adjustment with that range.

3. Paging System: Preamplifiers and amplifier to distribute paging messages to sound-masking loudspeakers.

    a. Controls:

        1) Volume control.
        2) Bass and treble controls.

    b. Sources:

        1) Telephone:

            a) Input Impedance: 600 ohms.
            b) Input Level: 10 V maximum.
            c) Input Sensitivity: 300 mV for maximum output.
            d) Gain, Maximum: 20 dB, adjustable in 20 one-dB steps.
            e) Frequency Response: 20 to 10,000 Hz.

        2) Auxiliary:

            a) Input Impedance: 100 kohms.
            b) Input Level: 10 V maximum.
            c) Input Sensitivity: 300 mV for maximum output.
            d) Gain, Maximum: 20 dB, adjustable in 20 one-dB steps.
            e) Frequency Response: 20 to 10,000 Hz.

        3) Microphone:

            a) Input Impedance: 600 ohms.
            b) Input Level: 30 mV maximum.
            c) Input Sensitivity: 1 mV for maximum output.
            d) Gain, Maximum: 70 dB, adjustable in 20 one-dB steps.
            e) Frequency Response: 20 to 10,000 Hz.

4. Amplifier shall have a 70.7-V constant voltage output to the loudspeakers. Size the amplifier to allow for 25 percent system expansion and transformer wattage tap adjustments.

D. Sound-Masking Loudspeakers: Connected to the control unit.

1. For plenum mounting, arrange units for upward dispersion, suspended from the building structure above the ceiling; adjustable, not less than 20 inches (510 mm) from finished ceiling.
2. For flush-with-ceiling mounting, arrange units for downward dispersion and equip with a perforated grill and accessories required for mounting in the suspended ceiling system.
3. Cone Type: 8 inches (200 mm) in diameter with 1-inch (25-mm) voice coil and minimum 5-oz. (142-g) ceramic magnet, mounted in an acoustic enclosure.
4. Cone Type: 5 inches (60 mm) in diameter with 1-inch (25-mm) voice coil and minimum 10-oz. (280-g) ceramic magnet, mounted in an acoustic enclosure.
5. Impedance: 16 ohms.
6. Rated Output Level: 10 W root mean square (rms).

7. Dispersion Angle: 100 degrees.
8. Sensitivity: 90-dB sound-pressure level (SPL) at 1 W/m on the reference axis.
9. Audio Output: 87 dBA, maximum.
10. Frequency Response: Plus or minus 3 dB from 90 to 10,000 Hz.
11. Line-Matching Transformer: 70.7 V, with power taps for 0.5, 1, 2, and 5 watts.

2.4 SPOT SOUND-MASKING SYSTEM

A. Description: Single, self-contained, plenum-mounted loudspeaker with sound-masking generator and associated controls.

B. Standard: Comply with ASTM E1374.

1. Power Supply: NFPA 70, Class 2.
2. House loudspeaker and controls shall be in a metal acoustic enclosure.

    a. For plenum mounting, arrange units for upward dispersion, suspended from the building structure above the ceiling; adjustable, not less than 20 inches (510 mm) from finished ceiling.
    b. For flush-with-ceiling mounting, arrange units for downward dispersion and equip with a perforated grill and accessories required for mounting in the suspended ceiling system.

3. Masking Sound: Digital, random sequence, white noise generator, electronic sound amplifier and filters for adjusting the sound spectrum.

    a. Masking Sound: 125 Hz to 8 kHz, with equalizer for adjusting the masking-sound spectrum at third-octave resolution.
    b. Masking-Sound Volume Adjustment: At least 10 steps, plus a continuous adjustment.

4. Loudspeaker:

    a. Cone Type: 8 inches (200 mm) in diameter with 1-inch (25-mm) voice coil and minimum 5-oz. (142-g) ceramic magnet, mounted in an acoustic enclosure.
    b. Cone Type: 5 inches (60 mm) in diameter with 1 inch (25 mm) voice coil and minimum 10 oz. (280 g) ceramic magnet, mounted in an acoustic enclosure.
    c. Impedance: 16 ohms.
    d. Rated Output Level: 10 W rms.
    e. Dispersion Angle: 100 degrees.
    f. Sensitivity: 90-dB sound-pressure level (SPL) at 1 W/m on the reference axis.
    g. Audio Output: 87 dBA, maximum for both masking sound and paging/music audio signals.
    h. Frequency Response: Plus or minus 3 dB from 90 to 10,000 Hz.

2.5 WIRE AND CABLE

A. Comply with Section 271513 "Communications Copper Horizontal Cabling" for balanced twisted pair cabling.

B. Category 5e Twisted Pair Cable: Four-pair, balanced-twisted pair cable, certified to comply with transmission characteristics of Category 5e cable at frequencies of up to 100 MHz.
   1. 100-ohm, 24 AWG solid copper.
   2. Riser or Plenum rated as directed.

C. Twisted Pair Cable Hardware: Hardware designed to connect, splice, and terminate twisted pair copper communications cable.
   1. Comply with the performance requirements of Category 5e.
   2. Comply with TIA-568-C.2, Type IDC, with modules designed for punch-down caps or tools.
   3. Cables shall be terminated with connecting hardware of same category or higher.

D. Loudspeaker Wire and Cables:

   1. Plenum-Rated Paired Cable: NFPA 70, Type CMP.

      a. One pair, twisted, No. 16 AWG, stranded (19x29) or No. 18 AWG, stranded (19x30) tinned-copper conductors as directed.
      b. PVC insulation.
      c. Unshielded.
      d. PVC jacket.
      e. Flame Resistance: Comply with NFPA 262.

E. Control-Circuit Conductors:

   1. Class 2 Control Circuits: Stranded copper, Type THHN/THWN-2, complying with UL 83 in raceway.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Loudspeaker Assemblies: Suspend with chains from building structure above ceilings, so bottom of assembly is 6 to 8 inches (150 to 200 mm) above upper plane of finished ceiling material.

C. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

   1. Install plenum cable in environmental air spaces, including plenum ceilings.
   2. Comply with requirements for raceways and boxes specified in Section 260533 "Raceway and Boxes for Electrical Systems."

3. Comply with requirements in Section 271513 "Communications Copper Horizontal Cabling."

D. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

E. Grounding: As recommended by manufacturers unless more stringent requirements are indicated. Ground equipment and conductors to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments with a maximum of 5 ohms to ground at main equipment location. Measure, record, and report ground resistance.

F. Impedance Matching: For system components, including connecting cable, provide end-to-end level and impedance-matched signal paths. Use matching networks and balancing devices at connections where necessary to avoid mismatches.

G. Splices, Taps, and Terminations: Make splices, taps, and terminations on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.2 IDENTIFICATION

A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operational Test: Start system to confirm proper operation. Remove malfunctioning units, replace with new units, and retest. Make initial sound-spectrum and -level adjustments for each zone.
2. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.
3. Masking Sound-Power Level Adjustments: Adjust independently for each space to minimum level between 40 or 47 and 50 dBA that will provide speech privacy between adjacent workstations while complying with other system requirements as directed.

B. Final Acceptance Testing: Provide a minimum of 10 days' notice of acceptance test performance schedule.

1. Perform sound-masking evaluation tests according to ASTM E1130 or ASTM E1573, with measurements and calculations according to ANSI S3.5 as directed. Report test results in accordance with the requirements in ASTM E1130 or ASTM E1573 as directed.
2. Tests and Calibration Conditions: Spaces shall be completely furnished but unoccupied; lights and HVAC systems shall be on; HVAC system testing and balancing shall be completed; and electronic ballasts, lighting relay panels, and low-voltage transformers shall be in place.
3. Test Conditions: Complying with ASTM E1130 and calculated according to ANSI S3.5.

4. Instrumentation: Use a professional-quality, sound-level meter with octave-band filters and documentation of recent calibration against recognized standards. Comply with ANSI S1.4-1
5. Record test observations, readings, and corrective actions.
6. System Tests: Include for each system zone.

    a. Loudspeaker Circuit Impedance Test: Measure impedance at 1000 Hz with amplifier disconnected.
    b. Ambient Sound-Level Tests: With system off, measure ambient sound level in one-third octave bands.
    c. Amplifier Noise Test: Check for performance with masking-noise generator off and amplifiers on.
    d. System Noise Test: With masking-noise signal on and amplifiers adjusted at a working level 10 dB above ambient sound level.
    e. Spatial Uniformity Test: Measure sound level at locations no greater than 15 feet (4.6 m) o.c. throughout covered spaces.
    f. Frequency Response Adjustment and Test: Adjust one-third octave frequency bands and other unit filters to provide response. Comply with ANSI S3.2, CTA 426, and ASTM E1110.

7. Adjust level of masking sound that is appropriate for the area and the overall volume.
8. Where required, space shall comply with HIPPA (45 CFR, Parts 160 and 164) for privacy.
9. Where required, space shall comply with the Gramm-Leach Bliley Act (15 U.S.C. 6801-6809) to protect consumer personal and financial information in open office layouts.

C. Recording Control Settings and System Adjustments: Record final control settings and programming, and final tap setting of loudspeaker-matching transformers. Record final sound-level measurements and observations.

3.4 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain services as directed.

END OF SECTION 275119.11

SECTION 275123.20 - COMMERCIAL INTERCOMMUNICATIONS AND PROGRAM SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes intercommunications and program systems with the following components:

1. Master stations.
2. Speaker-microphone stations.
3. Call-switch unit.
4. Intercommunication amplifier.
5. Loudspeakers/speaker microphones.
6. Conductors and cables.
7. Raceways.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For intercommunications and program systems.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:

1. Reflected ceiling plans, drawn to scale, on which ceiling-mounted items including luminaires, diffusers, grilles, speakers, sprinklers, access panels, and special moldings are shown and coordinated with each other, using input from installers of the items involved.
2. Elevation drawings, drawn to scale, on which wall-mounted items including luminaires, intercommunications components, windows, doors, access panels, wall finishes, trims, piping, and conduit are shown and coordinated with each other, using input from installers of the items involved.

B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On USB media or compact disk, complete with data files.
3. Device address list.

4. Printout of software application and graphic screens.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 SYSTEM DESCRIPTION

A. Equipment: Modular, using solid-state components, fully rated for continuous duty unless otherwise indicated. Select equipment for normal operation on input power supplied at 110 to 130 V, 60 Hz without requirement of any external power conditioning equipment.

B. Expansion Capability: Increase number of stations in the future by 25 percent above those indicated without adding any internal or external components or main backbone cable conductors.

C. Integration: Coordinate features and select components to form an integrated system. Match components and interconnections for optimum performance of specified functions.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

2.3 FUNCTIONAL DESCRIPTION OF MANUALLY SWITCHED SYSTEMS

A. Master Station:

1. Communicating selectively with other master and speaker-microphone stations by actuation of selector switches.
2. Communicating with individual stations in privacy.
3. Include other master-station connections in a multiple-station conference call.
4. Conversation override by a designated master station.
5. Remote door lock and access control function.

B. Speaker-Microphone Station:

1. Remote Monitoring: Initiated without a warning tone signal at monitored station. Designated speaker-microphone stations shall have a privacy switch to prevent another station from listening and to permit incoming calls.
2. Hands-free communication.
3. Calling master station by actuation of call switch.
4. Returns a busy signal to indicate that master station is already in use.
5. Free of noise and distortion during operation and when in standby mode.

6. Embedded HID or Weigand-formatted, proximity-type, access control card reader as directed.
7. Remote door lock and access control function, controlled by master station.

2.4 FUNCTIONAL DESCRIPTION OF MICROPROCESSOR-SWITCHED SYSTEMS

A. Master Station:

1. Communicating selectively with other master and speaker-microphone stations by dialing station's number on a 12-digit keypad.
2. Communicating with individual stations in privacy.
3. Include other master-station connections in a multiple-station conference call.
4. Access separate paging speakers or groups of paging speakers by dialing designated numbers on a 12-digit keypad.
5. Override any conversation by a designated master station.
6. Display selected station.
7. Remote door lock and access control function.

B. Speaker-Microphone Station:

1. Remote Monitoring: Initiated without a warning tone signal at monitored station. Designated speaker-microphone stations have a privacy switch to prevent another station from listening and to permit incoming calls.
2. Hands-free communication.
3. Calling master station by actuation of call switch.
4. Return a busy signal to indicate that station is already in use.
5. Free of noise and distortion during operation and when in standby mode.

2.5 MASTER STATION FOR MANUALLY SWITCHED SYSTEMS

A. Station-Selector and Talk-Listen Switches: Heavy-duty type with gold-plated contacts rated for five million operations.

B. Volume Control: Regulates incoming-call volume.

C. LED Annunciation: Identifies calling stations and stations in use. LED remains on until call is answered.

D. Tone Annunciation: Momentary audible tone signal announces incoming calls.

E. Speaker Microphone: Transmits and receives calls.

F. Handset with Hook Switch: Telephone type with 18-inch- (450-mm-) long, permanently coiled cord. Arrange to disconnect speaker when handset is lifted.

G. Equipment Cabinet: Comply with ECA/EIA-310-E. Lockable, ventilated metal cabinet houses terminal strips, power supplies, amplifiers, system volume control, and auxiliary equipment.

2.6 MASTER STATION FOR MICROPROCESSOR-SWITCHED SYSTEMS

A. 12-Digit Keypad Selector: Transmits calls to other stations and initiates commands for programming and operation.

B. Volume Control: Regulates incoming-call volume.

C. LED Annunciation: Identifies calling stations and stations in use. LED remains on until call is answered.

D. Tone Annunciation: Momentary audible tone signal announces incoming calls.

E. Handset with Hook Switch: Telephone type with 18-inch- (450-mm-) long, permanently coiled cord. Arrange to disconnect speaker when handset is lifted.

F. Reset Control: Cancels call and resets system for next call.

G. Equipment Cabinet: Comply with ECA/EIA-310-E. Lockable, ventilated metal cabinet houses terminal strips, power supplies, amplifiers, system volume control, and other switching and control devices required for conversation channels and control functions.

2.7 SPEAKER-MICROPHONE STATIONS

A. Mounting: Flush unless otherwise indicated, and suitable for mounting conditions indicated.

B. Faceplate: Stainless steel or anodized aluminum with tamperproof mounting screws.

C. Back Box: Two-gang galvanized steel with 2-1/2-inch (64-mm) minimum depth.

D. Speaker: 3 inches (76 mm), 2.3 oz. (65 g) minimum; permanent magnet.

E. Tone Annunciation: Recurring momentary tone indicates incoming calls.

F. Call Switch: Mount on faceplate. Permits calls to master station.

G. Privacy Switch: Mount on faceplate. When in on position, switch prevents transmission of sound from remote station to system; when in off position, without further switch manipulation, response can be made to incoming calls.

H. Handset with Hook Switch: Telephone type with 18-inch- (450-mm-) long, permanently coiled cord. Arrange to disconnect speaker when handset is lifted.

2.8 CALL-SWITCH UNIT

A. Enclosure: Single-gang box with stainless-steel faceplate.

B. Call Switch: Momentary contact signals system that a call has been placed.

C. Privacy Switch: Prevents transmission of sound signals from station to system.

D. Volume Control: Operated by screwdriver blade through a hole in faceplate to adjust output level of associated speaker.

E. Handset with Hook Switch: Telephone type with 18-inch- (450-mm-) long, permanently coiled cord. Arrange to disconnect speaker when handset is lifted.

2.9 INTERCOMMUNICATION AMPLIFIER

A. Minimum Output Power: 2 W; adequate for all functions.

B. Total Harmonic Distortion: Less than 5 percent at rated output power with load equivalent to one station connected to output terminals.

C. Minimum Signal-to-Noise Ratio: 45 dB, at rated output.

D. Frequency Response: Within plus or minus 3 dB from 70 to 10,000 Hz.

E. Output Regulation: Maintains output level within 2 dB from full to no load.

F. Input Sensitivity: Matched to input circuit and to provide full-rated output with sound-pressure level of less than 10 dynes/sq. cm impinging on master stations, speaker microphones, or handset transmitters.

G. Amplifier Protection: Prevents damage from shorted or open output.

2.10 CONE-TYPE LOUDSPEAKERS

A. Minimum Axial Sensitivity: 91 dB at 3 feet (1 m), with 1-W input.

B. Frequency Response: Within plus or minus 3 dB from 70 to 15,000 Hz.

C. Minimum Dispersion Angle: 100 degrees.

D. Line Transformer: Maximum insertion loss of 0.5 dB, power rating equal to speaker's, and at least four level taps.

E. Enclosures: Steel housings or back boxes, acoustically dampened, with front face of at least 0.0478-inch (1.2-mm) steel and whole assembly rust proofed and factory primed; complete with mounting assembly and suitable for surface ceiling, flush ceiling, pendant, or wall mounting; with relief of back pressure.

F. Baffle: For flush speakers, minimum thickness of 0.032-inch (0.8-mm) aluminum brushed to a satin sheen and lacquered with textured white finish.

G. Vandal-Proof, High-Strength Baffle: For flush or surface-mounted speakers as directed, self-aging cast aluminum with tensile strength of 44,000 psi (303 MN/sq. m), 0.025-inch (0.65-mm) minimum thickness; countersunk heat-treated alloy mounting screws; and textured white epoxy finish.

H. Size: 8 inches (200 mm) with 1-inch (25-mm) voice coil and minimum 5-oz. (140-g) ceramic magnet.

2.11 HORN-TYPE LOUDSPEAKERS

A. Speakers shall be all-metal, weatherproof construction; complete with universal mounting brackets.

B. Frequency Response: Within plus or minus 3 dB from 275 to 14,000 Hz.

C. Minimum Power Rating of Driver: 15 W, continuous.

D. Minimum Dispersion Angle: 110 degrees.

E. Line Transformer: Maximum insertion loss of 0.5 dB, power rating equal to speaker's, and at least four level taps.

2.12 CONDUCTORS AND CABLES

A. Conductors: Jacketed, twisted pair and twisted multipair, untinned solid copper. Sizes as recommended by system manufacturer, but no smaller than No. 22 AWG.

B. Insulation: Thermoplastic, not less than 1/32 inch (0.8 mm) thick.

C. Shielding: For speaker-microphone leads and elsewhere where recommended by manufacturer; No. 34 AWG, tinned, soft-copper strands formed into a braid or equivalent foil.

1. Minimum Shielding Coverage on Conductors: 60 percent.

D. Plenum Cable: Listed and labeled for plenum installation.

2.13 RACEWAYS

A. Intercommunication and Program System Raceways and Boxes: Comply with requirements in Section 2705283 "Pathways for Communications Systems."

B. Intercommunication and Program System Raceways and Boxes: Same as required for electrical branch circuits specified in Section 270528 "Pathways for Communications Systems."

C. Outlet boxes shall be not less than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.

D. Flexible metal conduit is prohibited.

PART 3 - EXECUTION

3.1 PREPARATION

A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.

B. Comply with requirements for raceways and boxes specified in Section 270528 "Pathways for Communications Systems."

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

D. Comply with requirements in Section 270528 "Pathways for Communications Systems" for installation of conduits and wireways.

3.2 INSTALLATION OF CABLES

A. Comply with NECA 1.

B. General Requirements:

1. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at outlets and terminals.
2. Splices, Taps, and Terminations: Arrange on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Cables may not be spliced.
3. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
4. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
5. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used.

C. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunication spaces with terminating hardware and interconnection equipment.
2. Suspend cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceiling by cable supports not more than 60 inches (1524 mm) apart.
3. Cable shall not be run through structural members or be in contact with pipes, ducts, or other potentially damaging items.

D. Separation of Wires: Separate speaker-microphone, line-level, speaker-level, video, and power wiring runs. Install in separate raceways or, where exposed or in same enclosure, separate conductors at least 12 inches (300 mm) apart for speaker microphones and adjacent parallel power and telephone wiring. Separate other intercommunication equipment conductors as recommended by equipment manufacturer.

3.3 INSTALLATION

A. Match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.

B. Weatherproof Equipment: For units that are mounted outdoors, in damp locations, or where exposed to weather, install consistent with requirements of weatherproof rating.

C. Speaker-Line Matching Transformer Connections: Make initial connections using tap settings indicated on Drawings.

D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

E. Mounting of Stations: Surface mount at 54 inches (137.2 cm) above finished floor to center of station unless otherwise indicated.

3.4 GROUNDING

A. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

B. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding.

C. Install grounding electrodes as specified in Section 270526 "Grounding and Bonding for Communications Systems."

3.5 SYSTEM PROGRAMMING

A. Programming: Fully brief Owner on available programming options. Record Owner's decisions and set up initial system program. Prepare a written record of decisions, implementation methodology, and final results.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. Tests and Inspections:

1. Schedule tests with at least seven days' advance notice.

2. After installing intercommunications and program systems and after electrical circuitry has been energized, test for compliance with requirements.
3. Operational Test: Test originating station-to-station, all-call and page messages at each intercommunication station. Verify proper routing and volume levels and that system is free of noise and distortion. Test each available message path from each station on system.
4. Frequency Response Test: Determine frequency response of two transmission paths, including all-call and paging, by transmitting and recording audio tones. Minimum acceptable performance is within 3 dB from 150 to 2500 Hz.
5. Acoustic Coverage Test: Feed pink noise into system using octaves centered at 500 and 4000 Hz. Use sound-level meter with octave-band filters to measure level at three locations in each paging zone. Maximum permissible variation in level is plus or minus 3 dB; in levels between adjacent zones, plus or minus 5 dB.

C. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified. Prepare a list of final tap settings of paging speaker-line matching transformers.

D. Intercommunications and program systems will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain the intercommunications and program systems as directed.

1. Train Owner's maintenance personnel on programming equipment for starting up and shutting down, troubleshooting, servicing, and maintaining the system and equipment.

END OF SECTION 275123.20

SECTION 275123.31 – RESIDENTIAL INTERCOMMUNICATIONS AND ACCESS CONTROL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes intercommunications and access control systems with the following components:

1. Master stations.
2. Speaker-microphone stations.
3. Call-switch unit.
4. Intercommunication amplifier.
5. Speaker microphones.
6. Conductors and cables.
7. Raceways.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For intercommunications and access control systems.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:

1. Reflected ceiling plans, drawn to scale, on which ceiling-mounted items including luminaires, diffusers, grilles, speakers, sprinklers, access panels, and special moldings are shown and coordinated with each other, using input from installers of the items involved.
2. Elevation drawings, drawn to scale, on which wall-mounted items including luminaires, intercommunications components, windows, doors, access panels, wall finishes, trims, piping, and conduit are shown and coordinated with each other, using input from installers of the items involved.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On USB media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 SYSTEM DESCRIPTION

A. Equipment: Modular, using solid-state components, fully rated for continuous duty unless otherwise indicated. Select equipment for normal operation on input power supplied at 110 to 130 V, 60 Hz without requirement of any external power conditioning equipment.

B. Expansion Capability: Increase number of stations in the future by 25 percent above those indicated without adding any internal or external components or main backbone cable conductors.

C. Integration: Coordinate features and select components to form an integrated system. Match components and interconnections for optimum performance of specified functions.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

2.3 FUNCTIONAL DESCRIPTION OF MANUALLY SWITCHED SYSTEMS

A. Master Station:

1. Communicating selectively with other master and speaker-microphone stations by actuation of selector switches.
2. Communicating with individual stations in privacy.
3. Include other master-station connections in a multiple-station conference call.
4. Conversation override by a designated master station.
5. Remote door lock and access control function.

B. Speaker-Microphone Station:

1. Remote Monitoring: Initiated without a warning tone signal at monitored station. Designated speaker-microphone stations shall have a privacy switch to prevent another station from listening and to permit incoming calls.
2. Calling master station by actuation of call switch.
3. Hands-free communication.
4. Calling master station by actuation of call switch.
5. Returns a busy signal to indicate that master station is already in use or building occupant's phone is busy.
6. Free of noise and distortion during operation and when in standby mode.
7. Embedded HID or Weigand-formatted, proximity-type, access control card reader as directed.
8. Remote door lock and access control function, controlled by master station or building occupant as directed.

2.4 FUNCTIONAL DESCRIPTION OF MICROPROCESSOR-SWITCHED SYSTEMS

A. Master Station:

1. Communicating selectively with other master and speaker-microphone stations by dialing station's number on a 12-digit keypad.
2. Communicating simultaneously with all other stations by dialing a designated number on a 12-digit keypad.
3. Communicating with individual stations in privacy.
4. Include other master-station connections in a multiple-station conference call.
5. Access separate paging speakers or groups of paging speakers by dialing designated numbers on a 12-digit keypad.
6. Override any conversation by a designated master station.
7. Display selected station.
8. Remote door lock and access control function.

B. Speaker-Microphone Station:

1. Remote Monitoring: Initiated without a warning tone signal at monitored station. Designated speaker-microphone stations have a privacy switch to prevent another station from listening and to permit incoming calls.
2. Hands-free communication.
3. Calling master station by actuation of call switch.
4. Return a busy signal to indicate that station is already in use.
5. Free of noise and distortion during operation and when in standby mode.

2.5 MASTER STATION FOR MANUALLY SWITCHED SYSTEMS

A. Station-Selector and Talk-Listen Switches: Heavy-duty type with gold-plated contacts rated for five million operations.

B. Volume Control: Regulates incoming-call volume.

C. LED Annunciation: Identifies calling stations and stations in use. LED remains on until call is answered.

D. Tone Annunciation: Momentary audible tone signal announces incoming calls.

E. Speaker Microphone: Transmits and receives calls.

F. Handset with Hook Switch: Telephone type with 18-inch- (450-mm-) long, permanently coiled cord. Arrange to disconnect speaker when handset is lifted.

G. Equipment Cabinet: Comply with ECA/EIA-310-E. Lockable, ventilated metal cabinet houses terminal strips, power supplies, amplifiers, system volume control, and auxiliary equipment.

2.6 MASTER STATION FOR MICROPROCESSOR-SWITCHED SYSTEMS

A. 12-Digit Keypad Selector: Transmits calls to other stations and initiates commands for programming and operation.

B. Volume Control: Regulates incoming-call volume.

C. LED Annunciation: Identifies calling stations and stations in use. LED remains on until call is answered.

D. Tone Annunciation: Momentary audible tone signal announces incoming calls.

E. Handset with Hook Switch: Telephone type with 18-inch- (450-mm-) long, permanently coiled cord. Arrange to disconnect speaker when handset is lifted.

F. Reset Control: Cancels call and resets system for next call.

G. Equipment Cabinet: Comply with ECA/EIA-310-E. Lockable, ventilated metal cabinet houses terminal strips, power supplies, amplifiers, system volume control, and other switching and control devices required for conversation channels and control functions.

2.7 SPEAKER-MICROPHONE STATIONS

A. Mounting: Flush unless otherwise indicated, and suitable for mounting conditions indicated.

B. Faceplate: Stainless steel or anodized aluminum with tamperproof mounting screws.

C. Back Box: Two-gang galvanized steel with 2-1/2-inch (64-mm) minimum depth.

D. Speaker: 3 inches (76 mm), 2.3 oz. (65 g) minimum; permanent magnet.

E. Tone Annunciation: Recurring momentary tone indicates incoming calls.

F. Call Switch: Mount on faceplate. Permits calls to master station.

G. Privacy Switch: Mount on faceplate. When in on position, switch prevents transmission of sound from remote station to system; when in off position, without further switch manipulation, response can be made to incoming calls.

H. Handset with Hook Switch: Telephone type with 18-inch- (450-mm-) long, permanently coiled cord. Arrange to disconnect speaker when handset is lifted.

2.8 CALL-SWITCH UNIT

A. Enclosure: Single-gang box with stainless-steel faceplate.

B. Call Switch: Momentary contact signals system that a call has been placed.

C. Privacy Switch: Prevents transmission of sound signals from station to system.

D. Volume Control: Operated by screwdriver blade through a hole in faceplate to adjust output level of associated speaker.

E. Handset with Hook Switch: Telephone type with 18-inch- (450-mm-) long, permanently coiled cord. Arrange to disconnect speaker when handset is lifted.

2.9 CONDUCTORS AND CABLES

A. Conductors: Jacketed, balanced twisted pair and balanced twisted multipair, untinned solid copper. Sizes as recommended by system manufacturer, but no smaller than No. 22 AWG.

B. Insulation: Thermoplastic, not less than 1/32 inch (0.8 mm) thick.

C. Plenum Cable: Listed and labeled for plenum installation.

2.10 RACEWAYS

A. Intercommunication and Access Control System Raceways and Boxes: Comply with requirements in Section 270528 "Pathways for Communications Systems."

B. Intercommunication and Access Control System Raceways and Boxes: Comply with requirements for electrical branch circuits specified in Section 270528 "Pathways for Communications Systems."

C. Outlet boxes shall be not less than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.

D. Flexible metal conduit is prohibited.

PART 3 - EXECUTION

3.1 INSTALLATION OF CABLES

A. Comply with NECA 1.

B. General Requirements:

1. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at outlets and terminals.
2. Splices, Taps, and Terminations: Arrange on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Cables may not be spliced.
3. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
4. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.

C. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunication spaces with terminating hardware and interconnection equipment.
2. Suspend cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceiling by cable supports not more than 60 inches (1524 mm) apart.
3. Cable shall not be run through structural members or be in contact with pipes, ducts, or other potentially damaging items.

D. Separation of Wires: Separate speaker-microphone, line-level, speaker-level, video, and power wiring runs. Install in separate raceways or, where exposed or in same enclosure, separate conductors at least 12 inches (300 mm) apart for speaker microphones and adjacent parallel power and telephone wiring. Separate other intercommunication equipment conductors as recommended by equipment manufacturer.

3.2 INSTALLATION

A. Comply with requirements in Section 270528 "Pathways for Communications Systems" for installation of conduits and wireways.

B. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.

C. Match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.

D. Weatherproof Equipment: For units that are mounted outdoors, in damp locations, or where exposed to weather, install consistent with requirements of weatherproof rating.

E. Speaker-Line Matching Transformer Connections: Make initial connections using tap settings indicated on Drawings.

F. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

G. Mounting of Stations: Surface mount at 54 inches (137.2 cm) above finished floor to center of station unless otherwise indicated.

3.3 GROUNDING

A. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

B. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding.

C. Install grounding electrodes as specified in Section 270526 "Grounding and Bonding for Communications Systems."

3.4 SYSTEM PROGRAMMING

A. Programming: Fully brief Owner on available programming options. Record Owner's decisions and set up initial system program. Prepare a written record of decisions, implementation methodology, and final results.

3.5 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Schedule tests with at least seven days' advance notice.
2. After installing intercommunications and access control systems and after electrical circuitry has been energized, test for compliance with requirements.
3. Operational Test: Test originating station-to-station, all-call, and access control messages at each intercommunication station. Verify proper routing and volume levels and that system is free of noise and distortion. Test each available message path and operation from each station on system.

B. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified. Prepare a list of final tap settings of paging speaker-line matching transformers.

C. Intercommunications and access control systems will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain the intercommunications and access control systems as directed.

1. Train Owner's maintenance personnel on programming equipment for starting up and shutting down, troubleshooting, servicing, and maintaining the system and equipment.

END OF SECTION 275123.31

SECTION 275123.50 - EDUCATIONAL INTERCOMMUNICATIONS AND PROGRAM SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes microprocessor-switched intercommunications, microprocessor-switched, IP-based telephone/intercommunications and program systems with the following components:

1. Administrative console.
2. Call control console.
3. Staff and classroom telephone stations.
4. Speaker-microphone stations.
5. Call-switch unit.
6. All-call amplifier.
7. Intercommunication amplifier.
8. Loudspeakers/speaker microphones.
9. Conductors and cables.
10. Raceways.
11. Local Area Network (LAN): Expansion of existing system or Dedicated new system.

B. Related Requirements:

1. Section 260523 "Control-Voltage Electrical Power Cables" for control systems communications cables and Classes 1, 2 and 3 control cables.
2. Section 271513 "Communications Copper Horizontal Cabling" for balanced twisted-pair cabling used for voice and data circuits.

1.2 DEFINITIONS

A. FXO: Foreign eXchange Office.

B. H.323: Audio and Video Protocol.

C. SIP: Session Initiation Protocol.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For educational intercommunications and program systems.

1. Include plans, elevations, sections, and mounting or attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

3. Include scaled drawings for administrative console and speaker-microphone station, station arrangement of built-in equipment.
4. Include diagrams for power, signal, and control wiring.

    a. Identify terminals to facilitate installation, operation, and maintenance.
    b. Single-line diagram showing interconnection of components.
    c. Cabling diagram showing cable routing.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) elevations, drawn to scale, and coordinated with each other, using input from installers of the items involved.

B. Qualification Data: For Installer and testing agency

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On USB media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 SYSTEM DESCRIPTION

A. Equipment: Modular type using solid-state components, fully rated for continuous duty unless otherwise indicated. Select equipment for normal operation on input power usually supplied at 110 to 130 V, 60 Hz in a satisfactory manner without the requirement of any external power conditioning equipment. Comply with UL 813.

B. Expansion Capability: Increase number of stations in the future by 25 percent above those indicated without adding any internal or external components or main trunk cable conductors.

C. Integration: Coordinate features and select components to form an integrated system. Match components and interconnections for optimum performance of specified functions.

D. Local Area Network: The system will utilize a LAN for the connectivity of all devices and components within the facility for the transmission of electronic data. The LAN will be an expansion to the existing or a separate standalone structure in support of the intercommunication system as dictated by the project design documents.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for location and application.

F. Weather-Resistant Equipment: Listed and labeled by an NRTL for duty outdoors or in damp locations.

2.3 FUNCTIONAL DESCRIPTION OF MICROPROCESSOR-SWITCHED SYSTEMS

A. Administrative Console:

1. Communicating selectively with other administrative and speaker-microphone stations by dialing station's number on a 12-digit keypad.
2. Communicating with individual stations in privacy.
3. Communicating on a minimum of three voice channels with up to two simultaneous conversations between administrative consoles and one conversation between an administrative console and a speaker-microphone station.
4. Increasing the number of conversation channels by adding a module in central-control cabinet.
5. Include up to three other station connections in a conference call.
6. Access separate paging speakers or groups of paging speakers by dialing designated numbers on a 12-digit keypad.
7. Display indicates selected station, originating station call, all-call, zone page, normal or emergency status of call(s), and time/date.
8. Communicating simultaneously with all other stations by dialing a designated number on a 12-digit keypad.
9. Automatic control of gain to ensure constant intercom speech level.
10. Controlling simultaneous distribution of program material to various combinations of speaker-microphone stations or groups over two program channels by using keypad to control sources and distribute programs.
11. Operating and controlling class-change signals to speakers and bells by using keypad.
12. User-programmable features include the following:

    a. Station calling by room number.
    b. Room station call-in priority levels.
    c. Audible signal schedule functions.
    d. Schedule characteristics of audible signals.
    e. Call-in tone characteristic.
    f. Grouping of rooms and speakers into zones for paging and program distribution purposes.

B. Speaker-Microphone Station:

1. Remote monitoring without a warning tone signal at monitored station. Designated speaker-microphone stations have a privacy switch to prevent another station from listening and to permit incoming calls.
2. Communicating hands free.
3. Calling administrative console by actuating call switch.
4. Returning a busy signal to indicate that station is already in use.

C. Speakers: Free of noise and distortion during operation and when in standby mode.

2.4 FUNCTIONAL DESCRIPTION OF IP-BASED TELEPHONE/INTERCOMMUNICATION SYSTEMS

A. Integrated central system with the following:

1. Direct-dial, full duplex private telephone communications between all locations equipped with telephones and IP-addressable speaker-microphone. Call initiation among administrative consoles and between administrative consoles and remote stations by dialing station's number on a 12-digit keypad.
2. 16 channels for unrestricted simultaneous communications.
3. Initial system operation with administrative console and remote stations, expandable to 720 stations as directed.
4. Direct-dial, two-way amplified voice intercommunication between administrative console telephones and remote stations without use of press-to-talk or talk-listen switches.
5. Automatic queuing for intercommunication channels, with automatic call waiting.
6. Call transfer among administrative consoles.
7. Display of selected station and answering calling station by pressing a single "response button."
8. Simultaneous communication with other stations on system by dialing a designated number on a 12-digit keypad.
9. Automatic gain control to ensure constant intercom speech level.
10. Simultaneous distribution of emergency announcements to all locations equipped with speakers by dialing a predetermined code number.
11. User-selectable facility for providing selected telephone stations with dial tone for external telephone calls.
12. Assignment of speaker locations within any one or more of eight zones for zone paging or time signal reception.
13. Digital readout displays on which up to three incoming calls are displayed with additional calls stored for subsequent display.
14. Off-site diagnostics to monitor system functions, operations, and faults through a serial data port on central-control station.
15. Control of simultaneous distribution of program material to various combinations of remote stations or groups by using keypad to control sources and distribute programs.
16. User-programmable features include the following:

    a. Station calling by room number.
    b. Room station call-in priority levels.
    c. Audible signal schedule functions.
    d. Schedule characteristics of audible signals.
    e. Call-in tone characteristic.

f. Precedence among administrative consoles as destinations for incoming calls from room stations.
g. Grouping rooms and speakers into zones for paging and program distribution purposes.

B. Remote Stations:

1. Staff and Classroom Telephone Station:

a. Corded handset or hands-free speakerphone operation.
b. Capable of placing outside call.
c. Ability to transfer calls.
d. Call forwarding functions.
e. Paging and emergency call placement.
f. Speed-dial programming.
g. Programmable restrictive functions.

2. Speaker-Microphone Station:

a. Having privacy from remote monitoring without a warning tone signal at monitored station. Designated speaker-microphone stations have a privacy switch to prevent another station from listening and to permit incoming calls.
b. Communicating hands free.
c. Calling administrative console by actuating call switch.
d. Returning a busy signal to indicate that station is already in use.

C. Speakers: Free of noise and distortion during operation and when in standby mode.

2.5 ADMINISTRATIVE CONSOLE FOR MICROPROCESSOR-SWITCHED SYSTEMS

A. 12-Digit Keypad Selector: Transmits calls to other stations and initiates commands for programming and operation.

B. Volume Control: Regulates incoming-call volume.

C. Tone Annunciation: Momentary audible tone signal announces incoming calls.

D. LED Annunciation: Identifies calling stations and stations in use. LED remains on until call is answered.

E. Speaker Microphone: Transmits intercom voice signals when used via a voice-operated switch.

1. Minimum Speaker Sensitivity: 91 dB at one meter, with 1-W input.

F. Hard Buttons: To transfer and place calls on hold.

G. Reset Control: Cancels call and resets system for next call.

H. Digital Display: 16-digit alphanumeric LCD readout to register up to four three-digit station numbers.

I. Central-Equipment Cabinet: Comply with EIA/ECA-310-E. Lockable, ventilated metal cabinet houses terminal strips, power supplies, amplifiers, system volume control, and other switching and control devices required for conversation channels and control functions.

2.6 SPEAKER-MICROPHONE STATIONS

A. Mounting: Flush unless otherwise indicated, and suitable for mounting conditions indicated.

B. Faceplate: Stainless steel or anodized aluminum with tamperproof mounting screws.

C. Enclosure: Two-gang galvanized steel with 2-1/2-inch (64-mm) minimum depth.

D. Speaker: Minimum axial sensitivity shall be 91 dB at one meter, with 1-W input. Voice coil shall be not less than 3 inches (76 mm), 2.3 oz. (65 g) minimum; permanent magnet.

E. Tone Annunciation: Recurring momentary tone indicates incoming calls.

F. Call Switch: Mount on faceplate. Permits calls to administrative console.

G. Privacy Switch: Mount on faceplate. When in on position, switch prevents transmission of sound from remote station to system; when in off position, without further switch manipulation, response can be made to incoming calls.

2.7 CALL-SWITCH UNIT

A. Mounting: Flush unless otherwise indicated, and suitable for mounting conditions indicated.

B. Faceplate: Stainless steel or anodized aluminum with tamperproof mounting screws.

C. Enclosure: Single-gang box with stainless-steel faceplate.

D. Call Switch: Momentary contact signals system that a call has been placed.

E. Privacy Switch: Prevents transmission of sound signals from station to system.

F. Volume Control: Operated by screwdriver blade through a hole in faceplate to adjust output level of associated speaker.

2.8 ALL-CALL AMPLIFIER

A. Output Power: 70-V balanced line. 80 percent of the sum of wattage settings of connected for each station and speaker connected in all-call mode of operation, plus an allowance for future stations.

B. Total Harmonic Distortion: Less than 5 percent at rated output power with load equivalent to quantity of stations connected in all-call mode of operation.

C. Minimum Signal-to-Noise Ratio: 60 dB, at rated output.

D. Frequency Response: Within plus or minus 2 dB from 50 to 12,000 Hz.

E. Output Regulation: Maintains output level within 2 dB from full to no load.

F. Input Sensitivity: Compatible with administrative console and central equipment so amplifier delivers full-rated output with sound-pressure level of less than 10 dynes/sq. cm impinging on administrative console, speaker microphones, or handset transmitters.

G. Amplifier Protection: Prevents damage from shorted or open output.

2.9 INTERCOMMUNICATION AMPLIFIER

A. Minimum Output Power: 15 W; adequate for all functions.

B. Total Harmonic Distortion: Less than 5 percent at rated output power with load equivalent to one station connected to output terminals.

C. Minimum Signal-to-Noise Ratio: 50 dB, at rated output.

D. Frequency Response: Within plus or minus 3 dB from 70 to 10,000 Hz.

E. Output Regulation: Maintains output level within 2 dB from full to no load.

F. Input Sensitivity: Matched to input circuit and to provide full-rated output with sound-pressure level of less than 10 dynes/sq. cm impinging on microphones in administrative console, speaker microphones, or handset transmitters.

G. Amplifier Protection: Prevents damage from shorted or open output.

2.10 CONE-TYPE LOUDSPEAKERS/SPEAKER MICROPHONES

A. Minimum Axial Sensitivity: 91 dB at one meter, with 1-W input.

B. Frequency Response: Within plus or minus 3 dB from 70 to 15,000 Hz.

C. Minimum Dispersion Angle: 100 degrees.

D. Line Transformer: Maximum insertion loss of 0.5 dB, power rating equal to speaker's, and at least four level taps.

E. Enclosures: Steel housings or back boxes, acoustically dampened, with front face of at least 0.0478-inch (1.2-mm) steel and whole assembly rust proofed and factory primed; complete with mounting assembly and suitable for surface ceiling, flush ceiling, pendant or wall mounting; with relief of back pressure.

F. Baffle: For flush speakers, minimum thickness of 0.032-inch (0.8-mm) aluminum brushed to a satin sheen and lacquered with textured white finish.

G. Vandal-Proof, High-Strength Baffle: For flush or surface-mounted speakers, self-aging cast aluminum with tensile strength of 44,000 psi (303 MN/sq. m), 0.025-inch (0.65-mm) minimum thickness; countersunk heat-treated alloy mounting screws; and textured white epoxy finish.

H. Size: 8 inches (200 mm) with 1-inch (25-mm) voice coil and minimum 5-oz. (140-g) ceramic magnet.

2.11 HORN-TYPE LOUDSPEAKERS/SPEAKER MICROPHONES

A. Speakers shall be all-metal, weatherproof construction; complete with universal mounting brackets.

B. Frequency Response: Within plus or minus 3 dB from 275 to 14,000 Hz.

C. Minimum Power Rating of Driver: 15 W, continuous.

D. Minimum Dispersion Angle: 110 degrees.

E. Line Transformer: Maximum insertion loss of 0.5 dB, power rating equal to speaker's, and at least four level taps.

2.12 IP ADDRESSABLE MODULES

A. Modules utilized for the operation of the intercommunication and paging functions.

1. POE 802.3af compliant.
2. Support DHCP.
3. RJ45 connectivity.

B. Speaker Modules:

1. Interface with speaker and multiple call switches.
2. Capable of providing privacy function for speaker/microphone when activated.
3. Rated for installation within air plenum spaces.

2.13 CONDUCTORS AND CABLES

A. Conductors: Jacketed, twisted pair and twisted multipair, untinned solid copper. Sizes as recommended by system manufacturer, but no smaller than No. 22 AWG.

B. Insulation: Thermoplastic, not less than 1/32 inch (0.8 mm) thick.

C. Shielding: For speaker-microphone leads and elsewhere where recommended by manufacturer; No. 34 AWG, tinned, soft-copper strands formed into a braid or equivalent foil.

1. Minimum Shielding Coverage on Conductors: 60 percent.

D. Plenum Cable: Listed and labeled for plenum installation.

2.14 RACEWAYS

A. Educational Intercommunication and Program System Raceways and Boxes: Comply with requirements in Section 270528 "Pathways for Communications Systems."

B. Educational Intercommunication and Program System Raceways and Boxes: Comply with requirements for electrical branch circuits specified in Section 270528 "Pathways for Communications Systems."

1. Outlet boxes shall be not less than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.

C. Flexible metal conduit is prohibited.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Comply with requirements in Section 270528 "Pathways for Communications Systems"" for installation of conduits and wireways.

C. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters, and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.

D. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

E. General Requirements:

1. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at outlets and terminals.
2. Splices, Taps, and Terminations: Arrange on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Cables may not be spliced.
3. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
4. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
5. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
6. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used.

F. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunication spaces with terminating hardware and interconnection equipment.
2. Suspend cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceiling by cable supports not more than 60 inches (1524 mm) apart.
3. Cable shall not be run through structural members or be in contact with pipes, ducts, or other potentially damaging items.

G. Separation of Wires: Separate speaker-microphone, line-level, speaker-level, and power wiring runs. Install in separate raceways or, where exposed or in same enclosure, separate conductors at least 12 inches (300 mm) apart for speaker microphones and adjacent parallel power and telephone wiring. Separate other intercommunication equipment conductors as recommended by equipment manufacturer.

H. Match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.

I. Weatherproof Equipment: For units that are mounted outdoors, in damp locations, or where exposed to weather, install consistent with requirements of weatherproof rating.

J. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

K. Mounting of Stations: Surface mount at 54 inches (137.2 cm) above finished floor to center of station unless otherwise indicated.

3.2 GROUNDING

A. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

B. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding.

3.3 SYSTEM PROGRAMMING

A. Programming: Fully brief Owner on available programming options. Record Owner's decisions and set up initial system program. Prepare a written record of decisions, implementation methodology, and final results.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative:

B. Tests and Inspections:

1. Schedule tests with at least seven days' advance notice of test performance.

2. After installing educational intercommunications and program systems and after electrical circuitry has been energized, test for compliance with requirements.
3. Operational Test: Test originating station-to-station, all-call, and page messages at each intercommunication station. Verify proper routing and volume levels and that system is free of noise and distortion. Test each available message path from each station on system.
4. Frequency Response Test: Determine frequency response of two transmission paths, including all-call and paging, by transmitting and recording audio tones. Minimum acceptable performance is within 3 dB from 150 to 2500 Hz.
5. Signal-to-Noise Ratio Test: Measure signal-to-noise ratio of complete system at normal gain settings as follows:

    a. Disconnect speaker microphone and replace it in the circuit with a signal generator using a 1000-Hz signal. Measure signal-to-noise ratio at paging speakers.
    b. Repeat test for three speaker microphones, and one administrative console microphone, and for each separately controlled zone of paging loudspeakers.
    c. Minimum acceptable ratio is 45 dB.

6. Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 150, 200, 400, 1000, and 2500 Hz into each intercom, paging, and all-call amplifier. For each frequency, measure distortion in the paging and all-call amplifier outputs. Maximum acceptable distortion at any frequency is 5 percent total harmonics.
7. Acoustic Coverage Test: Feed pink noise into system using octaves centered at 500 and 4000 Hz. Use sound-level meter with octave-band filters to measure level at five locations in each paging zone. Maximum permissible variation in level is plus or minus 3 dB; in levels between adjacent zones, plus or minus 5 dB.
8. Power Output Test: Measure electrical power output of each paging amplifier at normal gain settings of 150, 1000, and 2500 Hz. Maximum variation in power output at these frequencies is plus or minus 3 dB.
9. Signal Ground Test: Measure and report ground resistance at system signal ground. Comply with testing requirements in Section 270526 "Grounding and Bonding for Communications Systems."

C. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified. Prepare a list of final tap settings of paging and independent room speaker-line matching transformers.

D. Educational intercommunications and program systems will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.5 ADJUSTING

A. On-Site Assistance: Engage a factory-authorized service representative to provide on-site assistance in adjusting sound levels, resetting transformer taps, and adjusting controls to meet occupancy conditions.

B. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain the educational intercommunications and program systems as directed.

1. Train Owner's maintenance personnel on programming equipment for starting up and shutting down, troubleshooting, servicing, and maintaining the system and equipment.

END OF SECTION 275123.50

SECTION 275223 - NURSE CALL/CODE BLUE SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes visual/tone nurse-call system.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Equipment cabinets.
2. Cabling diagrams.
3. Station installation details.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

B. Compatibility: System shall be capable of integration with any brand of phone system (wired or wireless), staff locating system, CCTV, and fire-alarm system.

C. Electrical Components, Devices, and Accessories: Listed and labeled according to UL 1069 as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.6 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning with Substantial Completion, provide software support for two years.

B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

PART 2 - PRODUCTS

2.1 NURSE-CALL SYSTEM GENERAL REQUIREMENTS

A. Station Zones: Able to program 256 station zones for each master station in the network with eight priority levels and addressable visual and audible annunciation of audible devices such as smoke detectors and door contacts.

B. System shall provide integrated and centralized "Code Blue" and "Staff Emergency" calls.

C. Expansion Capability: Equipment ratings, housing volume, spare keys, switches, relays, annunciator modules, terminals, and cable conductor quantities adequate to increase the number of stations in the future by 25 percent above those indicated without adding internal or external components or main trunk cable conductors.

D. Resistance to Electrostatic Discharge: System, components, and cabling, and the selection, arrangement, and connection of materials and circuits, shall be protected against damage or diminished performance when subjected to electrostatic discharges of up to 25,000 V in an environment with a relative humidity of 20 percent or less.

E. Equipment: Microprocessor, electronic, modular.

F. Master Nurse-Call Station: Programmed via a PC.

G. Wall-Mounted Component Connection Method: Components connect to system wiring in back boxes with factory-wired plug connectors.

H. Telephone Interface: Permit use of wired and wireless telephones to execute nurse-call master station functions.

I. Third-Party Pager Interface: Programmable to send tone, numeric, and alphanumeric message to pocket pagers or personal digital assistants and to use industry standard-protocol, RS-485 interface.

2.2 VISUAL/TONE NURSE-CALL SYSTEM

A. Operational Requirements:

1. Patient Station Call: Lights a steady call-placed lamp on the station, steady lamps in the zone light and corridor dome light associated with the patient's room, and steady lamps at the central annunciator and other system display devices and displays message on master

and staff/duty stations. At the same time, it sounds a programmed tone at intervals, at the respective annunciator and master and staff/duty stations. Legends at the central annunciator and master station identify the calling station.

2. Pull-Cord-Call Station Call: Flashes a call-placed lamp on the station and distinctive-color lamps in the zone light and corridor dome light and at the central annunciator and staff/duty stations. At the same time, it sounds a programmed tone at intervals, at the central annunciator and master and staff/duty stations. A legend at the master station identifies the calling station, priority as programmed, and bed identification.
3. Emergency-Call Station Call: Produces the same responses as pull-cord-call station calls except rapidly flashing red emergency digital display and tone repetition rates are more frequent, tone frequency is higher, and lamps in the zone light and corridor dome light are a different color. Indicator lamps may be extinguished and the system reset only at the calling station. Displays message on pocket pagers, sounds programmed tone on phones, and displays message on display equipped phones.
4. System Reset: Operating reset button at the originating station cancels signals associated with the call. Illuminates a green digital display on the patient station and log presence on the master station.
5. Cord-Set Removal: Initiates a patient station call when the cord set is removed from the jack in the patient station faceplate. Displays location and "cord removed" message on master station, pocket pagers, and display equipped phones. Inserting a cord-set plug or a dummy plug into the jack and operating the station reset button resets the call.
6. Patient Control Unit: Controls entertainment volume and channel selection. Nurse button on the unit initiates a patient station call. Integral speaker reproduces entertainment sound.
7. Emergency Bath Station Call: Illuminates the digital display on the emergency bath station; rapidly flashes white dome lamp; displays location, priority, and bath on master station; and sounds programmed tone on master station display equipped phones and pocket pagers.
8. Staff/Duty Station Operation: Operation shall be identified to patient station except the message staff shall display on all devices when the staff call button is activated.
9. Privacy Key Activation: When privacy key is activated on patient station, the system shall disconnect the patient station microphone and slowly flash yellow privacy digital display on the patient station. Displays "privacy" on master station when selecting this room/bed.

B. Central Annunciator:

1. Lamp type.
2. Lamp Legends: Machine lettered and legible from a distance of at least 48 inches (1200 mm) when a call is present. Legend shall identify initiating station and priority of call.
3. Power-on Indicator: Digital, or push-to-test switch.
4. Audible Signal: Electronic tone.

C. Central Equipment Cabinet:

1. Lockable metal.
2. Houses power supplies, controls, terminal strips, and other components.
3. Power-on indicator lamp.

D. Single-Patient Station: Call-placed lamp, reset push button, and polarized receptacle matching cord-set plug; mounted in a single faceplate.

E. Dual-Patient Station: Single call-placed lamp, single reset push button, and two polarized receptacles matching cord-set plug; mounted in a single faceplate.

F. Ambulatory-Patient Station: Call push-button switch, call-placed lamp, and reset push button; mounted in a single faceplate.

G. Staff/Duty Stations: A minimum of two call lamps, one for routine calls and one for emergency calls; and an audible tone signal device.

2.3 SYSTEM COMPONENTS

A. Emergency-Call Station: Locking-type push button, labeled "Push to Call Help"; reset trigger to release push button and cancel call; and call-placed lamp, mounted in a single faceplate.

B. Emergency-Bath Station:

1. Consists of a sliding, chemical-resistant, ABS red fascia marked with the word "URGENT" in bold letters.
2. Capable of being activated with nylon pull cord or by sliding the face of the unit downwards.
3. Activation of the station shall illuminate a reassurance digital display on the face of the unit in addition to notifying the master station.
4. Water resistant and able to withstand routine cleaning and chemical disinfectants.
5. Uses magnetic reed switch technology for reliability and corrosion resistance.
6. Mounts on a single-gang electrical box wire to the respective patient station or input controller.

C. Code Blue Station:

1. Consists of a sliding, chemical-resistant, ABS blue fascia marked with the word "CODE" in bold letters.
2. Capable of being activated with nylon pull cord or by sliding the face of the unit downwards.
3. Activation of the station shall illuminate a reassurance digital display on the face of the unit in addition to notifying the master station.
4. Water resistant and able to withstand routine cleaning and chemical disinfectants.
5. Uses magnetic reed switch technology for reliability and corrosion resistance.
6. Mounts on a single-gang electrical box wire to the respective patient station or input controller.

D. Staff, Emergency Station:

1. Consists of a sliding, chemical-resistant, ABS red fascia marked with the word "EMERGENCY" in bold letters.
2. Capable of being activated with nylon pull cord or by sliding the face of the unit downwards.
3. Activation of the station shall illuminate a reassurance digital display on the face of the unit in addition to notifying the master station.
4. Mounts on a single-gang electrical box wire to the input controller.

E. Pull-Cord-Call Station:

1. Pull-Down Switch: Lever-locking type, labeled "Pull Down to Call Help."
2. Reset trigger.
3. Call-placed lamp.
4. Water-resistant construction.

F. Patient Control Unit:

1. Equipped with plug and 96-inch- (2400-mm-) long white cord.
2. Ethylene oxide, sterilizable.

G. Call-Button Cord Set:

1. Plug and 72-inch (1800-mm) white cord; cord set shall be resistant to medical gas environment equipped with momentary-action, call-button switch.
2. Ethylene oxide, sterilizable.
3. Washable cord.
4. Palladium switch contacts in high-impact white housing with cord-set strain relief.
5. Attachment: Stainless-steel bed clamp with permanently attached polyester film strap.
6. Quantity: Three cord sets for every 10 patient beds.

H. Geriatric Call-Button Cord Set:

1. Plug and 72-inch (1800-mm) white cord.
2. Resistant to medical gas environment equipped with momentary-action, light-pressure switch in soft outer jacket.
3. Ethylene oxide, sterilizable.
4. Washable cord.
5. Palladium switch contacts in high-impact white housing with cord-set strain relief.
6. Attachment: Stainless-steel bed clamp with permanently attached polyester film strap.
7. Quantity: Two cord sets for every 10 patient beds.

I. Squeeze-Bulb Switch Cord Set:

1. Plug and 72-inch (1800-mm) washable tube with white cord set.
2. Resistant to medical gas environment; washable; equipped with neoprene squeeze-bulb activator, and plug-mounted, momentary contact switch.
3. Ethylene oxide, sterilizable.
4. Attachment: Stainless-steel bed clamp with permanently attached polyester film strap.
5. Quantity: Two cord sets for every 10 patient beds.

J. Breath Call Cord:

1. Flexible PVC jacketed cable and a momentary contact air-pressure sensitive switch.
2. Cord: 108 inches (2700 mm) long.
3. Include an adjustable arm for clamping and suitable for use in oxygen atmospheres.
4. Include 12 replacement straws.

K. Pillow Speakers:

1. Eight-conductor, DIN, flexible PVC jacketed cable.
2. Contain nurse-call button, volume control, speaker, and channel control in molded flame-retardant ABS housing.
3. Cord: 96 inches (2400 mm) long with sheet clip.

L. Call-Button Plug:

1. Designed to plug into patient station cord-set receptacle.
2. Button switches call circuit.
3. Two plugs for every 10 patient beds.

M. Dummy Plugs:

1. Designed to plug into patient station cord-set receptacle when call-button plug or patient cord set is not used.
2. Three plugs for every 10 patient beds.

N. Indicator Lamps: Digital type with rated life of 20 years unless otherwise indicated.

O. Station Faceplates:

1. Stainless steel, a minimum of 0.0375 inch (0.95 mm) thick.
2. Finish: Brushed.
3. Machine-engraved labeling identifies indicator lamps and controls.

P. Station Faceplates:

1. High-impact plastic.
2. Color: Beige.
3. Molded or machine-engraved labeling identifies indicator lamps and controls.

Q. Corridor Dome Lights and Zone Lights:

1. Three-lamp signal lights.
2. Lamps: Front replaceable without tools, low voltage with rated life of 7500 hours. Barriers are such that only one color is displayed at a time.
3. Lenses: Heat-resistant, shatterproof, translucent polymer that will not deform, discolor, or craze when exposed to hospital cleaning agents.
4. Filters: Two per unit, amber and red.

R. Cable:

1. Conductors: Jacketed single and multiple, twisted-pair copper cables.
2. Sizes and Types: As recommended by equipment manufacturer.
3. Cable for Use in Plenums: Listed and labeled for plenum installation.

S. Grounding Components: Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems."

2.4 SOFTWARE REQUIREMENTS

A. Telephone System Interface:

1. Permits use of wired and/or wireless telephones to execute nurse-call master station.
2. Two-way communication with patient and staff stations.
3. Two-way communication with the master nurse station.
4. "All Call," group call, and staff call paging.
5. Capable of being programmed to forward calls destined for a master nurse station to any connected telephone.
6. Telephones connected to the telephone interface shall have the same call tone ring patterns as those generated at the master nurse station.
7. Telephones having a display shall indicate the call type, priority code, and the calling station number of incoming calls.
8. Telephones shall be capable of initiating a service request for a particular patient station, logging calls on the master station's reminder list, and activating door lock mechanisms associated with a call station.
9. Capable of routine setup and configuration changes using the keypads on display telephone and/or the master station.

B. Display Telephones:

1. Digital telephones for use as mini-master nurse-call stations.
2. Digital display shall indicate the call type, priority code, and calling station number of incoming calls.
3. Ring patterns shall be identical to those generated at the master station.
4. Capable of two-way communication with patient and staff stations and the master station, and other telephones interfaced with the system.
5. Capable of placing or answering outside calls when interfaced with the facility telephone system.
6. Capable of "All Call," group call, and staff call paging and of initiating service requests, logging calls to the reminder list, and activating optional door controls.

C. Third-Party Pocket Pager Interface:

1. Equipped with a standalone pocket pager interface.
2. Connects with the facility paging system and transmit alphanumeric messages to the pocket pagers as preprogrammed in the system.

D. Statistical Software:

1. Includes a data statistical software package that stores, sorts, and analyzes activities occurring on the nurse-call system network.
2. Windows based and operated on a PC that is connected to the nurse-call system network.
3. Stores events on the PC's hard disk. Accumulation of these stored events shall make up the database that is used to generate reports and statistics.
4. Events stored by the software shall include date, day of week, time, ward, priority, and room number.
5. Capable of assigning a patient name to bed number.
6. Stored events shall include, but not be limited to, calls placed, call priority, calls cancelled at the nurse station, calls cancelled at the point of origin, regenerated calls, calls

answered, calls sent to pager interface, staff presence registration, staff presence cancellation, service request, service cancellation, and system and network error messages.

E. Data Analysis Software:

1. Capable of analyzing the stored information and generating computed analysis.
2. Analysis of the database can be conducted by specifying one, many, or all of the following parameters of the database: date, day of week, time, wards, priority, and room number.
3. Analysis shall include, but not be limited to, total number of calls placed, average call response time (from call placed to call cancellation), total number of presence registrations, average presence time in a room, total number of service requests, average response time (from audio answer to call cancellation), and average ring time (from call placed to audio answer).

F. Statistical Software Package:

1. Capable of displaying multiple calls/events on a PC monitor or on a RS-485 data-bus-driven digital display panel.
2. Calls from patient or staff stations and associated devices shall be displayed by priority. Display shall be customizable as follows:

    a. Choice of color by type of call.
    b. Choice of display size (character size).
    c. Choice of priority levels, type of events, points of origin.
    d. Identification of facility.
    e. Identification of ward.
    f. Identification of patient with specific patient information.

2.5 CONDUCTORS AND CABLES

A. Audio Cables:

1. Conductors: Jacketed, twisted-pair and twisted-multipair, untinned solid copper. Sizes as recommended by system manufacturer, but no smaller than No. 22 AWG.
2. Insulation: Thermoplastic, not less than 1/32 inch (0.8 mm) thick.
3. Minimum Shielding Coverage on Conductors: 60 percent.
4. Plenum Cable: Listed and labeled for plenum installation.

B. Data Cable and Hardware: Category 5e or Category 6 balanced twisted-pair cabling and hardware as directed. Comply with requirements in Section 271513 "Communications Copper Horizontal Cabling."

C. Power Conductors and Cables: Copper, solid, No. 20 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Power Conductors and Cables: Copper, solid, No. 20 AWG. Comply with requirements in Section 260523 "Control Voltage Electrical Power Conductors and Cables."

E. Grounding Conductors and Cables: Copper, stranded, No. 16 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

F. Grounding Conductors and Cables: Copper, stranded, No. 16 AWG. Comply with requirements in Section 260523 "Control Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Wiring Method:

1. Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used.

    a. Install plenum cable in environmental air spaces, including plenum ceilings.
    b. Conceal raceway and cables except in unfinished spaces.

2. Cable Trays: Comply with requirements in Section 270536 "Cable Trays for Communications Systems."
3. Conduit and Boxes: Comply with requirements in Section 270528 Pathways for Communications Systems. Flexible metal conduit shall not be used.

    a. Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.

B. Install cables without damaging conductors, shield, or jacket.

C. Do not bend cables, while handling or installing, to radii smaller than as recommended by manufacturer.

D. Pull cables without exceeding cable manufacturer's recommended pulling tensions.

1. Pull cables simultaneously if more than one is being installed in same raceway.
2. Use pulling compound or lubricant if necessary. Use compounds that will not damage conductor or insulation.
3. Use pulling means, including fish tape, cable, rope, and basket-weave wire or cable grips, that will not damage media or raceway.

E. Install exposed raceways and cables parallel and perpendicular to surfaces or exposed structural members and follow surface contours. Secure and support cables by straps, staples, or similar fittings designed and installed so as not to damage cables. Secure cable at intervals not

exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, or fittings.

F. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

G. Separation of Wires: Separate speaker/microphone, line-level, speaker-level, and power-wiring runs. Run in separate raceways or, if exposed or in same enclosure, provide 12-inch (300-mm) minimum separation between conductors to speaker/microphones and adjacent parallel power and telephone wiring. Provide separation as recommended by equipment manufacturer for other conductors.

H. Splices, Taps, and Terminations: Make splices, taps, and terminations on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Install terminal cabinets where there are splices, taps, or terminations for eight or more conductors.

I. Impedance and Level Matching: Carefully match input and output impedances and signal levels at signal interfaces. Provide matching networks if required.

J. Identification of Conductors and Cables: Comply with requirements in Section 270553 "Identification for Communications Systems" for cable administration, cable schedule, and cable and wire identification.

K. Equipment Identification:

1. Comply with requirements in Section 270553 "Identification for Communications Systems" for equipment labels and signs and labeling installation requirements.
2. Label stations, controls, and indications using approved consistent nomenclature.

3.2 GROUNDING

A. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other signal impairments.

B. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding except at connection to main building ground bus.

C. Grounding Provisions: Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems."

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. Schedule tests a minimum of seven days in advance.
2. Report: Submit a written record of test results.
3. Operational Test: Perform an operational system test and demonstrate proper operations, adjustment, and sensitivity of each station. Perform tests that include originating station-to-station and "All Call" messages and pages at each nurse-call station. Verify proper routing, volume levels, and freedom from noise and distortion. Test each available message path from each station on the system. Meet the following criteria:

    a. Speaker Output: 90 dB plus or minus 3 dB, 300 to 3000 Hz, reference level threshold of audibility 0 dB at 0.02 mPa of sound pressure.
    b. Gain from patient's bedside station to nurse station, with distortion less than 65 dB (plus or minus 3 dB, 300 to 3000 Hz).
    c. Signal-to-Noise Ratio: Hum and noise level at least 45 dB below full output.

4. Test Procedure:

    a. Frequency Response: Determine frequency response of two transmission paths by transmitting and recording audio tones.
    b. Signal-to-Noise Ratio: Measure the ratio of signal to noise of the complete system at normal gain settings using the following procedure: Disconnect a speaker/microphone and replace it in the circuit with a signal generator using a 1000-Hz signal. Measure the ratio of signal to noise and repeat the test for four speaker microphones.
    c. Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 300, 400, 1000, and 3000 Hz into each nurse-call equipment amplifier and measure the distortion in the amplifier output.

D. Retesting: Rectify deficiencies indicated by tests and completely retest work affected by such deficiencies at Contractor's expense. Verify, by the system test, that the total system meets these Specifications and complies with applicable standards. Report results in writing.

E. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.

F. Prepare test and inspection reports.

3.4 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sound levels and controls to suit actual occupied conditions. Provide up to three visits to Project during other-than-normal operating hours for this purpose.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train or Train Owner's maintenance personnel and caregiver staff to adjust, operate, and maintain nurse-call equipment as directed.

END OF SECTION 275223

SECTION 275313 - CLOCK SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Master clock and program control unit.
2. Secondary indicating clocks.
3. Program signal devices.
4. Clock circuit power boosters.
5. System wire and cable.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include dimensions of individual components and describe features and operating sequences, both automatic and manual.

B. Shop Drawings: For clock systems.

1. Details of seismic restraints including mounting, anchoring, and fastening devices for the system components.
2. Details of seismic strengthening of master clock enclosures or mounting racks as directed.
3. Dimensioned Outline Drawings of the Mounting Rack for the Master Clock: Show internal seismic bracing and locate center of gravity of fully equipped and assembled unit. Locate and describe mounting and anchorage provisions.

C. Delegated-Design Submittal: For the master clock and housing indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of the master clock and housing.
2. Design Calculations: Calculate requirements for selecting seismic restraints.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for the master clock, accessories, and components, from manufacturer.

B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Master clock and housing shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.2 MASTER AND SECONDARY CLOCK SYSTEM

A. System Functions and Features:

1. Supply power to remote indicating clocks except those indicated to have correction signals applied through a data circuit.
2. As directed, maintain correct synchronized time and transmit time-correction signals over dedicated system wiring from a master clock to any one or two type(s) of secondary indicating clocks, including the following:

a. Analog Synchronous Clocks: Correct for minute- and second-hand synchronization at least once each hour and for hour-hand synchronization at least once each day.
b. Digital Clocks: Test clocks automatically for synchronization with master time control at least once every hour and automatically correct those not synchronized with the time reference unit. Automatically correct clocks immediately when power is restored after an outage of power to the master clock.

3. Initiate and execute programs for scheduled automatic operation of remote devices. Include audible signal devices and visual signal devices and on and off switching of equipment and circuits.
4. Provide for manual control of programmed signal and equipment-switching circuits.
5. Communicate with remote PC for access to UTC time base and to permit programming from remote location.
6. Maintain system access security with a minimum of one level, two levels or three levels of user-access control to restrict use of system controls to authorized personnel as directed. Levels of access apply to both local access and access from a remote computer. Access to user programming and control functions is accomplished by entering a minimum three-digit code. Access levels include the following:

a. Access to review existing programs only.

b. Access to normal system operating controls.
c. Access to all user-programming and control functions.

7. Regulate system timing functions using power-line frequency, backed up for power outages by an internal battery-powered, crystal-controlled oscillator.
8. Provide for programming multiple independent event schedules into memory and running them simultaneously for different output circuits.

    a. Quantity of Programmable Schedules: As directed.
    b. Number of Weekly Events That Can Be Programmed for Each Schedule: As directed.
    c. Simultaneous operation of independent schedules shall be limited only by the number of signal-device and equipment-switching output circuits.
    d. Advance Programming for Automatic Holiday Schedule Changes: Number of schedule changes that can be programmed to suit holidays and vacations as directed, and each change may be programmed up to a year in advance to occur on any day of the calendar year.

9. Provide manually initiated or programming for automatic daylight savings time correction as directed.
10. Provide for adjustments to master clock output signals. Duration of momentary signal shall be individually programmable for each signal and equipment-control output circuit from 1 to 99 seconds. Signals shall be programmable for either on or off switching to suit equipment-operation scheduling.

2.3 MASTER CLOCK

A. Description: Microprocessor-based, software-controlled unit complying with Class A device requirements in 47 CFR 15.

1. Programming and control switches.
2. Informational Display: LED or backlit LCD type.

    a. Normally shows current time, date, and day of week display.
    b. Provides programming cues when system is being programmed.

3. Output Circuits for Power and Correction of Secondary Indicating Clocks:

    a. Wired Synchronous Clock Power-and-Correction Circuits: For analog and digital clocks; a minimum of one or two required as directed. Relay controlled.
    b. Wired Synchronous Digital Clock Power-and-Correction Circuits: One required.
    c. Existing Clock Power-and-Correction Circuit: An output circuit suitable as directed.

4. Data Output Port for Digital Secondary Clock Correction Circuit: RS485 or similar circuit for scheduled periodic correction signals.
5. Modem and PC interface software suitable for remote programming.
6. Circuits for Audible and Visual Signal Devices: Relay controlled, manually switchable, using controls on the master clock. Rated 120-V ac, five or 10 A minimum as directed. A minimum number of circuits as directed.

7. Circuits for Programmable Switching of Remote Equipment and Circuits: Relay controlled, manually switchable, using controls on the master clock. Rated 120-V ac, 5or 10 A minimum as directed. A minimum number of circuits as directed.
8. Power Supplies: Capacity for internal loads and power-and correction circuits of connected clocks.
9. Enclosure: Metal cabinet with locking front panel. When cabinet is locked, display indication shall be visible on or through front panel face. Arrange cabinet for surface, semi-recessed, or flush mounting as indicated.
10. Housing: Rack-mounting metal enclosure with display indication visible on front panel face.

    a. Reinforce mounting and attachment capable of resisting seismic forces described in Section 270548.16 "Seismic Controls for Communications Systems."

11. Battery Backup for Time Base: Lithium battery to maintain the timekeeping function and retain the programs in memory during outage of normal ac power supply for up to 10 years.

2.4 SECONDARY INDICATING CLOCKS

A. Analog Clock: Equipped with a sweep second hand. Movement shall be driven by self-starting, permanently lubricated, sealed synchronous motor equipped with a correcting solenoid actuator, or be a microprocessor-based, second impulse unit, compatible with the master clock.

B. Digital Clock: Microprocessor-controlled unit complying with Class A device requirements in 47 CFR 15, with red LED digital time display of hours and minutes, minutes, and seconds.

1. Display Height: 2-1/2-Inch (64-mm) Clock: Hour and minute numerals readable at 50 feet (15 m).
2. Display Height: 4-Inch (102-mm) Clock: Hour and minute numerals readable at 100 feet (30 m).
3. Display Format: Selectable between 12-hour with "PM" LED display and 24-hour formats.
4. Connections for Power and Correction:

    a. Wired synchronous connection to the master clock for both operating power and correction.

        1) Time-Base Backup: Internal alkaline battery shall back up internal time base to maintain timekeeping during power outages of up to six days' duration.
        2) Time-Base Backup: Internal capacitor shall back up internal time base to maintain timekeeping during power outages of up to 12 hours' duration.

    b. Correction by RS485, Ethernet, or similar data line with operating power supplied over a separate connection.
    c. Power Connection for Secondary Indicating Clocks: Plug connector or Wire pigtail or compression splice as directed.

C. Interval-Timer Clock: Digital microprocessor-controlled, 4-inch (102-mm) unit with 2-1/2-inch (64-mm), red LED digital display for hours and minutes and 1-5/16-inch (33-mm) display for seconds; a separately mounted, mode-control switch; and the following features:

1. Display Visibility: Hour and minute numerals readable at 30 feet (10 m) in normal ambient light.
2. Operating Modes:

    a. Normal: Clock operates as a regular secondary system clock, displaying corrected time in normal display configuration, selectable between 12- and 24-hour formats, with "PM" digital display for 12-hour format.
    b. Count-Down or Count-Up Timer: Selected by mode-control switch count-up and count-down positions, and capable of being preset at the mode-control station.
    c. Code Blue: Automatically selected by a signal through a wiring connection from the code-blue system. This signal captures control of the clock regardless of current mode or correction status and instantly initiates count-up operation, starting at time 00:00:00. While in this mode, other clock functions, including correction, shall run in the background. Clock shall revert to normal operating mode when the initiating-signal system is reset.

3. Mode-Selector Switch: Push-button or rotary, multi-position type, flush mounted; with start, stop, and reset capability in both count-up and count-down modes.
4. Audible tone signal: Housed in clock or mode-selector-switch box. Sounds at end of preset up or down count.

D. Secondary Indicating Clock Characteristics:

1. Clock Type: Analog or Digital as directed.
2. Face Configuration: Single or Double as directed.
3. Mounting: As directed.
4. Nominal Dimensions: As directed.
5. Casing Finish: As directed.
6. Special Environmental Conditions: As directed.
7. Dial Face Color: As directed.
8. Analog Clock Crystal: Clear glass, acrylic or polycarbonate as directed.
9. Face Color: As directed.
10. Display Height: As directed.
11. Seconds Display: Yes or No as directed.
12. Digital Clock Lens: Antiglare acrylic material.
13. Battery Backup: Yes or No as directed.
14. Interval-Timer Display: Yes or No as directed.

2.5 PROGRAM SIGNAL DEVICES

A. Bells: Heavy-duty, modular, vibrating type with the following sound-output ratings measured at 10 feet (3 m):

1. 4-Inch (100-mm) Bell: 90 dB.
2. 6-Inch (150-mm) Bell: 95 dB.

3. 10-Inch (250-mm) Bell: 104 dB.

B. Chimes: Heavy-duty, modular, vibrating chimes with polished-chrome tone bar and enamel-finished housing. Minimum sound-output rating measured at 10 feet (3 m) shall be 75 dB.

C. Clock Buzzers: Adjustable output signal device designed for mounting within clock housing or outlet box.

1. Sound-Output Rating Measured at 3 Feet (1 m): 75 dB.
2. Audible Tone Frequency: Manufacturer's standard between 120 Hz and 2 kHz.

D. Horns: Modular, adjustable-output, vibrating type with minimum full-intensity-rated sound output of 103 dB measured at 10 feet (3 m).

E. Projector Horns: As directed, Adjustable-output, vibrating type with single or double projector arranged to channel sound in the direction of the projector axis, and with minimum full-intensity-rated sound output of 104 dB measured at 10 feet (3 m).

F. Loudspeakers for audible tones.

G. Visible Signal Devices: As directed, Strobe lights with blue or yellow polycarbonate lens and xenon flash tube, with lens mounted on an aluminum faceplate and the word "Program" engraved in letters at least 1 inch (25 mm) high on lens. Lamp unit shall have a minimum rated light output of 75 candela.

H. Combination Audible and Visible Signal Devices: Factory-integrated horn and strobe light in a single mounting assembly.

I. Outdoor Signal Equipment: Weatherproof models listed for outdoor use.

J. Mounting Arrangement for Signal Devices: Designed for attachment with screws on the mounting plate of a flush-mounted back box unless otherwise indicated.

K. Enclosures for Flush-Mounting Bells and Horns: Enclosure, mounting plate, and grille assembly shall be furnished by device manufacturer to match features of the device to be mounted. Enclosure shall be recessed in wall, completely enclosing the device, with grille mounting over the open side of the enclosure and flush with the wall.

L. Connection Provision for Signal-Indicating Devices: Plug connector or Wire pigtail or compression splice as directed.

2.6 CLOCK CIRCUIT POWER BOOSTER

A. Description: Transformer power supply, mounted in steel cabinet with hinged door, and having fuse-protected input and output circuits.

2.7 BACK BOXES FOR SECONDARY INDICATING CLOCKS AND PROGRAM DEVICES

A. Description: Box and cover-plate assembly shall be furnished by device manufacturer and be suitable for device to be mounted. Back boxes shall be equipped with knockouts and hanger straps or mounting adapters arranged for flush mounting the device unless otherwise indicated.

2.8 GUARDS

A. Description: Formed-steel wire, shaped to fit around guarded device, with 1-inch (25-mm) maximum clearance.

1. Mounting Provisions: Fixed tabs, welded to guard and arranged for screw attachment to mounting surface.
2. Finish for Indoor Devices: Clear epoxy lacquer over zinc plating.
3. Finish for Outdoor Devices: Black powder coat over zinc plating and primer.

2.9 RACK-MOUNTING PROVISION FOR MASTER CLOCK

A. Equipment Cabinet: Floor or Wall-mounted, rack type as directed. Comply with EIA-310-D and the following:

1. Cabinet Housing: Constructed of steel, with front and rear doors; with manufacturer's standard tumbler locks, keyed alike.

a. Front door shall have a clear panel in front of the master clock display.
b. Housing shall enclose master clock and auxiliary clock system components, plus a minimum of 20 percent spare capacity for future equipment.

2.10 CONDUCTORS AND CABLES

A. Conductors: Jacketed, twisted pair and twisted multipair, untinned solid copper. Sizes as recommended by system manufacturer, but not smaller than No. 22 AWG. Voltage drop for signal, control, and clock correction circuits shall not exceed 10 percent under peak load conditions.

B. 120-V AC and Class 1 Signal and Control Circuits: Stranded, single conductors of size and type recommended by system manufacturer.

C. Class 2 and Class 3 Signal and Control Circuits: Single conductor or twisted-pair cable, unshielded, unless manufacturer recommends shielded cable.

D. Data Circuits: Category 6 minimum, unshielded, balanced twisted-pair cable, unless manufacturer recommends shielded cable.

E. Insulation: Thermoplastic, not less than 1/32 inch (0.8 mm) thick.

F. Plenum Cable: Listed and labeled for plenum installation.

G. Conductor Color-Coding: Uniformly identified and coordinated with wiring diagrams.

H. Shielding: For speaker-microphone leads and at other locations recommended by manufacturer; No. 34 AWG tinned, soft-copper strands formed into a braid or equivalent foil.

1. Minimum Shielding Coverage on Conductors: 60 percent.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Mount system components with fastening methods and devices designed to resist the seismic forces indicated in Section 270548.16 "Seismic Controls for Electrical Systems."

3.2 WIRING METHODS

A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

D. Support cables not enclosed in raceways on J-Hooks. Install, size, and space J-Hooks to comply with TIA/EIA-568-B.

3.3 ELECTRICAL CONNECTIONS

A. Make splices, taps, and terminations on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

B. Use plug connectors or splices for connections to clocks and signal devices as directed.

C. Ground clocks, programming equipment, and conductor and cable shields to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

3.4 IDENTIFICATION

A. Comply with Section 270553 "Identification for Electrical Systems."

B. Color-code wires, and apply wire and cable marking tape to designate wires and cables so they are uniformly identified and coordinated with wiring diagrams throughout the system.

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Perform operational-system tests to verify compliance with the Specifications and make adjustments to bring system into compliance. Include operation of all modes of clock correction and all programming and manually programmed signal and relay operating functions.
2. Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.

C. Clock system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.6 ADJUSTING

A. Program system according to Owner's requirements. Set system so signal devices operate on Owner-required schedules and are activated for durations selected by Owner. Program equipment-control output circuits to suit Owner's operating schedule for equipment controlled.

B. Adjust sound-output level of adjustable signal devices to suit Owner's requirements.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain clock-and-program-control system components as directed.

END OF SECTION 275313

SECTION 281300 - ACCESS CONTROL SOFTWARE AND DATABASE MANAGEMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Security access central-control station.
2. One or more security access networked workstations.
3. Security access operating system and application software.
4. Security access controllers connected to high-speed electronic-data transmission network.

B. Related Requirements:

1. Section 281500 "Access Control System Hardware Devices" for access control system hardware, such as keypads, card readers, and biometric identity devices.

1.3 DEFINITIONS

A. Credential: Data assigned to an entity and used to identify that entity.

B. DTS: Digital Termination Service. A microwave-based, line-of-sight communication provided directly to the end user.

C. Identifier: A credential card; keypad personal identification number; or code, biometric characteristic, or other unique identification entered as data into the entry-control database for the purpose of identifying an individual. Where this term is presented with an initial capital letter, this definition applies.

D. Location: A Location on the network having a workstation-to-controller communications link, with additional controllers at the Location connected to the workstation-to-controller link with a TIA 485-A communications loop. Where this term is presented with an initial capital letter, this definition applies.

E. Workstation: Personal computer. Applies to the central station, workstations, and file servers.

F. RAS: Remote access services.

G. RF: Radio frequency.

H. ROM: Read-only memory. ROM data are maintained through losses of power.

I. TCP/IP: Transport control protocol/Internet protocol.

J. TWAIN: Technology without an Interesting Name. A programming interface that lets a graphics application, such as an image editing program or desktop publishing program, activate a scanner, frame grabber, or other image-capturing device.

K. WMP: Windows media player.

L. Wiegand: Patented magnetic principle that uses specially treated wires embedded in the credential card.

M. WYSIWYG: What You See Is What You Get. Text and graphics appear on the screen the same as they will in print.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Reference each product to a location on Drawings. Test and evaluation data presented in Product Data shall comply with SIA BIO-01.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Diagrams for cable management system.
2. System labeling schedules, including electronic copy of labeling schedules that are part of the cable and asset identification system of the software specified in Parts 2 and 3.
3. Wiring Diagrams. For power, signal, and control wiring. Show typical wiring schematics including the following:

    a. Workstation outlets, jacks, and jack assemblies.
    b. Patch cords.
    c. Patch panels.

4. Cable Administration Drawings: As specified in "Identification" Article.
5. Battery and charger calculations for central station, workstations, and controllers.

C. Product Schedules.

D. Samples: For workstation outlets, jacks, jack assemblies, and faceplates. For each exposed product and for each color and texture specified.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For security system to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Workstation operating system documentation.
2. Workstation installation and operating documentation, manuals, and software for the workstation and all installed peripherals. Software shall include system restore, emergency boot diskettes, and drivers for all installed hardware. Provide separately for each workstation.
3. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and PDF files on USB or cloud media of the hard-copy submittal.
4. System installation and setup guides with data forms to plan and record options and setup decisions.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Laser Printers: Three toner cassettes and one replacement drum unit.
2. Credential card blanks, ready for printing. Include enough credential cards for all personnel to be enrolled at the site plus an extra 50 percent for future use.
3. Fuses of all kinds, power and electronic, equal to 10 percent of amount installed for each size used, but no fewer than three units.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers trained and approved by manufacturer.

1. Cable installer must have on staff an RCDD certified by Building Industry Consulting Service International.

B. Source Limitations: Obtain central station, workstations, controllers, Identifier readers, and all software through one source from single manufacturer.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Central Station, Workstations, and Controllers:

1. Store in temperature- and humidity-controlled environment in original manufacturer's sealed containers. Maintain ambient temperature between 50 and 85 deg F (10 and 30 deg C), and not more than 80 percent relative humidity, noncondensing.
2. Open each container; verify contents against packing list; and file copy of packing list, complete with container identification, for inclusion in operation and maintenance data.

3. Mark packing list with the same designations assigned to materials and equipment for recording in the system labeling schedules that are generated by software specified in "Cable and Asset Management Software" Article.
4. Save original manufacturer's containers and packing materials and deliver as directed, under provisions covering extra materials.

1.10 PROJECT CONDITIONS

A. Environmental Conditions: System shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

1. Control Station: Rated for continuous operation in ambient conditions of 60 to 85 deg F (16 to 30 deg C) and a relative humidity of 20 to 80 percent, noncondensing.
2. Indoor, Controlled Environment: NEMA 250, Type 1 enclosure. As directed, system components, except the central-station control unit, installed in air-conditioned or temperature-controlled indoor environments shall be rated for continuous operation in ambient conditions of 36 to 122 deg F (2 to 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing.
3. Indoor, Uncontrolled Environment: NEMA 250, Type enclosures as directed. As directed, system components installed in non-air-conditioned or non-temperature-controlled indoor environments shall be rated for continuous operation in ambient conditions of 0 to 122 deg F (minus 18 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing.
4. Outdoor Environment: NEMA 250, NEMA 250, Type enclosures as directed. System components installed in locations exposed to weather shall be rated for continuous operation in ambient conditions of minus 30 to plus 122 deg F (minus 34 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, condensing. Rate for continuous operation where exposed to rain as specified in NEMA 250, winds up to 85 mph (137 km/h) and snow cover up to 24 inches (610 mm) thick.
5. Hazardous Environment: System components located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers shall be rated, listed, and installed according to NFPA 70.
6. Corrosive Environment: For system components subjected to corrosive fumes, vapors, and wind-driven salt spray in coastal zones, provide NEMA 250, Type 4X or Type 6P enclosures as directed.

PART 2 - PRODUCTS

2.1 ACCESS CONTROL SOFTWARE

2.2 DESCRIPTION

A. Security Access System: Workstation-based central station, one or more networked workstation-based workstations, and field-installed controllers, connected by a high-speed electronic-data transmission network.

B. System Software: Based on 32 or 64-bit as directed, central-station, workstation operating system, server operating system, and application software. Software shall have the following capabilities:

1. Multiuser and multitasking to allow for independent activities and monitoring to occur simultaneously at different workstations.
2. Graphical user interface to show pull-down menus and a menu-tree format that complies with interface guidelines of the operating system.
3. System license for the entire system including capability for future additions that are within the indicated system size limits specified in this Section.
4. Open-architecture system that allows importing and exporting of data and interfacing with other systems that are compatible with operating system.
5. Password-protected operator login and access.
6. Open-database-connectivity compliant.

C. Network connecting the central station and workstations shall be a LAN or WAN as directed, using TCP/IP with a capacity of connecting up to 99 workstations. System shall be portable across multiple communication platforms without changing system software.

D. Network(s) connecting workstations and controllers shall consist of one or more of the following:

1. Local area, IEEE 802.3 Fast Ethernet Gigabit-Ethernet or 100 BASE-TX as directed, star topology network based on TCP/IP.
2. Local area, IEEE 802.11 compatible wireless mesh network, based on TCP/IP.

2.3 OPERATION

A. Security access system shall use a single database for access-control and credential-creation functions.

B. Distributed Processing: A fully distributed processing system.

1. Access-control information, including time, date, valid codes, access levels, and similar data, shall be downloaded to controllers so each controller can make access-control decisions.
2. Intermediate controllers for access control are prohibited.
3. In the event that communications with the central controller are lost, controllers shall automatically buffer event transactions until communications are restored, at which time buffered events shall be uploaded to the central station.

C. Number of Locations:

1. Support at least 32,000 separate Locations using a single workstation with combinations of direct-connect, or TCP/IP LAN connections to each Location.
2. Each Location shall have its own database and history in the central station.
3. Locations may be combined to share a common database.

D. Data Capacity:

1. 130 different card-reader formats.
2. 999 comments.
3. 48 graphic file types for importing maps.

E. Location Capacity:

1. 1024 reader-controlled doors.
2. 50,000 total-access credentials.
3. 2048 supervised alarm inputs.
4. 2048 programmable outputs.
5. 32,000 custom action messages per Location to instruct operator on action required when alarm is received.

F. System Network Requirements:

1. System components shall be interconnected and shall provide automatic communication of status changes, commands, field-initiated interrupts, and other communications required for proper system operation.
2. Communication shall not require operator initiation or response and shall return to normal after partial- or total-network interruption such as power loss or transient upset.
3. System shall automatically annunciate communication failures to the operator and shall identify the communications link that has experienced a partial or total failure.
4. Communications controller may be used as an interface between the central-station display systems and the field device network. Communications controller shall provide functions required to attain the specified network communications performance.

G. Central station shall provide operator interface, interaction, display, control, and dynamic and real-time monitoring. Central station shall control system networks to interconnect all system components, including workstations and field-installed controllers.

H. Field equipment shall include controllers, sensors, and controls.

1. Controllers shall serve as an interface between the central station and sensors and controls.
2. Data exchange between the central station and the controllers shall include down-line transmission of commands, software, and databases to controllers.
3. The up-line data exchange from the controller to the central station shall include status data such as intrusion alarms, status reports, and entry-control records.
4. Controllers are classified as alarm-annunciation or entry-control type.

I. False-Alarm Reduction: The design of the central station and controllers shall contain features to reduce false alarms. Equipment and software shall comply with SIA CP-01.

J. Error Detection:

1. Use a cyclic code method to detect single- and double-bit errors, burst errors of eight bits or fewer, and at least 99 percent of all other multibit and burst errors between controllers and the central station.
2. Interactive or product error-detection codes alone will not be acceptable.
3. A message shall be in error if one bit is received incorrectly.
4. Retransmit messages with detected errors.

5. Allow for an operator-assigned two-digit decimal number to each communications link representing the number of retransmission attempts.
6. Central station shall print a communication failure alarm message when the number of consecutive retransmission attempts equals the assigned quantity.
7. Monitor the frequency of data transmission failure for display and logging.

K. Data Line Supervision: System shall initiate an alarm in response to opening, closing, shorting, or grounding of data transmission lines.

L. Door Hardware Interface:

1. Comply with requirements in Section 087100 "Door Hardware" and Section 087111 "Door Hardware (Descriptive Specification)" for door hardware required to be monitored or controlled by the security access system.
2. Electrical characteristics of controllers shall match the signal and power requirements of door hardware.

2.4 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70, "National Electrical Code."

C. Comply with SIA DC-01 and SIA DC-03 and SIA DC-07.

2.5 APPLICATION SOFTWARE

A. System Software: Based on 32-bit, Microsoft Windows central-station and workstation operating system and application software.

1. Multiuser multitasking shall allow independent activities and monitoring to occur simultaneously at different workstations.
2. Graphical user interface shall show pull-down menus and a menu-tree format.
3. Capability for future additions within the indicated system size limits.
4. Open architecture that allows importing and exporting of data and interfacing with other systems that are compatible with operating system.
5. Password-protected operator login and access.

B. Peer Computer Control Software: Detect a failure of a central computer and cause the other central computer to assume control of all system functions without interruption of operation. Both central computers shall have drivers to support this mode of operation.

C. Application Software: Interface between the alarm annunciation and entry-control controllers to monitor sensors and DTS links, operate displays, report alarms, generate reports, and help train system operators.

1. Reside at the central station, workstations, and controllers as required to perform specified functions.

2. Operate and manage peripheral devices.
3. Manage files for disk I/O, including creating, deleting, and copying files; and automatically maintain a directory of all files, including size and location of each sequential and random-ordered record.
4. Import custom icons into graphics to represent alarms and I/O devices.
5. Globally link I/O so that any I/O can link to any other I/O within the same Location without requiring interaction with the host workstation. This operation shall be at the controller.
6. Globally code I/O links so that any access-granted event can link to any I/O with the same Location without requiring interaction with the host workstation. This operation shall be at the controller.
7. Messages from workstation to controllers and controllers to controllers shall be on a polled network that utilizes check summing and acknowledgment of each message. Communication shall be automatically verified, buffered, and retransmitted if message is not acknowledged.
8. Selectable poll frequency and message time-out settings shall handle bandwidth and latency issues for TCP/IP, RF, and other workstation-to-controller communications methods by changing the polling frequency and the amount of time the system waits for a response.
9. Automatic and encrypted backups for database and history backups shall be automatically stored at the central-control workstation or a selected workstation as directed and encrypted with a nine-character alphanumeric password that must be used to restore or read data contained in backup.
10. Operator audit trail for recording and reporting all changes made to database and system software.
11. Support network protocol and topology, TCP/IP, Novel Netware, Digital Pathworks, Banyan Vines, LAN/WAN, and RAS.

D. Workstation Software:

1. Password levels shall be individually customized at each workstation to allow or disallow operator access to program functions for each Location.
2. Workstation event filtering shall allow user to define events and alarms that will be displayed at each workstation. If an alarm is unacknowledged (not handled by another workstation) for a preset amount of time, the alarm will automatically appear on the filtered workstation.

E. Controller Software:

1. Controllers shall operate as autonomous, intelligent processing units.

    a. Controllers shall make decisions about access control, alarm monitoring, linking functions, and door-locking schedules for their operation, independent of other system components.
    b. Controllers shall be part of a fully distributed processing-control network.
    c. The portion of the database associated with a controller, and consisting of parameters, constraints, and the latest value or status of points connected to that controller, shall be maintained in the controller.

2. The following functions shall be fully implemented and operational within each controller:

a. Monitoring inputs.
b. Controlling outputs.
c. Automatically reporting alarms to the central station.
d. Reporting of sensor and output status to the central station on request.
e. Maintaining real time, automatically updated by the central station at least once a day.
f. Communicating with the central station.
g. Executing controller resident programs.
h. Diagnosing.
i. Downloading and uploading data to and from the central station.

3. Controller Operations at a Location:

a. Up to 64 controllers connected to TIA 485-A communications loop. Globally operating I/O linking and anti-passback functions between controllers within the same Location without central-station or workstation intervention. Linking and anti-passback shall remain fully functional within the same Location even when the central station or workstations are off-line.
b. In the event of communication failure between the central station and a Location, there shall be no degradation in operations at the controllers at that Location. Controllers at each Location shall be connected to a memory buffer with a capacity to store up to 10,000 events; there shall be no loss of transactions in system history files until the buffer overflows.
c. Buffered events shall be handled in a first-in-first-out mode of operation.

4. Individual Controller Operation:

a. Controllers shall transmit alarms, status changes, and other data to the central station when communications circuits are operable. If communications are not available, controllers shall function in a stand-alone mode; operational data, including the status and alarm data normally transmitted to the central station, shall be stored for later transmission to the central station. Storage capacity for the latest 1024 events shall be provided at each controller.
b. Card-reader ports of a controller shall be custom configurable for at least 120 different card-reader or keypad formats. Multiple reader or keypad formats may be used simultaneously at different controllers or within the same controller.
c. Controllers shall provide a response to card readers or keypad entries in less than 0.25 seconds, regardless of system size.
d. Controllers that are reset, or powered up from a nonpowered state, shall automatically request a parameter download and reboot to their proper working state. This shall happen without any operator intervention.
e. Initial Startup: When controllers are brought on-line, database parameters shall be automatically downloaded to them. After initial download is completed, only database changes shall be downloaded to each controller.
f. On failure for any reason, controllers shall perform an orderly shutdown and force controller outputs to a predetermined failure-mode state, consistent with the failure modes shown and the associated control device.
g. After power is restored, following a power failure, startup software shall initiate self-test diagnostic routines, after which controllers shall resume normal operation.
h. After controller failure, if the database and application software are no longer resident, controllers shall not restart but shall remain in the failure mode until

repaired. If database and application programs are resident, controllers shall immediately resume operation. If not, software shall be restored automatically from the central station.

5. Communications Monitoring:

   a. System shall monitor and report status of TIA 485-A communications loop of each Location.
   b. Communication status window shall display which controllers are currently communicating, a total count of missed polls since midnight, and which controller last missed a poll.
   c. Communication status window shall show the type of CPU, the type of I/O board, and the amount of RAM for each controller.

6. Operating systems shall include a real-time clock function that maintains seconds, minutes, hours, day, date, and month. The real-time clock shall be automatically synchronized with the central station at least once a day to plus or minus 10 seconds. The time synchronization shall be automatic, without operator action and without requiring system shutdown.

F. workstation-to-Controller Communications:

1. Central-station or workstation communications shall use the following:

   a. Direct connection using serial ports of the workstation.
   b. TCP/IP LAN interface cards.
   c. Dial-up or cable modems for connections to Locations.

2. Each serial port used for communications shall be individually configurable for "direct communications," "modem communications incoming and outgoing," or "modem communications incoming only," or as an ASCII output port. Serial ports shall have adjustable data transmission rates and shall be selectable under program control.
3. Use multiport communications board if more than two serial ports are needed.

   a. Use a 4-, 8-, or 16-serial port configuration that is expandable to 32- or 64-serial ports.
   b. Connect the first board to an internal PCI bus adapter card.

4. Direct serial, TCP/IP, and dial-up, cable, or satellite communications shall be alike in the monitoring or control of the system except for the connection that must first be made to a dial-up or voice-over IP Location.
5. TCP/IP network interface card (NIV) shall have an option to set the poll-frequency and message-response time-out settings.
6. Workstation-to-controller and controller-to-controller communications (direct, dial-up, or TCP/IP) shall use a polled-communication protocol that checks sum and acknowledges each message. All communications in this subparagraph shall be verified and buffered and retransmitted if not acknowledged.

G. Direct Serial or TCP/IP workstation-to-Controller Communications:

1. Communication software on the workstation shall supervise the workstation-to-controller communications link.
2. Loss of communications to any controller shall result in an alarm at all workstations running the communication software.
3. When communications are restored, all buffered events shall automatically upload to the workstation, and any database changes shall be automatically sent to the controller.

H. Broadband Workstation-to-Controller Communications:

1. Communication software on the workstation shall supervise the workstation-to-controller communications link during dial-up modem connect times.
2. Communication software shall be programmable to routinely poll each of the remote dial-up or cable modem Locations, collecting event logs and verifying phone lines at operator-selectable time intervals for each Location.
3. System shall be programmable for dialing and connecting to all dial-up or cable modem Locations and for retrieving the accrued history transactions on an automatic basis as often as once every 10 minutes and up to once every 9999 minutes.
4. Failure to communicate to a dial-up Location three times in a row shall result in an alarm at the workstation.
5. Time offset capabilities shall be present so that Locations in a different geographical time zone than the host workstation will be set to, and maintained at, the proper local time. This feature shall allow for geographical time zones that are ahead of or behind the host workstation.
6. The controller connected to a dial-up or cable modem shall automatically buffer all normal transactions until its buffer reaches 80 percent of capacity. When the transaction buffer reaches 80 percent, the controller shall automatically initiate a call to the central station and upload all transactions.
7. Alarms shall be reported immediately.
8. Dial-up or cable modems shall be provided by manufacturer of the system. Modems used at the controller shall be powered by the controller. Power to the modem shall include battery backup if the controller is so equipped.

I. Controller-to-Controller Communications:

1. TIA 485-A, four-wire, point-to-point, regenerative (repeater) communications network methodology.
2. TIA 485-A communications signal shall be regenerated at each controller.

J. Database Downloads:

1. All data transmissions from workstations to a Location, and between controllers at a Location, shall include a complete database checksum to check the integrity of the transmission. If the data checksum does not match, a full data download shall be automatically retransmitted.
2. If a controller is reset for any reason, it shall automatically request and receive a database download from the workstation. The download shall restore data stored at the controller to their normal working state and shall take place with no operator intervention.

K. Operator Interface:

1. Inputs in system shall have two icon representations, one for the normal state and one for the abnormal state.
2. When viewing and controlling inputs, displayed icons shall automatically change to the proper icon to display the current system state in real time. Icons shall also display the input's state, whether armed or bypassed, and if the input is in the armed or bypassed state due to a time zone or a manual command.
3. Outputs in system shall have two icon representations, one for the secure (locked) state and one for the open (unlocked) state.
4. Icons displaying status of the I/O points shall be constantly updated to show their current real-time condition without prompting by the operator.
5. The operator shall be able to scroll the list of I/Os and press the appropriate toolbar button, or right click, to command the system to perform the desired function.
6. Graphic maps or drawings containing inputs, outputs, and override groups shall include the following:

    a. Database to import and store full-color maps or drawings and allow for input, output, and override group icons to be placed on maps.
    b. Maps to provide real-time display animation and allow for control of points assigned to them.
    c. System to allow inputs, outputs, and override groups to be placed on different maps.
    d. Software to allow changing the order or priority in which maps will be displayed.

7. Override Groups Containing I/Os:

    a. System shall incorporate override groups that provide the operator with the status and control over user-defined "sets" of I/Os with a single icon.
    b. Icon shall change automatically to show the live summary status of points in that group.
    c. Override group icon shall provide a method to manually control or set to time-zone points in the group.
    d. Override group icon shall allow the expanding of the group to show icons representing the live status for each point in the group, individual control over each point, and the ability to compress the individual icons back into one summary icon.

8. Schedule Overrides of I/Os and Override Groups:

    a. To accommodate temporary schedule changes that do not fall within the holiday parameters, the operator shall have the ability to override schedules individually for each input, output, or override group.
    b. Each schedule shall be composed of a minimum of two dates with separate times for each date.
    c. The first time and date shall be assigned the override state that the point shall advance to when the time and date become current.
    d. The second time and date shall be assigned the state that the point shall return to when the time and date become current.

9. Copy command in database shall allow for like data to be copied and then edited for specific requirements, to reduce redundant data entry.

L. Operator Access Control:

1. Control operator access to system controls through three password-protected operator levels. System operators and managers with appropriate password clearances shall be able to change operator levels for operators.
2. Three successive attempts by an operator to execute functions beyond their defined level during a 24-hour period shall initiate a software tamper alarm.
3. A minimum of 1024 unique user accounts shall be available with the system software. System shall display the operator's name or initials in the console's first field. System shall print the operator's name or initials, action, date, and time on the system printer at login and logoff.
4. The password shall not be displayed or printed.
5. Each password shall be definable and assignable for the following:

    a. Selected commands to be usable.
    b. Access to system software.
    c. Access to application software.
    d. Individual zones that are to be accessed.
    e. Access to database.

M. Operator Commands:

1. Command Input: Plain-language words and acronyms shall allow operators to use the system without extensive training or data-processing backgrounds. System prompts shall be a word, a phrase, or an acronym.
2. Command inputs shall be acknowledged and processing shall start in not less than one second(s).
3. Tasks that are executed by operator's commands shall include the following:

    a. Acknowledge Alarms: Used to acknowledge that the operator has observed the alarm message.
    b. Place Zone in Access: Used to remotely disable intrusion-alarm circuits emanating from a specific zone. System shall be structured so that console operator cannot disable tamper circuits.
    c. Place Zone in Secure: Used to remotely activate intrusion-alarm circuits emanating from a specific zone.
    d. System Test: Allows the operator to initiate a system-wide operational test.
    e. Zone Test: Allows the operator to initiate an operational test for a specific zone.
    f. Print reports.
    g. Change Operator: Used for changing operators.
    h. Security Lighting Controls: Allows the operator to remotely turn on or turn off security lights.
    i. Display Graphics: Used to show any graphic displays implemented in the system. Graphic displays shall be completed within 20 seconds from time of operator command.
    j. Run system tests.
    k. Generate and format reports.
    l. Request help with the system operation.

        1) Include in main menus.
        2) Provide unique, descriptive, context-sensitive help for selections and functions with the press of one function key.
        3) Provide navigation to specific topic from within the first help window.

4) Help shall be accessible outside the application program.

m. Entry-Control Commands:

1) Lock (secure) or unlock (open) each controlled entry and exit up to four times a day through time-zone programming.
2) Arm or disarm each monitored input up to four times a day through time-zone programming.
3) Enable or disable readers or keypads up to two times a day through time-zone programming.
4) Enable or disable cards or codes up to four times a day per entry point through access-level programming.

4. Command Input Errors: Show operator input assistance when a command cannot be executed because of operator input errors. Assistance screen shall use plain-language words and phrases to explain why the command cannot be executed. Error responses that require an operator to look up a code in a manual or other document are not acceptable. Conditions causing operator assistance messages include the following:

a. Command entered is incorrect or incomplete.
b. Operator is restricted from using that command.
c. Command addresses a point that is disabled or out of service.
d. Command addresses a point that does not exist.
e. Command is outside the system's capacity.

N. Alarms:

1. System Setup:

a. Assign manual and automatic responses to incoming-point status change or alarms.
b. Automatically respond to input with a link to other inputs, outputs, or operator-response plans; unique sound with use of WAV files; and maps or images that graphically represent the point location.
c. Sixty-character message field for each alarm.
d. Operator-response-action messages shall allow message length of at least 65,000 characters, with database storage capacity of up to 32,000 messages. Setup shall assign messages as directed.
e. Secondary messages shall be assignable by the operator for printing to provide further information and shall be editable by the operator.
f. Allow 25 secondary messages with a field of four lines of 60 characters each.
g. Store the most recent 1000 alarms for recall by the operator using the report generator.

2. Software Tamper:

a. Annunciate a tamper alarm when unauthorized changes to system database files are attempted. Three consecutive unsuccessful attempts to log onto system shall generate a software tamper alarm.
b. Annunciate a software tamper alarm when an operator or other individual makes three consecutive unsuccessful attempts to invoke functions beyond the authorization level.

c. Maintain a transcript file of the last 5000 commands entered at each central station to serve as an audit trail. System shall not allow write access to system transcript files by any person, regardless of their authorization level.
d. Allow only acknowledgment of software tamper alarms.

3. Read access to system transcript files shall be reserved for operators with the highest password authorization level available in system.
4. Animated Response Graphics: Highlight alarms with flashing icons on graphic maps; display and constantly update the current status of alarm inputs and outputs in real time through animated icons.
5. Alarm Handling: Each input may be configured so that an alarm cannot be cleared unless it has returned to normal, with options of requiring the operator to enter a comment about disposition of alarm. Allow operator to silence alarm sound when alarm is acknowledged.
6. Alarm Automation Interface: High-level interface to central-station alarm automation software systems. Allows input alarms to be passed to and handled by automation systems in the same manner as burglar alarms, using a TIA 232-F ASCII interface.
7. CCTV Alarm Interface: Allow commands to be sent to CCTV systems during alarms (or input change of state) through serial ports.
8. Camera Control: Provides operator ability to select and control cameras from graphic maps.

O. Alarm Monitoring: Monitor sensors, controllers, and DTS circuits and notify operators of an alarm condition. Display higher-priority alarms first and, within alarm priorities, display the oldest unacknowledged alarm first. Operator acknowledgment of one alarm shall not be considered acknowledgment of other alarms nor shall it inhibit reporting of subsequent alarms.

1. Displayed alarm data shall include type and location of alarm. Printed alarm data shall include type of alarm, location of alarm, date and time (to nearest second) of occurrence, and operator responses.
2. Maps shall automatically display the alarm condition for each input assigned to that map if that option is selected for that input location.
3. Alarms initiate a status of "pending" and require the following two handling steps by operators:

   a. First Operator Step: "Acknowledged." This action shall silence sounds associated with the alarm. The alarm remains in the system "Acknowledged" but "Un-Resolved."
   b. Second Operator Step: Operators enter the resolution or operator comment, giving the disposition of the alarm event. The alarm shall then clear.

4. Each workstation shall display the total pending alarms and total unresolved alarms.
5. Each alarm point shall be programmable to disallow the resolution of alarms until the alarm point has returned to its normal state.
6. Alarms shall transmit to the central station in real time except for allowing connection time for dial-up locations.
7. Alarms shall be displayed and managed from a minimum of four different windows.

   a. Input Status Window: Overlay status icon with a large red blinking icon. Selecting the icon will acknowledge the alarm.

b. History Log Transaction Window: Display name, time, and date in red text. Selecting red text will acknowledge the alarm.
c. Alarm Log Transaction Window: Display name, time, and date in red. Selecting red text will acknowledge the alarm.
d. Graphic Map Display: Display a steady colored icon representing each alarm input location. Change icon to flashing red when the alarm occurs. Change icon from flashing red to steady red when the alarm is acknowledged.

8. Once an alarm is acknowledged, the operator shall be prompted to enter comments about the nature of the alarm and actions taken. Operator's comments may be manually entered or selected from a programmed predefined list, or a combination of both.
9. For locations where there are regular alarm occurrences, provide programmed comments. Selecting that comment shall clear the alarm.
10. The time and name of the operator who acknowledged and resolved the alarm shall be recorded in the database.
11. Identical alarms from the same alarm point shall be acknowledged at the same time the operator acknowledges the first alarm. Identical alarms shall be resolved when the first alarm is resolved.
12. Alarm functions shall have priority over downloading, retrieving, and updating database from workstations and controllers.
13. When a reader-controlled output (relay) is opened, the corresponding alarm point shall be automatically bypassed.

P. Monitor Display: Display text and graphic maps that include zone status integrated into the display. Colors are used for the various components and current data. Colors shall be uniform throughout the system.

1. Color Code:

a. FLASHING RED: Alerts operator that a zone has gone into an alarm or that primary power has failed.
b. STEADY RED: Alerts operator that a zone is in alarm and alarm has been acknowledged.
c. YELLOW: Advises operator that a zone is in access.
d. GREEN: Indicates that a zone is secure and that power is on.

2. Graphics:

a. Support 32,000 graphic display maps and allow import of maps from a minimum of 16 standard formats from another drawing or graphics program.
b. Allow I/O to be placed on graphic maps by the drag-and-drop method.
c. Operators shall be able to view the inputs, outputs, and the point's name by moving the mouse cursor over the point on the graphic map.
d. Inputs or outputs may be placed on multiple graphic maps. The operator shall be able to toggle to view graphic maps associated with I/Os.
e. Each graphic map shall have a display-order sequence number associated with it to provide a predetermined order when toggled to different views.
f. Camera icons shall have the ability to be placed on graphic maps that, when selected by an operator, will open a video window, display the camera associated with that icon, and provide pan-tilt-zoom control.

g. Input, output, or camera placed on a map shall allow the ability to arm or bypass an input, open or secure an output, or control the pan-tilt-zoom function of the selected camera.

Q. System test software enables operators to initiate a test of the entire system or of a particular portion of the system.

1. Test Report: The results of each test shall be stored for future display or printout. The report shall document the operational status of system components.

R. Report-Generator Software: Include commands to generate reports for displaying, printing, and storing on disk and tape. Reports shall be stored by type, date, and time. Report printing shall be the lowest-priority activity. Report-generation mode shall be operator selectable but set up initially as periodic, automatic, or on request. Include time and date printed and the name of operator generating the report. Report formats may be configured by operators.

1. Automatic Printing: Setup shall specify, modify, or inhibit the report to be generated; the time the initial report is to be generated; the time interval between reports; the end of the period; and the default printer.
2. Printing on Request: An operator may request a printout of any report.
3. Alarm Reports: Reporting shall be automatic as initially set up. Include alarms recorded by system over the selected time and information about the type of alarm (such as door alarm, intrusion alarm, tamper alarm, etc.), the type of sensor, the location, the time, and the action taken.
4. Access and Secure Reports: Document zones placed in access, the time placed in access, and the time placed in secure mode.
5. Custom Reports: Reports tailored to exact requirements of who, what, when, and where. As an option, custom report formats may be stored for future printing.
6. Automatic History Reports: Named, saved, and scheduled for automatic generation.
7. Cardholder Reports: Include data, or selected parts of the data, as well as the ability to be sorted by name, card number, imprinted number, or by any of the user-defined fields.
8. Cardholder by Reader Reports: Based on who has access to a specific reader or group of readers by selecting the readers from a list.
9. Cardholder by Access-Level Reports: Display everyone that has been assigned to the specified access level.
10. Who Is "In" (Muster) Report:

    a. Emergency Muster Report: One-click operation on toolbar launches report.
    b. Cardholder Report. Contain a count of persons who are "In" at a selected Location and a detailed listing of name, date, and time of last use, sorted by the last reader used or by the group assignment.

11. Panel Labels Reports: Printout of control-panel field documentation including the actual location of equipment, programming parameters, and wiring identification. Maintain system installation data within system database so that data are available on-site at all times.
12. History Reports: Custom reports that allow the operator to select any date, time, event type, device, output, input, operator, Location, name, or cardholder to be included or excluded from the report.

    a. Initially store history on the hard disk of the host workstation.

b. Permit viewing of the history on workstations or print history to any system printer.
c. The report shall be definable by a range of dates and times with the ability to have a daily start and stop time over a given date range.
d. Each report shall depict the date, time, event type, event description, and device; or I/O name, cardholder group assignment, and cardholder name or code number.
e. Each line of a printed report shall be numbered to ensure that the integrity of the report has not been compromised.
f. Total number of lines of the report shall be given at the end of the report. If the report is run for a single event such as "Alarms," the total shall reflect how many alarms occurred during that period.

13. Reports shall have the following four options:

a. View on screen.
b. Print to system printer. Include automatic print spooling and "Print To" options if more than one printer is connected to the system.
c. "Save to File" with full path statement.
d. System shall have the ability to produce a report indicating status of system inputs and outputs or of inputs and outputs that are abnormal, out of time zone, manually overridden, not reporting, or in alarm.

14. Custom Code List Subroutine: Allow the access codes of system to be sorted and printed according to the following criteria:

a. Active, inactive, or future activate or deactivate.
b. Code number, name, or imprinted card number.
c. Group, Location access levels.
d. Start and stop code range.
e. Codes that have not been used since a selectable number of days.
f. In, out, or either status.
g. Codes with trace designation.

15. The reports of system database shall allow options so that every data field may be printed.
16. The reports of system database shall be constructed so that the actual position of the printed data shall closely match the position of the data on the data-entry windows.

S. Anti-Passback:

1. System shall have global and local anti-passback features, selectable by Location. System shall support hard and soft anti-passback.
2. Hard Anti-Passback: Once a credential holder is granted access through a reader with one type of designation (IN or OUT), the credential holder may not pass through that type of reader designation until the credential holder passes through a reader of opposite designation.
3. Soft Anti-Passback: Should a violation of the proper IN or OUT sequence occur, access shall be granted, but a unique alarm shall be transmitted to the control station, reporting the credential holder and the door involved in the violation. A separate report may be run on this event.

4. Timed Anti-Passback: A controller capability that prevents an access code from being used twice at the same device (door) within a user-defined amount of time.
5. Provide four separate zones per Location that can operate without requiring interaction with the host workstation (done at controller). Each reader shall be assignable to one or all four anti-passback zones. In addition, each anti-passback reader can be further designated as "Hard," "Soft," or "Timed" in each of the four anti-passback zones. The four anti-passback zones shall operate independently.
6. The anti-passback schemes shall be definable for each individual door.
7. The Master Access Level shall override anti-passback.
8. System shall have the ability to forgive (or reset) an individual credential holder or the entire credential-holder population anti-passback status to a neutral status.

T. Visitor Assignment:

1. Provide for and allow an operator to be restricted to only working with visitors. The visitor badging subsystem shall assign credentials and enroll visitors. Allow only those access levels that have been designated as approved for visitors.
2. Provide an automated log of visitor name, time and doors accessed, and name of person contacted.
3. Allow a visitor designation to be assigned to a credential holder.
4. Security access system shall be able to restrict the access levels that may be assigned to credentials issued to visitors.
5. Allow operator to recall visitors' credential-holder file once a visitor is enrolled in the system.
6. The operator may designate any reader as one that deactivates the credential after use at that reader. The history log shall show the return of the credential.
7. System shall have the ability to use the visitor designation in searches and reports. Reports shall be able to print all or any visitor activity.

U. Training Software: Enables operators to practice system operation, including alarm acknowledgment, alarm assessment, response force deployment, and response force communications. System shall continue normal operation during training exercises and shall terminate exercises when an alarm signal is received at the console.

V. Entry-Control Enrollment Software: Database management functions that allow operators to add, delete, and modify access data as needed.

1. The enrollment station shall not have alarm response or acknowledgment functions.
2. Provide multiple, password-protected access levels. Database management and modification functions shall require a higher operator access level than personnel enrollment functions.
3. The program shall provide means to disable the enrollment station when it is unattended, to prevent unauthorized use.
4. The program shall provide a method to enter personnel identifying information into the entry-control database files through enrollment stations. In the case of personnel identity-verification subsystems. Allow entry of personnel identifying information into the system database using menu selections and data fields. The data field names shall be customized during setup to suit user and site needs. Personnel identity-verification subsystems selected for use with the system shall fully support the enrollment function and shall be compatible with the entry-control database files.

5. Cardholder Data: Provide 99 user-defined fields. System shall have the ability to run searches and reports using any combination of these fields. Each user-defined field shall be configurable, using any combination of the following features:

    a. MASK: Determines a specific format with which data must comply.
    b. REQUIRED: Operator is required to enter data into field before saving.
    c. UNIQUE: Data entered must be unique.
    d. DEACTIVATE DATE: Data entered will be evaluated as an additional deactivate date for all cards assigned to this cardholder.
    e. NAME ID: Data entered will be considered a unique ID for the cardholder.

6. Personnel Search Engine: A report generator with capabilities such as search by last name, first name, group, or any predetermined user-defined data field; by codes not used in definable number of days; by skills; or by seven other methods.
7. Multiple Deactivate Dates for Cards: User-defined fields to be configured as additional stop dates to deactivate any cards assigned to the cardholder.
8. Batch card printing.
9. Default card data can be programmed to speed data entry for sites where most card data are similar.
10. Enhanced ASCII File Import Utility: Allows the importing of cardholder data and images.
11. Card Expire Function: Allows readers to be configured to deactivate cards when a card is used at selected devices.

2.6 SYSTEM DATABASE

A. Database and database management software shall define and modify each point in database using operator commands. Definition shall include parameters and constraints associated with each system device.

B. Database Operations:

1. System data management shall be in a hierarchical menu-tree format, with navigation through expandable menu branches and manipulated with use of menus and icons in a main menu and system toolbar.
2. Navigational Aids:

    a. Toolbar icons for add, delete, copy, print, capture image, activate, deactivate, and muster report.
    b. Point and click feature to facilitate data manipulation.
    c. Next and previous command buttons visible when editing database fields to facilitate navigation from one record to the next.
    d. Copy command and copy tool in the toolbar to copy data from one record to create a new similar record.

3. Data entry shall be automatically checked for duplicate and illegal data and shall be verified for valid format.
4. System shall generate a memo or note field for each item that is stored in database, allowing the storing of information about any defining characteristics of the item. Memo

field is used for noting the purpose for which the item was entered, reasons for changes that were made, and the like.

C. File Management:

1. File management shall include database backup and restoration system, allowing selection of storage media, including 3.5-inch floppy disk, Zip and Jaz drives, and designated network resources.
2. Operations shall be both manual and automatic modes. The number of automatic sequential backups before the oldest backup will be overwritten; FIFO mode shall be operator selectable.
3. Backup program shall provide manual operation from any workstation on the LAN and shall operate while system remains operational.

D. Operator Passwords:

1. Support up to 32,000 individual system operators, each with a unique password.
2. One to eight alphanumeric characters.
3. Allow passwords to be case sensitive.
4. Passwords shall not be displayed when entered.
5. Passwords shall have unique and customizable password profile and allow several operators to share a password profile. Include the following features in the password profile:

    a. Predetermine the highest-level password profile for access to all functions and areas of program.
    b. Allow or disallow operator access to any program operation, including the functions of View, Add, Edit, and Delete.
    c. Restrict doors to which an operator can assign access.

6. Operators shall use a user name and password to log on to system. This user name and password shall be used to access database areas and programs as determined by the associated profile.
7. Make provision to allow the operator to log off without fully exiting program. User may be logged off but program will remain running while displaying the login window for the next operator.

E. Access Card/Code Operation and Management: Access authorization shall be by card, by a manually entered code (PIN), or by a combination of both (card plus PIN).

1. Access authorization shall verify the facility code first, the card or card-and-PIN validation second, and the access level (time of day, day of week, date), anti-passback status, and number of uses last.
2. Use data-entry windows to view, edit, and issue access levels. Access-authorization entry-management system shall maintain and coordinate all access levels to prevent duplication or the incorrect creation of levels.
3. Allow assignment of multiple cards/codes to a cardholder.
4. Allow assignment of up to four access levels for each Location to a cardholder. Each access level may contain any combination of doors.
5. Each door may be assigned four time zones.
6. Access codes may be up to 11 digits in length.

7. Software shall allow the grouping of locations so cardholder data can be shared by all locations in the group.
8. Visitor Access: Issue a visitor badge for data tracking or photo ID purposes without assigning that person a card or code.
9. Cardholder Tracing: Allow for selection of cardholder for tracing. Make a special audible and visible annunciation at control station when a selected card or code is used at a designated code reader. Annunciation shall include an automatic display of the cardholder image.
10. Allow each cardholder to be given either an unlimited number of uses or a number from one to 9999 that regulates the number of times the card can be used before it is automatically deactivated.
11. Provide for cards and codes to be activated and deactivated manually or automatically by date. Provide for multiple deactivate dates to be preprogrammed.

F. Security Access Integration:

1. Photo ID badging and photo verification shall use the same database as the security access and may query data from cardholder, group, and other personal information to build a custom ID badge.
2. Automatic or manual image recall and manual access based on photo verification shall also be a means of access verification and entry.
3. System shall allow sorting of cardholders together by group or other characteristic for a fast and efficient method of reporting on, and enabling or disabling, cards or codes.

G. Operator Comments:

1. With the press of one appropriate button on the toolbar, the user shall be permitted to enter operator comments into the history at any time.
2. Automatic prompting of operator comment shall occur before the resolution of each alarm.
3. Operator comments shall be recorded by time, date, and operator number.
4. Comments shall be sorted and viewed through reports and history.
5. The operator may enter comments in two ways; either or both may be used:

    a. Manually entered through keyboard data entry (typed), up to 65,000 characters per each alarm.
    b. Predefined and stored in database for retrieval on request.

6. System shall have a minimum of 999 predefined operator comments with up to 30 characters per comment.

H. Group:

1. Group names may be used to sort cardholders into groups that allow the operator to determine the tenant, vendor, contractor, department, division, or any other designation of a group to which the person belongs.
2. System software shall have the capacity to assign one of 32,000 group names to an access authorization.
3. Make provision in software to deactivate and reactivate all access authorizations assigned to a particular group.
4. Allow sorting of history reports and code list printouts by group name.

I. Time Zones:

1. Each zone consists of a start and stop time for seven days of the week and three holiday schedules. A time zone is assigned to inputs, outputs, or access levels to determine when an input shall automatically arm or disarm, when an output automatically opens or secures, or when access authorization assigned to an access level will be denied or granted.
2. Up to four time zones may be assigned to inputs and outputs to allow up to four arm or disarm periods per day or four lock or unlock periods per day; up to three holiday override schedules may be assigned to a time zone.
3. Data-entry window shall display a dynamically linked bar graph showing active and inactive times for each day and holiday, as start and stop times are entered or edited.
4. System shall have the capacity for 2048 time zones for each Location.

J. Holidays:

1. Three different holiday schedules may be assigned to a time zone. Holiday schedule consists of date in format MM/DD/YYYY and a description. When the holiday date matches the current date of the time zone, the holiday schedule replaces the time-zone schedule for that 24-hour period.
2. System shall have the capacity for 32,000 holidays.
3. Three separate holiday schedules may be applied to a time zone.
4. Holidays have an option to be designated as occurring on the designated date each year. These holidays remain in the system and will not be purged.
5. Holidays not designated to occur each year shall be automatically purged from the database after the date expires.

K. Access Levels:

1. System shall allow for the creation of up to 32,000 access levels.
2. One level shall be predefined as the Master Access Level. The Master Access Level shall work at all doors at all times and override any anti-passback.
3. System shall allow for access to be restricted to any area by reader and by time. Access levels shall determine when and where an Identifier is authorized.
4. System shall be able to create multiple door and time-zone combinations under the same access level so that an Identifier may be valid during different time periods at different readers even if the readers are on the same controller.

L. User-Defined Fields:

1. System shall provide a minimum of 99 user-defined fields, each with up to 50 characters, for specific information about each credential holder.
2. System shall accommodate a title for each field; field length shall be 20 characters.
3. A "Required" option may be applied to each user-defined field that, when selected, forces the operator to enter data in the user-defined field before the credential can be saved.
4. A "Unique" option may be applied to each user-defined field that, when selected, will not allow duplicate data from different credential holders to be entered.
5. Data format option may be assigned to each user-defined field that will require the data to be entered with certain character types in specific spots in the field entry window.

6. A user-defined field, if selected, will define the field as a deactivate date. The selection shall automatically cause the data to be formatted with the windows MM/DD/YYYY date format. The credential of the holder will be deactivated on that date.
7. A search function shall allow any one user-defined field or combination of user-defined fields to be searched to find the appropriate cardholder. The search function shall include a search for a character string.
8. System shall have the ability to print cardholders based on and organized by the user-defined fields.

2.7 SURGE AND TAMPER PROTECTION

A. Surge Protection: Protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads. Include surge protection for external wiring of each conductor-entry connection to components.

1. Minimum Protection for Power Connections 120 V and More: Auxiliary panel suppressors complying with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."
2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Connections: Comply with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits" as recommended by manufacturer for type of line being protected.

B. Tamper Protection: Tamper switches on enclosures, control units, pull boxes, junction boxes, cabinets, and other system components shall initiate a tamper-alarm signal when unit is opened or partially disassembled. Control-station control-unit alarm display shall identify tamper alarms and indicate locations.

2.8 CENTRAL-STATION HARDWARE

A. Central-Station Computer: Standard workstation of modular design.

B. Desktop Workstations
1. Performance Requirements:

a. Performance requirements may dictate equipment exceeding minimum requirements indicated.
b. Capable of running Microsoft Windows.
c. Energy Star compliant.
d. Processor:

1) Minimum Speed: As directed
2) Cores: As directed.
3) Series: As directed.

e. RAM:

1) Capacity: As directed.

2) Speed and Type: 1333.

f. Primary Hard Drive:

1) Media: As directed.
2) Number of Hard Drives: One or Two as directed.
3) Capacity: As directed.
4) Minimum Average Seek Time: As directed.
5) Cache Buffer Size: As directed.

g. Second Hard Drive:

1) Media: As directed.
2) Capacity: As directed.
3) Minimum Average Seek Time: As directed.
4) Cache Buffer Size: As directed.

h. Optical Drive:

1) Type: As directed.
2) Minimum Average Access Time: As directed.
3) Data Transfer Speed: As directed.
4) Reading Formats: Data, audio, recordable, and rewritable as directed.

i. Optical Read and Write Drive:

1) Include with at least 2 MB of data buffer.
2) Type: As directed.
3) Minimum Data Buffer Capacity: As directed.
4) Minimum Average Access Time: As directed.
5) Nominal Data Transfer Rates:

a) Reading: As directed.
b) Writing: As directed.

6) Average access time of 150 ms or less.
7) MTBF of at least 100,000 power-on hours.

j. Expansion slots: Minimum of 4, 32 or 64 bit as directed.
k. Video Card:

1) Capable of supporting monitors as directed.
2) Resolution: 1920 by 1200 pixels minimum for each monitor.
3) RAM: As directed.
4) Controller Speed: As directed.
5) On-Board Memory Speed: As directed.
6) On-Board Memory Data Width: As directed.

l. Sound Card:

1) At least 128 voice wavetable synthesis.

2) Capable of delivering three-dimensional sound effects.
3) High-resolution 16-bit stereo digital audio recording and playback with user-selectable sample rates up to 48,000 Hz.

m. Network Interface Card: Include card with connection, as applicable.

1) 10-100-1000 base TX Ethernet with RJ45 connector port.
2) 100 base FX Ethernet with SC or ST port.

n. Wireless Ethernet, 802.11 a/b/g/n.
o. Optical Modem: Full duplex link for connection to optical fiber cable provided.
p. I/O Ports:

1) Two USB 3.0 ports on front panel, six on back panel, and three internal on motherboard.
2) One serial port.
3) One parallel port.
4) Two PS/2 ports.
5) One RJ-45.
6) One stereo line-in and line-out on back panel.
7) One microphone and headphone connector on front panel.
8) One IEEE 1394 on front and back panel with workstationI-e card.
9) One ESATA port on back panel.

q. Battery: Life of at least three years to maintain system clock/calendar and ROM, as a minimum.

2. Keyboard:

a. 101 key enhanced keyboard.
b. Full upper- and lowercase ASCII keyset, numeric keypad, dedicated cursor control keypad, and 12 programmable function keys.
c. Wireless operation within up to 72 inches (1800 mm) in front of workstation.

3. Pointing Device:

a. Either a two- or three-button mouse.
b. Wireless operation within up to 72 inches (1800 mm) in front of workstation.

4. Flat Panel Display Monitor:

a. Number of Displays: One or Two as directed.
b. Display Support: As directed.
c. Color display with number of inches (mm) as directed of diagonal viewable area.
d. Aspect Ratio: 16 to 9.
e. Resolution: 1920 by 1080 pixels at 60 Hz with pixel size of 0.277 mm or smaller.
f. Digital or analog input signal.
g. Response Time: As directed.
h. Dynamic Contrast Ratio: 50000 to 1.
i. Brightness: 250 cd/sq. m.
j. Energy Star compliant.

k. Antiglare display.

5. Speakers:

a. Two, with individual controls for volume, bass and treble.
b. Signal to Noise Ratio: At least 65 dB.
c. Power: At least 4 W per speaker/channel.
d. Magnetic shielding to prevent distortion on the video monitor.

6. I/O Cabling: Include applicable cabling to connect I/O devices.
7. Software:

a. Factory installed operating system.

C. Portable Workstations

1. Performance Requirements:

a. Performance requirements may dictate equipment exceeding minimum requirements indicated.
b. Energy Star compliant.
c. Hardware and software shall support local down-loading to DDC controllers.
d. Data transfer rate to DDC controller shall be at network speed.

2. Processor:

a. Minimum Speed: As directed.
b. Cores: As directed.
c. Series: As directed.

3. RAM:

a. Capacity: As directed.
b. Speed and Type: As directed.

4. Hard Drive:

a. Media: As directed
b. Number of Hard Drives: One or Two as directed.
c. Capacity: As directed.
d. Minimum Average Seek Time: As directed.
e. Cache Buffer Size: As directed.

5. Video Card: Quantity of RAM as directed.
6. Input and Output Ports:

a. Serial port.
b. Shared port for external keyboard or mouse.
c. Four USB 3.0 ports.
d. Ethernet port.
e. HDMI port.
f. IEEE 1394 port.

7. Battery:

    a. Capable of supporting operation of portable workstation for a minimum of 8 hours.
    b. Battery life of at least three years.
    c. Battery charge time of less than three hours.
    d. Spare Batteries: One or Two as directed.

8. Keyboard:

    a. 85-key backlit keyboard.
    b. Full upper- and lowercase ASCII keyset.

9. Integral Pointing Device: Touchpad with two buttons. Gesture enabled.
10. Display:

    a. Inches as directed diagonal or larger high-definition WLED color display.
    b. Antiglare screen.
    c. 1920 by 1080 pixel resolution.
    d. Brightness: 300 nits.

11. Network Interfaces

    a. Network Interface Card: Include card with connection, as application.

        1) 10-100-1000 base TX Ethernet with RJ45 connector port.
        2) 100 base FX Ethernet with SC or ST port.

    b. Wireless:

        1) Internal with integrated antenna, capable of supporting 802.11 a/b/g/n.

12. Digital Video Disc Rewrite Recorder (DVD+/-RW):

    a. Compatible with DVD disks and data, audio, recordable and rewritable compact disks.
    b. Nominal Data Transfer Rates:

        1) Reading: As directed.
        2) Writing: As directed.

    c. 160-ms access time.

13. Accessories:

    a. Nylon carrying case.
    b. Docking station.
    c. Mobile broadband card.
    d. Wireless optical mouse.
    e. Portable hard drive as directed.
    f. Light-sensitive Web cam and noise-cancelling digital array microphone.
    g. Category 6a patch cable. Minimum cable length as directed.

h. HDMI cable. Minimum cable length as directed.

D. Servers

1. Description: x86 based computer used for client-server computing.
2. Mounting: As directed.
3. Power: As directed Single or dual power supply, minimum 300 W.
4. Performance Requirements:

    a. Performance requirements may dictate equipment exceeding minimum requirements indicated.
    b. Energy Star compliant.

5. Processor:

    a. Minimum Speed: As directed.
    b. Cores: As directed.
    c. Series: As directed.

6. RAM:

    a. Capacity: As directed.
    b. Speed and Type: As directed.
    c. Expandable Capacity: As directed.

7. Redundant Array of Independent Disks: As directed.
8. Drive Bays: Eight at 2.5 inches (65 mm) or eight at 3.5 inches (90 mm). Hot swappable.
9. Hard Drives: Solid state. Rotating disc, nominal rotational speed of 7200 rpm.
10. Hard-Drive Storage: As directed.
11. Network Interface: Dual port Gigabit Ethernet or Optical fiber as directed.
12. DVD +RW Drive.
13. Color, flat-screen display with inches as directed of diagonal viewable area.
14. Keyboard and mouse.
15. Next-day on-site warranty for two or three-year period as directed following Substantial Completion.
16. Servers shall include the following:

    a. Full-feature backup server (server and backup minimum requirement).
    b. Software licenses.
    c. Cable installation between server(s) and network.

17. Web Server:

    a. If required to be separate, include Web server hardware and software to match, except backup server is not required.
    b. Firewalls between server Web and networks.
    c. Password protection for access to server from Web server.
    d. Cable installation between the server(s) and building Ethernet network.

18. Power each server through a dedicated UPS unit.

2.9 CONTROLLERS

A. Controllers: Intelligent peripheral control unit, complying with UL 294, that stores time, date, valid codes, access levels, and similar data downloaded from the central station or workstation for controlling its operation.

B. Subject to compliance with requirements in this article, manufacturers may use multipurpose controllers.

C. Battery Backup: Sealed, lead acid; sized to provide run time during a power outage of 90 minutes, complying with UL 924.

D. Alarm Annunciation Controller:

1. The controller shall automatically restore communication within 10 seconds after an interruption with the field device network, with dc line supervision on each of its alarm inputs.

    a. Inputs: Monitor dry contacts for changes of state that reflect alarm conditions. Provides at least eight alarm inputs, which are suitable for wiring as normally open or normally closed contacts for alarm conditions.
    b. Alarm-Line Supervision:

        1) Supervise the alarm lines by monitoring each circuit for changes or disturbances in the signal, and for conditions as described in UL 1076 for line security equipment by monitoring for abnormal open, grounded, or shorted conditions using dc change measurements. System shall initiate an alarm in response to an abnormal current, which is a dc change of 5 or 10 percent as directed or more for longer than 500 ms.
        2) Transmit alarm-line-supervision alarm to the central station during the next interrogation cycle after the abnormal current condition.

    c. Outputs: Managed by central-station software.

2. Auxiliary Equipment Power: A GFI service outlet inside the controller enclosure.

E. Entry-Control Controller:

1. Function: Provide local entry-control functions including one- and two-way communications with access-control devices such as card readers, keypads, door strikes, magnetic latches, gate and door operators, and exit push buttons.

    a. Operate as a stand-alone portal controller using the downloaded database during periods of communication loss between the controller and the field-device network.
    b. Accept information generated by the entry-control devices; automatically process this information to determine valid identification of the individual present at the portal:

1) On authentication of the credentials or information presented, check privileges of the identified individual, allowing only those actions granted as privileges.
2) Privileges shall include, but are not limited to, time of day control, day of week control, group control, and visitor escort control.

c. Maintain a date-, time-, and Location-stamped record of each transaction. A transaction is defined as any successful or unsuccessful attempt to gain access through a controlled portal by the presentation of credentials or other identifying information.

2. Inputs:

a. Data from entry-control devices; use this input to change modes between access and secure.
b. Database downloads and updates from the central station that include enrollment and privilege information.

3. Outputs:

a. Indicate success or failure of attempts to use entry-control devices and make comparisons of presented information with stored identification information.
b. Grant or deny entry by sending control signals to portal-control devices and mask intrusion-alarm annunciation from sensors stimulated by authorized entries.
c. Maintain a date-, time-, and Location-stamped record of each transaction and transmit transaction records to the central station.
d. Door Prop Alarm: If a portal is held open for longer than 20 seconds or time listed in a schedule as directed, alarm sounds.

4. With power supplies sufficient to power at voltage and frequency required for field devices and portal-control devices.
5. Data Line Problems: For periods of loss of communication with the central station, or when data transmission is degraded and generating continuous checksum errors, the controller shall continue to control entry by accepting identifying information, making authentication decisions, checking privileges, and controlling portal-control devices.

a. Store up to 1000 transactions during periods of communication loss between the controller and access-control devices for subsequent upload to the central station on restoration of communication.

6. Controller Power: NFPA 70, Class II power-supply transformer, with 12- or 24-V ac secondary, backup battery and charger.

a. Backup Battery: Premium, valve or Valve-regulated, recombinant-sealed, lead-calcium battery as directed; spill proof; with a full one-year warranty and a pro rata 19 or 9-year warranty as directed. With single-stage, constant-voltage-current, limited battery charger, comply with battery manufacturer's written instructions for battery terminal voltage and charging current recommendations for maximum battery life.
b. Backup Battery: Valve-regulated, recombinant-sealed, lead-acid battery; spill proof. With single-stage, constant-voltage-current, limited battery charger, comply

with battery manufacturer's written instructions for battery terminal voltage and charging current recommendations for maximum battery life.

c. Backup Power-Supply Capacity: Five or 90 minutes of battery supply as directed. Submit battery and charger calculations.

d. Power Monitoring: Provide manual, dynamic battery-load test, initiated and monitored at the control center; with automatic disconnection of the controller when battery voltage drops below controller limits. Report by using local controller-mounted digital displays and by communicating status to central station. Indicate normal power on and battery charger on trickle charge. Indicate and report the following:

1) Trouble Alarm: Normal power-off load assumed by battery.
2) Trouble Alarm: Low battery.
3) Alarm: Power off.

2.10 DOOR AND GATE HARDWARE INTERFACE

A. Exit Device with Alarm: Operation of the exit device shall generate an alarm and annunciate a local alarm. Exit device and alarm contacts are specified in Section 087100 "Door Hardware."

B. Exit Alarm: Operation of a monitored door shall generate an alarm. Exit devices and alarm contacts are specified in Section 087100 "Door Hardware."

C. Electric Door Strikes: Use end-of-line resistors to provide power-line supervision. Signal switches shall transmit data to controller to indicate when the bolt is not engaged and the strike mechanism is unlocked, and they shall report a forced entry. Power and signal shall be from the controller. Electric strikes are specified in Section 087100 "Door Hardware."

D. Electromagnetic Locks: End-of-line resistors shall provide power-line supervision. Lock status sensing signal shall positively indicate door is secure. Power and signal shall be from the controller. Electromagnetic locks are specified in Section 087100 "Door Hardware."

E. Vehicle Gate Operator: Interface electrical operation of gate with controls in this Section. Vehicle gate operators shall be connected, monitored, and controlled by the security access controllers. Vehicle gate and accessories are specified in Section 323113 "Chain Link Fences and Gates."

2.11 FIELD-PROCESSING SOFTWARE

A. Operating System:

1. Local processors shall contain an operating system that controls and schedules that local processor's activities in real time.
2. Local processor shall maintain a point database in its memory that includes parameters, constraints, and the latest value or status of all points connected to that local processor.
3. Execution of local processor application programs shall utilize the data in memory resident files.

4. Operating system shall include a real-time clock function that maintains the seconds, minutes, hours, date, and month, including day of the week.
5. Local processor real-time clock shall be automatically synchronized with the central station at least once per day to plus or minus 10 seconds (the time synchronization shall be accomplished automatically, without operator action and without requiring system shutdown).

B. Startup Software:

1. Causes automatic commencement of operation without human intervention, including startup of all connected I/O functions.
2. Local processor restart program based on detection of power failure at the local processor shall be included in the local processor software.
3. Initiates operation of self-test diagnostic routines.
4. Upon failure of the local processor, if the database and application software are no longer resident, the local processor shall not restart and systems shall remain in the failure mode indicated until the necessary repairs are made.
5. If the database and application programs are resident, the local processor shall immediately resume operation.

C. Operating Mode:

1. Local processors shall control and monitor inputs and outputs as specified, independent of communications with the central station or designated workstations.
2. Alarms, status changes, and other data shall be transmitted to the central station or designated workstations when communications circuits are operable.
3. If communications are not available, each local processor shall function in a stand-alone mode and operational data, including the status and alarm data normally transmitted to the central station or designated workstations, shall be stored for later transmission to the central station or designated workstations.
4. Storage for the latest 4000 events shall be provided at local processors, as a minimum.
5. Local processors shall accept software downloaded from the central station.
6. Panel shall support flash ROM technology to accomplish firmware downloads from a central location.

D. Failure Mode: Upon failure for any reason, each local processor shall perform an orderly shutdown and force all local processor outputs to a predetermined (failure-mode) state, consistent with the failure modes shown and the associated control device.

E. Functions:

1. Monitoring of inputs.
2. Control of outputs.
3. Reporting of alarms automatically to the central station.
4. Reporting of sensor and output status to central station upon request.
5. Maintenance of real time automatically updated by the central station at least once a day.
6. Communication with the central station.
7. Execution of local processor resident programs.
8. Diagnostics.
9. Download and upload data to and from the central station.

2.12 FIELD-PROCESSING HARDWARE

A. Alarm Annunciation Local Processor:

1. Respond to interrogations from the field device network, recognize and store alarm status inputs until they are transmitted to the central station, and change outputs based on commands received from the central station.
2. Local processor shall also automatically restore communication within 10 seconds after an interruption with the field device network and provide dc line supervision on each of its alarm inputs.
3. Local processor inputs shall monitor dry contacts for changes of state that reflect alarm conditions.
4. Local processor shall have at least eight alarm inputs which allow wiring contacts as normally open or normally closed for alarm conditions; and shall provide line supervision for each input by monitoring each input for abnormal open, grounded, or shorted conditions using dc current change measurements.
5. Local processor shall report line supervision alarms to the central station.
6. Alarms shall be reported for any condition that remains abnormal at an input for longer than 500 milliseconds.
7. Alarm condition shall be transmitted to the central computer during the next interrogation cycle.
8. Local processor outputs shall reflect the state of commands issued by the central station.
9. Outputs shall be a form C contact and shall include normally open and normally closed contacts.
10. Local processor shall have at least four command outputs.
11. Local processor shall be able to communicate with the central station via RS-485 or TCP/IP as a minimum.

B. Processor Power Supply:

1. Local processor and sensors shall be powered from an uninterruptible power source.
2. Uninterruptible power source shall provide eight hours of battery back-up power in the event of primary power failure and shall automatically fully recharge the batteries within 12 hours after primary power is restored.
3. If the facility is without an emergency generator, the uninterruptible power source shall provide 24 hours of battery backup power.
4. There shall be no equipment malfunctions or perturbations or loss of data during the switch from primary to battery power and vice versa.
5. Batteries shall be sealed, non-outgassing type.
6. Power supply shall be equipped with an indicator for ac input power and an indicator for dc output power.
7. Loss of primary power shall be reported to the central station as an alarm.

C. Auxiliary Equipment Power: A GFI service outlet shall be furnished inside the local processor's enclosure.

D. Entry-Control Local Processor:

1. Entry-control local processor shall respond to interrogations from the field device network, recognize and store alarm status inputs until they are transmitted to the central station, and change outputs based on commands received from the central station.

2. Local processor shall also automatically restore communication within 10 seconds after an interruption with the field device network and provide dc line supervision on each of its alarm inputs.
3. Entry-control local processor shall provide local entry-control functions including communicating with field devices such as card readers, keypads, door strikes, magnetic latches, gate and door operators, and exit push buttons.
4. Processor shall also accept data from entry-control field devices as well as database downloads and updates from the central station that include enrollment and privilege information.
5. Processor shall send indications of successful or failed attempts to use entry-control field devices and shall make comparisons of presented information with stored identification information.
6. Processor shall grant or deny entry by sending control signals to portal-control devices and mask intrusion-alarm annunciation from sensors stimulated by authorized entries.
7. Entry-control local processor shall use inputs from entry-control devices to change modes between access and secure.
8. Local processor shall maintain a date-time- and location-stamped record of each transaction and transmit transaction records to the central station.
9. Processor shall operate as a stand-alone portal controller using the downloaded database during periods of communication loss between the local processor and the central station.
10. Processor shall store a minimum of 4000 transactions during periods of communication loss between the local processor and the central station for subsequent upload to the central station upon restoration of communication.
11. Local processor inputs shall monitor dry contacts for changes of state that reflect alarm conditions.
12. Local processor shall have at least eight alarm inputs which allow wiring contacts as normally open or normally closed for alarm conditions; and shall also provide line supervision for each input by monitoring each input for abnormal open, grounded, or shorted conditions using dc current change measurements.
13. Local processor shall report line supervision alarms to the central station.
14. Alarms shall be reported for any condition that remains abnormal at an input for longer than 500 ms.
15. Alarm condition shall be transmitted to the central station during the next interrogation cycle.
16. Entry-control local processor shall include the necessary software drivers to communicate with entry-control field devices. Information generated by the entry-control field devices shall be accepted by the local processor and automatically processed to determine valid identification of the individual present at the portal.
17. Upon authentication of the credentials or information presented, the local processor shall automatically check privileges of the identified individual, allowing only those actions granted as privileges.
18. Privileges shall include, but are not limited to, time of day control, day of week control, group control, and visitor escort control. The local processor shall maintain a date-time- and location-stamped record of each transaction.
19. Transaction is defined as any successful or unsuccessful attempt to gain access through a controlled portal by the presentation of credentials or other identifying information.
20. Local processor outputs shall reflect the state of commands issued by the central station.
21. Outputs shall be a form C contact and shall include normally open and normally closed contacts.
22. Local processor shall have at least four addressable outputs.

23. The entry-control local processor shall also provide control outputs to portal-control devices.
24. Local processor shall be able to communicate with the central station via RS-485 or TCP/IP as a minimum.
25. The system manufacturer shall provide strategies for downloading database information for panel configurations and cardholder data to minimize the required download time when using IP connectivity.

2.13 TRANSFORMERS

A. NFPA 70, Class II control transformers, NRTL listed. Transformers for security access-control system shall not be shared with any other system.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation.

B. Examine roughing-in for LAN and control cable conduit systems to workstations, controllers, card readers, and other cable-connected devices to verify actual locations of conduit and back boxes before device installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Comply with recommendations in SIA CP-01.

B. Comply with TIA 606-B, "Administration Standard for Commercial Telecommunications Infrastructure."

C. Product Schedules: Obtain detailed product schedules from manufacturer of access-control system or develop product schedules to suit Project. Fill in all data available from Project plans and specifications and publish as Product Schedules for review and approval.

1. Record setup data for control station and workstations.
2. For each Location, record setup of controller features and access requirements.
3. Propose start and stop times for time zones and holidays, and match up access levels for doors.
4. Assign action message names and compose messages.
5. Set up alarms. Establish interlocks between alarms, intruder detection, and video surveillance features.
6. Prepare and install alarm graphic maps.
7. Develop user-defined fields.
8. Develop screen layout formats.

9. Discuss badge layout options; design badges.
10. Complete system diagnostics and operation verification.
11. Prepare a specific plan for system testing, startup, and demonstration.
12. Develop acceptance test concept and, on approval, develop specifics of the test.
13. Develop cable and asset-management system details; input data from construction documents. Include system schematics and Visio Technical Drawings in electronic format as directed.

D. In meetings with Architect and Owner, present Product Schedules and review, adjust, and prepare final setup documents. Use approved, final Product Schedules to set up system software.

3.3 DENTIFICATION

A. In addition to requirements in this article, comply with applicable requirements in Section 270553 "Identification for Communications Systems" and with TIA 606-B.

B. Using software specified in "Cable and Asset Management Software" Article, develop cable administration drawings for system identification, testing, and management. Use unique, alphanumeric designation for each cable, and label cable and jacks, connectors, and terminals to which it connects with the same designation. Use logical and systematic designations for facility's architectural arrangement.

C. Label each terminal strip and screw terminal in each cabinet, rack, or panel.

1. All wiring conductors connected to terminal strips shall be individually numbered, and each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with the name and number of the particular device as shown.
2. Each wire connected to building-mounted devices is not required to be numbered at the device if the color of the wire is consistent with the associated wire connected and numbered within the panel or cabinet.

D. At completion, cable and asset management software shall reflect as-built conditions.

3.4 SYSTEM SOFTWARE AND HARDWARE

A. Develop, install, and test software and hardware, and perform database tests for the complete and proper operation of systems involved. Assign software license to Owner.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to supervise and assist with startup service.

1. Complete installation and startup checks according to approved procedures that were developed in "Preparation" Article and with manufacturer's written instructions.
2. Enroll and prepare badges and access cards for Owner's operators, management, and security personnel.

3.6 PROTECTION

A. Maintain strict security during the installation of equipment and software. Rooms housing the control station, and workstations that have been powered up shall be locked and secured with an activated burglar alarm and access-control system reporting to a central station complying with UL 1610, "Central-Station Burglar-Alarm Units," during periods when a qualified operator in the employ of Contractor is not present.

3.7 DEMONSTRATION

A. As directed engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain security access system. See Section 017900 "Demonstration and Training."

B. Develop separate training modules for the following:

1. Computer system administration personnel to manage and repair the LAN and databases and to update and maintain software.
2. Operators who prepare and input credentials to man the control station and workstations and to enroll personnel.
3. Security personnel.
4. Hardware maintenance personnel.
5. Corporate management.

END OF SECTION 281300

SECTION 281500 - ACCESS CONTROL HARDWARE DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Card readers, credential cards, and keypads
2. Biometric identity-verification equipment
3. Cables
4. Transformers

B. Related Requirements:

1. Section 281300 "Access Control System Software and Database Management" for control and monitoring applications, workstations, and interfaces.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Diagrams for cable management system.
2. System labeling schedules, including electronic copy of labeling schedules that are part of the cable and asset identification system of the software specified in Parts 2 and 3.
3. Wiring Diagrams. For power, signal, and control wiring. Show typical wiring schematics including the following:

    a. Workstation outlets, jacks, and jack assemblies.
    b. Patch cords.
    c. Patch panels.

4. Cable Administration Drawings: As specified in "Identification" Article.
5. Battery and charger calculations for central station, workstations, and controllers.

C. Product Schedules.

D. Samples: For workstation outlets, jacks, jack assemblies, and faceplates. For each exposed product and for each color and texture specified.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Credential card blanks, ready for printing. Include enough credential cards for all personnel to be enrolled at the site plus an extra 50 percent for future use.
2. Fuses of all kinds, power and electronic, equal to 10 percent of amount installed for each size used, but no fewer than three units.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers trained and approved by manufacturer.

1. Cable installer must have on staff an RCDD certified by Building Industry Consulting Service International.

B. Source Limitations: Obtain central station, workstations, controllers, Identifier readers, and all software through one source from single manufacturer.

1.8 PROJECT CONDITIONS

A. Environmental Conditions: System shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

1. Control Station: Rated for continuous operation in ambient conditions of 60 to 85 deg F (16 to 30 deg C) and a relative humidity of 20 to 80 percent, noncondensing.
2. Indoor, Controlled Environment: NEMA 250, Type 1 enclosure. System components, except the central-station control unit, installed in air-conditioned or temperature-controlled indoor environments as directed, shall be rated for continuous operation in ambient conditions of 36 to 122 deg F (2 to 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing.
3. Indoor, Uncontrolled Environment: NEMA 250, type enclosures as directed. As directed, system components installed in non-air-conditioned or non-temperature-controlled indoor environments shall be rated for continuous operation in ambient conditions of 0 to 122 deg F (minus 18 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing.
4. Outdoor Environment: NEMA 250, NEMA 250, type enclosures as directed. System components installed in locations exposed to weather shall be rated for continuous

operation in ambient conditions of minus 30 to plus 122 deg F (minus 34 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, condensing. Rate for continuous operation where exposed to rain as specified in NEMA 250, winds up to 85 mph (137 km/h) and snow cover up to 24 inches (610 mm) thick.

5. Hazardous Environment: System components located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers shall be rated, listed, and installed according to NFPA 70.
6. Corrosive Environment: For system components subjected to corrosive fumes, vapors, and wind-driven salt spray in coastal zones, provide NEMA 250, Type 4X or Type 6P enclosures as directed.

PART 2 - PRODUCTS

2.1 OPERATION

A. Security access system hardware shall use a single database for access-control and credential-creation functions.

2.2 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NFPA 70, "National Electrical Code."

C. Comply with SIA DC-01 and SIA DC-03 and SIA DC-07.

2.3 CARD READERS, CREDENTIAL CARDS, AND KEYPADS

A. Card Readers:

1. Card-Reader Power: Powered from its associated controller, including its standby power source, and shall not dissipate more than 5 W.
2. Response Time: Card reader shall respond to passage requests by generating a signal that is sent to the controller. Response time shall be 800 ms or less, from the time the card reader finishes reading the credential card until a response signal is generated.
3. Enclosure: Suitable for surface, semi-flush, pedestal, or weatherproof mounting. Mounting types shall additionally be suitable for installation in the following locations:

    a. Indoors, controlled environment.
    b. Indoors, uncontrolled environment.
    c. Outdoors, with built-in heaters or other cold-weather equipment to extend the operating temperature range as needed for operation at the site.

4. Display: Digital visual indicator shall provide visible and audible status indications and user prompts. Indicate power on or off, whether user passage requests have been accepted or rejected, and whether the door is locked or unlocked.

5. Stripe Swipe Readers: Bidirectional, reading cards swiped in both directions, powered by the controller. Reader shall be set up for ABA Track.

    a. ABA Track: Magnetic stripe that is encoded on track 2, at 75-bpi density in binary-coded decimal format; for example, 5-bit, 16-character set.
    b. Readers for outdoors shall be in a polymeric plastic enclosure with all electronics potted in plastic. Rated for operation in ambient conditions of minus 40 to plus 160 deg F (minus 40 to plus 70 deg C) in a humidity range of 10 to 90 percent.

6. Wiegand Swipe Reader: Set up for 33 or 26-bit data cards as directed. Comply with SIA AC-01.
7. Wiegand Key-Insert Reader: Set up for 33 or 26-bit data cards as directed.
8. Bar-Code Reader: Set up for Code number as directed.
9. Insert Readers: Requiring the card to be inserted from the bottom or side as directed, powered by the controller.
10. Touch-Plate and Proximity Readers:

    a. Active-detection proximity card readers shall provide power to compatible credential cards through magnetic induction and shall receive and decode a unique identification code number transmitted from the credential card.
    b. Passive-detection proximity card readers shall use a swept-frequency, RF field generator to read the resonant frequencies of tuned circuits laminated into compatible credential cards. The resonant frequencies read shall constitute a unique identification code number.
    c. The card reader shall read proximity cards in a range from direct contact to at least 6 inches (150 mm) from the reader.

B. Keypads:

1. Entry-control keypads shall use a unique combination of alphanumeric and other symbols as an Identifier.
2. Keypads shall contain an integral alphanumeric/special symbols keyboard with symbols arranged in ascending ASCII-code ordinal sequence or random scrambled order as directed.
3. Communication protocol shall be compatible with the local processor.
4. Keypad Display:

    a. As directed, keypads shall include a digital visual indicator and shall provide visible or visible and audible status indications and user prompts.

        1) Display shall indicate power on or off and whether user passage requests have been accepted or rejected.

    b. Design of the keypad display or keypad enclosure shall limit viewing angles of the keypad as follows:

        1) Maximum Horizontal Viewing Angle: Plus or minus 5 degrees or less off a vertical plane perpendicular to the plane of the face of the keypad display.
        2) Maximum Vertical Viewing Angle: Plus or minus 15 degrees or less off a horizontal plane perpendicular to the plane of the face of the keypad display.

5. Keypad Response Time:

    a. The keypad shall respond to passage requests by generating a signal to the local processor. The response time shall be 800 ms or less from the time the last alphanumeric symbol is entered until a response signal is generated.

6. Keypad Power:

    a. The keypad shall be powered from the source as shown and shall not dissipate more than 150 W.

7. Keypad Mounting Method:

    a. Keypads shall be suitable for surface, semi-flush, pedestal, or weatherproof mounting as required.

8. Keypad Duress Codes:

    a. Keypads shall provide a means for users to indicate a duress situation by entering a special code.

C. Keypad and Wiegand-Swipe-Reader Combination: Designed to require an entry on the keypad before presenting the credential card.

1. Keypad: As directed, allow the entry of four numeric digits or alphanumeric characters that are associated with a specific credential. Keypads shall contain an integral alphanumeric/special symbol keyboard with symbols arranged in ascending ASCII-code ordinal sequence or random scrambled order as directed. Keypad display or enclosure shall limit viewing angles of the keypad as follows:

    a. Maximum Horizontal Viewing Angle: Plus or minus 5 degrees or less off a vertical plane perpendicular to the plane of the face of the keypad display.
    b. Maximum Vertical Viewing Angle: Plus or minus 15 degrees or less off a horizontal plane perpendicular to the plane of the face of the keypad display.

2. Wiegand Swipe Reader: As directed, set up for 33 or 26-bit data cards to generate a unique card identification code. Comply with SIA AC-01.
3. The reader shall have "flash" download capability to accommodate card format changes. The card reader shall have capability of transmitting data to security control panel and shall comply with ISO/IEC 7816.
4. Communication Protocol: Compatible with local processor.

D. Credential Cards:

1. Modification: Entry-control cards shall be able to be modified by lamination direct print process during the enrollment process without reduction of readability. The design of the credential cards shall allow for the addition of at least one slot or hole to accommodate the attachment of a clip for affixing the credential card to the badge holder used at the site.
2. Card Size and Dimensional Stability: Credential cards shall be 2-1/8 by 3-3/8 inches (54 by 86 mm). The credential card material shall be dimensionally stable so that an

undamaged card with deformations resulting from normal use shall be readable by the card reader.

3. Card Material: Abrasion resistant, nonflammable, nontoxic, and impervious to solar radiation and effects of ultraviolet light.
4. Card Construction:

    a. Core and laminate or monolithic construction.
    b. Lettering, logos, and other markings shall be hot stamped into the credential material or direct printed.
    c. As directed, incorporate holographic images or phosphorous ink as a security enhancement.
    d. Furnish equipment for on-site assembly and lamination of credential cards.

2.4 PUSH-BUTTON SWITCHES

A. Push-Button Switches: Momentary-contact back-lighted push buttons with stainless-steel switch enclosures.

B. Electrical Ratings:

1. Minimum continuous current rating of 10 A at 120-V ac or 5 A at 240-V ac.
2. Contacts that will make 720 VA at 60 A and that will break at 720 VA at 10 A.

C. Enclosures: Flush or surface mounting. Push buttons shall be suitable for flush mounting in the switch enclosures.

D. Enclosures shall additionally be suitable for installation in the following locations:

1. Indoors, controlled environment.
2. Indoors, uncontrolled environment.
3. Outdoors.

E. Power: Push-button switches shall be powered from their associated controller, using dc control.

2.5 CABLES

A. General Cable Requirements: Comply with requirements in Section 270513 "Conductors and Cables for Communications Systems" and as recommended by system manufacturer for integration requirement.

B. PVC-Jacketed, TIA 232-F.

1. As directed, Three or Nine, No. 22 AWG, stranded (7x30) tinned copper conductors.
2. Polypropylene insulation.
3. Aluminum foil-polyester tape shield with 100 percent shield coverage.
4. PVC jacket.
5. Conductors are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
6. Flame Resistance: Comply with UL 1581.

C. Plenum-Rated TIA 232-F Cables:

1. As directed, Three or Nine, No. 22 AWG, stranded (7x30) tinned copper conductors.
2. PE insulation.
3. Aluminum foil-polyester tape shield with 100 percent shield coverage.
4. Fluorinated ethylene propylene jacket.
5. Conductors are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
6. Flame Resistance: Comply with NFPA 262.

D. PVC-Jacketed, TIA 485-A Cables:

1. Paired, two pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. NFPA 70 Type: Type CM or Type CMG.
6. Flame Resistance: Comply with UL 1581.

E. Plenum-Rated TIA 485-A Cables:

1. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.
2. Fluorinated ethylene propylene insulation.
3. Unshielded.
4. Fluorinated ethylene propylene jacket.
5. NFPA 70 Type: Type CMP
6. Flame Resistance: NFPA 262, Flame Test.

F. Multiconductor, PVC, Reader and Wiegand Keypad Cables:

1. No. 22 AWG, paired and twisted multiple conductors, stranded (7x30) tinned copper conductors, semirigid PVC insulation, overall aluminum-foil/polyester-tape shield with 100 percent shield coverage, plus tinned copper braid shield with 65 percent shield coverage, and PVC jacket.
2. NFPA 70, Type CMG.
3. Flame Resistance: UL 1581 vertical tray.
4. For TIA 232-F applications.

G. Paired, PVC, Reader and Wiegand Keypad Cables:

1. Three pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors, polypropylene insulation, individual aluminum-foil/polyester-tape shielded pairs each with No. 22 AWG, stranded tinned copper drain wire, 100 percent shield coverage, and PVC jacket.
2. NFPA 70, Type CM.
3. Flame Resistance: UL 1581 vertical tray.

H. Paired, PVC, Reader and Wiegand Keypad Cables:

1. Three pairs, twisted, No. 20 AWG, stranded (7x28) tinned copper conductors, polyethylene (polyolefin) insulation, individual aluminum-foil/polyester-tape shielded pairs each with No. 22 AWG, stranded (19x34) tinned copper drain wire, 100 percent shield coverage, and PVC jacket.
2. NFPA 70, Type CM.
3. Flame Resistance: UL 1581 vertical tray.

I. Paired, Plenum-Type, Reader and Wiegand Keypad Cables:

1. Three pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, plastic insulation, individual aluminum-foil/polypropylene-tape shielded pairs each with No. 22 AWG, stranded tinned copper drain wire, 100 percent shield coverage, and fluorinated-ethylene-propylene jacket.
2. NFPA 70, Type CMP.
3. Flame Resistance: NFPA 262 flame test.

J. Multiconductor, Plenum-Type, Reader and Wiegand Keypad Cables:

1. Six conductors, No. 20 AWG, stranded (7x28) tinned copper conductors, fluorinated-ethylene-propylene insulation, overall aluminum-foil/polyester-tape shield with 100 percent shield coverage plus tinned copper braid shield with 85 percent shield coverage, and fluorinated-ethylene-propylene jacket.
2. NFPA 70, Type CMP.
3. Flame Resistance: NFPA 262 flame test.

K. LAN Cabling:

1. Comply with requirements in Section 271513 "Communications Copper Horizontal Cabling."

2.6 TRANSFORMERS

A. NFPA 70, Class II control transformers, NRTL listed. Transformers for security access-control system shall not be shared with any other system.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with recommendations in SIA CP-01.

B. Comply with TIA 606-B, "Administration Standard for Commercial Telecommunications Infrastructure."

C. Product Schedules: Obtain detailed product schedules from manufacturer of access-control system or develop product schedules to suit Project. Fill in all data available from Project plans and specifications and publish as Product Schedules for review and approval.

D. In meetings with Architect and Owner, present Product Schedules and review, adjust, and prepare final setup documents. Use approved, final Product Schedules to set up system software.

3.2 CABLING

A. Comply with NECA 1, "Good Workmanship in Electrical Construction."

B. Install cables and wiring according to requirements in Section 270513 "Conductors and Cables for Communications Systems."

C. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters. Conceal raceway and wiring except in unfinished spaces.

D. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Use NRTL-listed plenum cable in environmental airspaces, including plenum ceilings. Conceal raceway and cables except in unfinished spaces.

E. Install LAN cables using techniques, practices, and methods that are consistent with Category 5e rating of components and optical fiber rating of components, and that ensure Category 6 and optical fiber performance of completed and linked signal paths, end to end.

F. Boxes and enclosures containing security-system components or cabling, and which are easily accessible to employees or to the public, shall be provided with a lock. Boxes above ceiling level in occupied areas of the building shall not be considered accessible. Junction boxes and small device enclosures below ceiling level and easily accessible to employees or the public shall be covered with a suitable cover plate and secured with tamperproof screws.

G. Install end-of-line resistors at the field device location and not at the controller or panel location.

3.3 CABLE APPLICATION

A. Comply with TIA 569-D, "Commercial Building Standard for Telecommunications Pathways and Spaces."

B. Cable application requirements are minimum requirements and shall be exceeded if recommended or required by manufacturer of system hardware.

C. TIA 232-F Cabling: Install at a maximum distance of 50 ft. (15 m) between terminations.

D. TIA 485-A Cabling: Install at a maximum distance of 4000 ft. (1220 m) between terminations.

E. Card Readers and Keypads:

1. Install number of conductor pairs recommended by manufacturer for the functions specified.

2. Unless manufacturer recommends larger conductors, install No. 22 AWG wire if maximum distance from controller to the reader is 250 ft. (75 m), and install No. 20 AWG wire if maximum distance is 500 ft. (150 m).
3. For greater distances, install "extender" or "repeater" modules recommended by manufacturer of the controller.
4. Install minimum No. 18 AWG shielded cable to readers and keypads that draw 50 mA or more.

F. Install minimum No. 16 AWG cable from controller to electrically powered locks. Do not exceed 250 ft. (75 m) or 500 ft. (150 m) between terminations as directed.

G. Install minimum No. 18 AWG ac power wire from transformer to controller, with a maximum distance of 25 ft. (8 m) between terminations.

3.4 GROUNDING

A. Comply with Section 270526 "Grounding and Bonding for Communications Systems."

B. Comply with IEEE 1100, "Recommended Practice for Power and Grounding Electronic Equipment."

C. Ground cable shields, drain conductors, and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

D. Bond shields and drain conductors to ground at only one point in each circuit.

E. Signal Ground:

1. Terminal: Locate in each equipment room and wiring closet; isolate from power system and equipment grounding.
2. Bus: Mount on wall of main equipment room with standoff insulators.
3. Backbone Cable: Extend from signal ground bus to signal ground terminal in each equipment room and wiring closet.

3.5 IDENTIFICATION

A. In addition to requirements in this article, comply with applicable requirements in Section 270553 "Identification for Communications Systems" and with TIA 606-B.

3.6 SYSTEM SOFTWARE AND HARDWARE

A. Develop, install, and test software and hardware, and perform database tests for the complete and proper operation of systems involved. Assign software license to Owner.

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. LAN Cable Procedures: Inspect for physical damage and test each conductor signal path for continuity and shorts. Use tester approved for type and kind of installed cable. Test for faulty connectors, splices, and terminations. Test according to TIA 568-C.1, "Commercial Building Telecommunications Cabling Standards - Part 1: General Requirements." Link performance for balanced twisted-pair cables must comply with minimum criteria in TIA 568-C.1.
2. Test each circuit and component of each system. Tests shall include, but are not limited to, measurements of power-supply output under maximum load, signal loop resistance, and leakage to ground where applicable. System components with battery backup shall be operated on battery power for a period of not less than 10 percent of the calculated battery operating time. Provide special equipment and software if testing requires special or dedicated equipment.
3. Operational Test: After installation of cables and connectors, demonstrate product capability and compliance with requirements. Test each signal path for end-to-end performance from each end of all pairs installed. Remove temporary connections when tests have been satisfactorily completed.

C. Devices and circuits will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.8 STARTUP SERVICE

A. Engage a factory-authorized service representative to supervise and assist with startup service.

1. Complete installation and startup checks according to approved procedures that were developed in "Preparation" Article and with manufacturer's written instructions.
2. Enroll and prepare badges and access cards for Owner's operators, management, and security personnel.

END OF SECTION 281500

SECTION 282000 - VIDEO SURVEILLANCE

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes a video surveillance system consisting of cameras, digital video recorder, data transmission wiring, and a control station with its associated equipment.

B. Related Requirements:

1. Section 281300 "Access Control System Software and Database Management" to integrate access control system interface and control.
2. Section 283100 "Intrusion Detection" to integrate video surveillance used for intrusion detection.
3. Section 283121 "Area and Perimeter Intrusion Detection" to integrate video surveillance used for intrusion detection.
4. Section 285121 "Detention Monitoring and Control Systems" to integrate video surveillance with detention monitoring interface and control.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include dimensions and data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For video surveillance. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Functional Block Diagram: Show single-line interconnections between components for signal transmission and control. Show cable types and sizes.
3. Dimensioned plan and elevations of equipment racks, control panels, and consoles. Show access and workspace requirements.
4. UPS: Sizing calculations.
5. Wiring Diagrams: For power, signal, and control wiring.

C. Design Data: Include equipment list consisting of every piece of equipment by model number, manufacturer, serial number, location, and date of original installation.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For video surveillance, cameras, camera-supporting equipment, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 PROJECT CONDITIONS

A. Environmental Conditions: Capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

1. Control Station: Rated for continuous operation in ambient temperatures of 60 to 85 deg F (16 to 29 deg C) and a relative humidity of 20 to 80 percent, noncondensing.
2. Interior, Controlled Environment: As directed system components, except central-station control unit, installed in air-conditioned or temperature-controlled interior environments shall be rated for continuous operation in ambient temperatures of 36 to 122 deg F (2 to 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing. Use NEMA 250, Type 1 enclosures.
3. Interior, Uncontrolled Environment: As directed system components installed in non-air-conditioned or temperature-controlled interior environments shall be rated for continuous operation in ambient temperatures of 0 to 122 deg F (minus 18 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing. Use NEMA 250, Type enclosures as directed.
4. Exterior Environment: System components installed in locations exposed to weather shall be rated for continuous operation in ambient temperatures of minus 30 to plus 122 deg F (minus 34 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, condensing. Rate for continuous operation when exposed to rain as specified in NEMA 250, winds up to 85 mph (137 km/h) and snow cover up to 24 inches (610 mm) thick. Use NEMA 250, Type enclosures as directed.
5. Security Environment: Camera housing for use in high-risk areas where surveillance equipment may be subject to physical violence.

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of cameras, equipment related to camera operation, and control-station equipment that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM REQUIREMENTS

A. Video-signal format shall comply with NTSC standard, composite interlaced video. Composite video-signal termination shall be 75 ohms.

B. Surge Protection: Protect components from voltage surges entering through power, communication, signal, control, or sensing leads. Include surge protection for external wiring of each conductor's entry connection to components.

1. Minimum Protection for Power Connections 120 V and More: Auxiliary panel suppressors complying with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."
2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Connections: Comply with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits" as recommended by manufacturer for type of line being protected.

C. Tamper Protection: Tamper switches on enclosures, control units, pull boxes, junction boxes, cabinets, and other system components shall initiate a tamper-alarm signal when unit is opened or partially disassembled. Control-station, control-unit alarm display shall identify tamper alarms and indicate locations.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Video surveillance system shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NECA 1.

D. Comply with NFPA 70.

E. Electronic data exchange between video surveillance system with an access-control system shall comply with SIA TVAC.

2.3 STANDARD CAMERAS

A. Color Camera:

1. Comply with UL 639.
2. Pickup Device: CCD interline transfer, 380,000 771(H) by 492(V) pixels.

3. Horizontal Resolution: 480 lines.
4. Signal-to-Noise Ratio: Not less than 50 dB, with camera AGC off.
5. With AGC, manually selectable on or off.
6. Sensitivity: Camera shall provide usable images in low-light conditions, delivering an image at a scene illumination of light level lux as directed at f-stop of lens as directed, with camera AGC off.
7. Sensitivity: Camera shall deliver 1-V peak-to-peak video signal at the minimum specified light level. Illumination for the test shall be with lamps rated at approximately 2200-K color temperature, and with camera AGC off.
8. Manually selectable modes for backlight compensation or normal lighting.
9. Scanning Synchronization: Determined by external synch over the coaxial cable. Camera shall revert to internally generated synchronization on loss of external synch signal.
10. White Balance: Auto-tracing white balance, with manually settable fixed balance option.
11. Motion Detector: Built-in digital.

B. Automatic Color Dome Camera: Assembled and tested as a manufactured unit, containing dome assembly, color camera, motorized pan and tilt, zoom lens, and receiver/driver.

1. Comply with UL 639.
2. Pickup Device: CCD interline transfer, 380,000 768(H) by 494(V) pixels.
3. Horizontal Resolution: 480 lines.
4. Signal-to-Noise Ratio: Not less than 50 dB, with camera AGC off.
5. With AGC, manually selectable on or off.
6. Sensitivity: Camera shall provide usable images in low-light conditions, delivering an image at a scene illumination of light level lux as directed at f-stop of lens as directed, with camera AGC off.
7. Sensitivity: Camera shall deliver 1-V peak-to-peak video signal at the minimum specified light level. Illumination for the test shall be with lamps rated at approximately 2200-K color temperature, and with camera AGC off.
8. Manually selectable modes for backlight compensation or normal lighting.
9. Pan and Tilt: Direct-drive motor, 360-degree rotation angle, and 180-degree tilt angle. Pan-and-tilt speed shall be controlled by operator. Movement from preset positions shall be not less than 300 degrees per second.
10. Preset Positioning: Eight user-definable scenes, each allowing 16-character titles. Controls shall include the following:

    a. In "sequence mode," camera shall continuously sequence through preset positions, with dwell time and sequencing under operator control.
    b. Motion detection shall be available at each camera position.
    c. Up to four preset positions may be selected to be activated by an alarm. Each of the alarm positions may be programmed to output a response signal.

11. Scanning Synchronization: Determined by external synch over the coaxial cable. Camera shall revert to internally generated synchronization on loss of external synch signal.
12. White Balance: Auto-tracing white balance, with manually settable fixed balance option.
13. Motion Detector: Built-in digital.
14. Dome shall support multiplexed control communications using coaxial cable recommended by manufacturer.

2.4 LENSES

A. Description: Optical-quality coated lens, designed specifically for video-surveillance applications and matched to specified camera. Provide color-corrected lenses.

1. Auto-Iris Lens: Electrically controlled iris with circuit set to maintain a constant video level in varying lighting conditions.
2. Fixed Lens: With calibrated focus ring.
3. Zoom Lens: Motorized, remote-controlled unit, rated as "quiet operating." Features include the following:

    a. Electrical Leads: Filtered to minimize video signal interference.
    b. Motor Speed: Variable.
    c. Lens shall be available with preset positioning capability to recall the position of specific scenes.

2.5 POWER SUPPLIES

A. Low-voltage power supplies matched for voltage and current requirements of cameras and accessories, and of type as recommended by manufacturer of camera and lens.

1. Enclosure: NEMA 250, type as directed.

2.6 CAMERA-SUPPORTING EQUIPMENT

A. Minimum Load Rating: Rated for load in excess of the total weight supported times a minimum safety factor of two.

B. Pan-and-Tilt Units: Motorized units arranged to provide remote-controlled aiming of cameras with smooth and silent operation and equipped with matching mounting brackets.

1. Panning Rotation: 0 to 355 degrees, with adjustable stops.
2. Tilt Movement: 90 degrees, plus or minus 5 degrees, with adjustable stops.
3. Speed: 12 degrees per second in both horizontal and vertical planes.
4. Wiring: Factory prewired for camera and zoom lens functions and pan-and-tilt power and control.
5. Built-in encoders or potentiometers for position feedback, and thermostat-controlled heater.
6. Pan-and-tilt unit shall be available with preset positioning capability to recall the position of a specific scene.

C. Mounting Brackets for Fixed Cameras: Type matched to items supported and mounting conditions. Include manual pan-and-tilt adjustment.

D. Protective Housings for Fixed and Movable Cameras: Steel or 6061 T6 aluminum enclosures with internal camera mounting and connecting provisions that are matched to camera/lens combination and mounting and installing arrangement of camera to be housed.

1. Tamper switch on access cover sounds an alarm signal when unit is opened or partially disassembled. Central-control unit shall identify tamper alarms and indicate location in alarm display. Tamper switches and central-control unit are specified in Section 283100 "Intrusion Detection."
2. Camera Viewing Window: Polycarbonate or Lexan window as directed, aligned with camera lens.
3. Duplex Receptacle: Internally mounted.
4. Alignment Provisions: Camera mounting shall provide for field aiming of camera and permit removal and reinstallation of camera lens without disturbing camera alignment.
5. Built-in, thermostat-activated heater and blower units. Units shall be automatically controlled so the environmental limits of the camera equipment are not exceeded.
6. Sun shield shall not interfere with normal airflow around the housing.
7. Mounting bracket and hardware for wall or ceiling mounting of the housing. Bracket shall be of same material as the housing; mounting hardware shall be stainless steel.
8. Finish: Housing and mounting bracket shall be factory finished using manufacturer's standard finishing process suitable for the environment.
9. Enclosure Rating: NEMA Type or Ingress Protection code as directed.

2.7 COLOR MONITORS

A. Screen Size (Diagonal Dimension): As directed.

B. Horizontal Resolution: 300 lines.

C. Minimum Front Panel Devices and Controls: Power switch; power-on indicator; and brightness, contrast, color, and tint controls.

D. Degaussing: Automatic.

E. Mounting: As directed Single, 14-inch (356-mm) or Dual, 9-inch (229-mm), vertical, EIA 19-inch (483-mm) electronic equipment rack or cabinet complying with CEA 310-E.

F. Electrical: 120-V ac, 60 Hz.

2.8 DIGITAL VIDEO RECORDERS

A. Description: Digital, time-lapse type, full-frame and motion recorder, with removable hard drive.

1. Recording Time: 400 hours minimum.
2. Resolution: 720 by 480 lines, minimum.
3. Programming shall be from trackball and push buttons on face of the recorder, settings shall be displayed on any video monitor connected to the recorder. Programming shall include the following:

    a. Motion analysis graph.
    b. Password protection.
    c. Alarm and timer controls.
    d. Continuous recording option.

e. Time-lapse operating modes.
f. Search video by time, event, or motion.

4. Programming: SmartMedia card for software updating, image archiving, and image transfer to a PC.
5. Storage: 80-GB, removable hard drive. Software shall permit hot-swapping drives.
6. Compression: MPEG-2.
7. Time and Date Generator: Records time (hr:min:sec) and date legend of each frame.
8. Audio Recording: 70 to 7000 Hz. Phono and microphone input; phono output.
9. Mounting: Standard 19-inch (483-mm) rack complying with CEA 310-E, or freestanding desktop.

2.9 NETWORK VIDEO RECORDERS

A. External storage or internal 250-1, 500-GB hard disk drive.

1. Video and audio recording over TCP/IP network.
2. Video recording of MPEG-2 and MPEG-4 streams.
3. Video recording up to 48 Mbps for internal storage and up to 100 Mbps for external storage.
4. Duplex Operation: Simultaneous recording and playback.
5. Continuous and alarm-based recording.
6. Full-Featured Search Capabilities: Search based on camera, time, or date.
7. Automatic data replenishment to ensure recording even if network is down.
8. Digital certification by watermarking.
9. Internal RAID storage or non-RAID storage of up to 1500 GB.
10. Capable of adding external RAID storage up to 7000 GB for models with no internal storage.
11. Full integration with LAN, Intranet, or Internet through standard Web browser or video management software.
12. Integrated Web server FTP server functionality.
13. Supports up to 16, 32, or 64 devices as directed.

2.10 DIGITAL SWITCHERS

A. Quad Switch: For displaying images from four cameras on a single monitor. Provide color switcher.

1. Controls: Unit-mounted front panel.
2. Resolution: 720 by 480 lines.
3. Modes: Auto, manual, and alarm. In manual mode, each channel can also be viewed in single display mode. In the event of an alarm, alarming channel shall automatically switch to full screen. If several alarms are activated, channels in alarm shall be in auto-switching mode.
4. Channel Loss Alarm: Audible buzzer; occurrence details shall be recorded.
5. Time: Indicate date and time.
6. Timing of Auto-Switcher: 1 to 30 seconds, selectable.
7. Mounting: Standard 19-inch (483-mm) rack complying with CEA 310-E, or freestanding desktop.

B. Manual Switch Bank: Low-loss, high-isolation, multiple-video switch to allow manual switching of multiple quad switches and cameras to a single output. Switches shall be illuminated.

C. Sequential Switchers: Automatically sequence outputs of multiple cameras to single monitor.

1. Switching Time Interval: Continuously adjustable, 5 to 20 seconds minimum, with manual override.
2. Skip-Sequential-Hold Switch: One for each camera, with LED to indicate active camera.
3. Camera Identification Legend: Either on-screen message or label at skip-sequential switch.
4. Alarm Switching: In the event of an alarm, alarming channel shall automatically switch the monitor to full screen.
5. Mounting: Standard 19-inch (483-mm) rack complying with CEA 310-E.

D. PTZ Controls: Arranged for multiple-camera control, with switches to select camera to be controlled.

1. Pan-and-Tilt Control: Joystick type.
2. Zoom Control: Momentary-contact, "in-out" push button.
3. Automatic-Scan Control: A push button for each camera with pan capability that places camera in automatic-scanning mode.

2.11 IP VIDEO SYSTEMS

A. Description:

1. System shall provide high-quality delivery and processing of IP-based video, audio, and control data using standard Ethernet-based networks.
2. System shall have seamless integration of all video surveillance and control functions.
3. Graphical user interface software shall manage all IP-based video matrix switching and camera control functions, two-way audio communication, alarm monitoring and control, and recording and archive/retrieval management. IP system shall also be capable of integrating into larger system environments.
4. System design shall include all necessary compression software for high-performance, dual-stream, MPEG-2/MPEG-4 video. Unit shall provide connections for all video cameras, camera PTZ control data, bidirectional audio, discreet sensor inputs, and control system outputs.
5. All camera signals shall be compressed, encoded, and delivered onto the network for processing and control by the IP video-management software.
6. Camera system units shall be ruggedly built and designed for extreme adverse environments, complying with NEMA Type environmental standards.
7. Encoder/decoder combinations shall place video, audio, and data network stream that can be managed from multiple workstations on the user's LAN or WAN.
8. All system interconnect cables, workstation PCs, PTZ joysticks, and network intermediate devices shall be provided for full performance of specified system.

2.12 VIDEO MOTION SENSORS (INTERIOR)

A. Device Performance: Detect changes in video signal within a user-defined protected zone. Video inputs shall be composite video as defined in SMPTE 170M. Provide an alarm output for each video input.

1. Detect movement within protected zone of intruders wearing clothing with a reflectivity that differs from that of background scene by a factor of two. Reject all other changes in video signal.
2. Modular design that allows for expansion or modification of number of inputs.
3. Controls:

    a. Size of detection zones.
    b. Sensitivity of detection of each protected zone.

4. Mounting: Standard 19-inch (483-mm) rack complying with CEA 310-E.

2.13 CONTROL STATIONS

A. Description: Heavy-duty, freestanding, modular, metal furniture units arranged to house electronic equipment. Coordinate component arrangement and wiring with components and wiring of other systems.

B. Equipment Mounting: Standard 19-inch (483-mm) rack complying with CEA 310-E.

C. Normal System Power Supply: 120 V, 60 Hz, through a locked disconnect device and an isolation transformer in central-station control unit. Central-station control unit shall supply power to all components connected to it unless otherwise indicated.

D. Power Continuity for Control Station: Batteries in power supplies of central-station control units and individual system components shall maintain continuous system operation during outages of both normal and backup ac system supply.

1. Batteries: Rechargeable, valve-regulated, recombinant, sealed, lead-acid type with nominal 10-year life expectancy. Capacity adequate to operate portions of system served including audible trouble signal devices for up to four hours and audible and visual alarm devices under alarm conditions for an additional 10 minutes.
2. Battery Charger: Solid-state, fully automatic, variable-charging-rate type. Charger shall recharge fully discharged battery within 24 hours.

E. Annunciation: Indicate change in system condition and switching of system or component to backup power.

2.14 SIGNAL TRANSMISSION COMPONENTS

A. Cable: Coaxial cable elements have 75-ohm nominal impedance. Comply with requirements in Section 270513 "Conductors and Cables for Communications Systems."

B. Video Surveillance Coaxial Cable Connectors: BNC type, 75 ohms. Comply with requirements in Section 270513 "Conductors and Cables for Communications Systems."

PART 3 - EXECUTION

3.1 WIRING

A. Comply with requirements in Section 270528 "Pathways for Communications Systems."

B. Wiring Method: Install cables in raceways unless otherwise indicated.

1. Except raceways are not required in accessible indoor ceiling spaces and attics.
2. Except raceways are not required in hollow gypsum board partitions.
3. Conceal raceways and wiring except in unfinished spaces.

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

D. Splices, Taps, and Terminations: For power and control wiring, use numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

E. For communication wiring, comply with the following:

1. Section 271313 "Communications Copper Backbone Cabling."
2. Section 271323 "Communications Optical Fiber Backbone Cabling."
3. Section 271333 "Communications Coaxial Backbone Cabling."
4. Section 271513 "Communications Copper Horizontal Cabling."
5. Section 271523 "Communications Optical Fiber Horizontal Cabling."
6. Section 271533 "Communications Coaxial Horizontal Cabling."

F. Grounding: Provide independent-signal circuit grounding recommended in writing by manufacturer.

3.2 VIDEO SURVEILLANCE SYSTEM INSTALLATION

A. Install cameras with 84-inch- (2134-mm-) minimum clear space below cameras and their mountings. Change type of mounting to achieve required clearance.

B. Set pan-and-tilt unit stops to suit final camera position and to obtain the field of view required for camera. Connect all controls and alarms and adjust.

C. Avoid ground loops by making ground connections only at the control station.

1. For 12- and 24-V dc cameras, connect the coaxial cable shields only at the monitor end.

D. Identify system components, wiring, cabling, and terminals according to Section 270553 "Identification for Communications Systems."

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Inspection: Verify that units and controls are properly installed, connected, and labeled, and that interconnecting wires and terminals are identified.
2. Pretesting: Align and adjust system and pretest components, wiring, and functions to verify that they comply with specified requirements. Conduct tests at varying lighting levels, including day and night scenes as applicable. Prepare video-surveillance equipment for acceptance and operational testing as follows:

    a. Verify operation of auto-iris lenses.
    b. Set back-focus of fixed focal length lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Adjust until image is in focus with and without the filter.
    c. Set back-focus of zoom lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Additionally, set zoom to full wide angle and aim camera at an object 50 to 75 feet (17 to 23 m) away. Adjust until image is in focus from full wide angle to full telephoto, with the filter in place.
    d. Set and name all preset positions; consult Owner's personnel.
    e. Set sensitivity of motion detection.
    f. Connect and verify responses to alarms.
    g. Verify operation of control-station equipment.

3. Test Schedule: Schedule tests after pretesting has been successfully completed and system has been in normal functional operation for at least 14 days. Provide a minimum of 10 days' notice of test schedule.
4. Operational Tests: Perform operational system tests to verify that system complies with Specifications. Include all modes of system operation.

C. Video surveillance system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.4 DEMONSTRATION

A. As directed engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain video-surveillance equipment.

END OF SECTION 282000

SECTION 283100 - INTRUSION DETECTION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes intrusion detection with communication links to perform monitoring, alarm, and control functions.

B. Related Sections:

1. Section 271313 "Communications Copper Backbone Cabling" for Category 5e, 6, and 7 backbone (riser-rated) cabling.
2. Section 271323 "Communications Optical Fiber Backbone Cabling" for multi- and single-mode backbone (riser-rated) optical fiber.
3. Section 271513 "Communications Copper Horizontal Cabling" for Category 5e, 6, and 7 horizontal (general use, riser-, and plenum-rated) cabling.
4. Section 271523 "Communications Optical Fiber Horizontal Cabling" for multi- and single-mode horizontal (general use, riser-, and plenum-rated) optical fiber.
5. Section 270513 "Conductors and Cables for Communications Systems" for power cabling between master control units and field-mounted devices and control units.
6. Section 281300 "Access Control System Software and Database Management" for applications, interfaces, and workstations.
7. Section 283121 "Perimeter Security Systems" for outdoor intrusion detection devices, including lighting and communications associated with chain-link fence gates.
8. Section 282000 "Video Surveillance" for CCTV cameras that are used as devices for video motion detection.

1.2 DEFINITIONS

A. Control Unit: System component that monitors inputs and controls outputs through various circuits.

B. Master Control Unit: System component that accepts inputs from other control units and may also perform control-unit functions. The unit has limited capacity for the number of protected zones and is installed at an unattended location or at a location where it is not the attendant's primary function to monitor the security system.

C. Monitoring Station: Facility that receives signals and has personnel in attendance at all times to respond to signals. A central station is a monitoring station that is listed.

D. Standard Intruder: A person who weighs 100 lb (45 kg) or less and whose height is 60 inches (1525 mm) or less; dressed in a long-sleeved shirt, slacks, and shoes unless environmental conditions at the site require protective clothing.

E. Standard-Intruder Movement: Any movement, such as walking, running, crawling, rolling, or jumping, of a "standard intruder" in a protected zone.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: Detail assemblies of standard components that are custom assembled for specific application on this Project.

1. Raceway Riser Diagrams: Detail raceway runs required for intrusion detection. Include designation of devices connected by raceway, raceway type and size, and type and size of wire and cable fill for each raceway run.
2. UPS: Sizing calculations.
3. Site and Floor Plans: Indicate final outlet and device locations, routing of raceways, and cables inside and outside the building. Include room layout for master control-unit console, terminal cabinet, racks, and UPS.
4. Master Control-Unit Console Layout: Show required artwork and device identification.
5. Device Address List: Coordinate with final system programming.
6. System Wiring Diagrams: Include system diagrams unique to Project. Show connections for all devices, components, and auxiliary equipment. Include diagrams for equipment and for system with all terminals and interconnections identified.
7. Details of surge-protection devices and their installation.
8. Sensor detection patterns and adjustment ranges.

C. Design Data: Include method of operation and supervision of each component and each type of circuit. Show sequence of operations for manually and automatically initiated system or equipment inputs. Description must cover this specific Project; manufacturer's standard descriptions for generic systems are unacceptable.

D. Samples: For units with factory-applied color finishes.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Product Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Intrusion Detection Devices: Furnish quantity equal to five percent of the number of units of each type installed, but no fewer than one of each type.
2. Fuses: Three of each kind and size.
3. Tool Kit: Provide six sets of tools for use with security fasteners, each packaged in a compartmented kit configured for easy handling and storage.

4. Security Fasteners: Furnish no fewer than 1 box for every 50 boxes or fraction thereof, of each type and size of security fastener installed.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: As directed, preparation of Shop Drawings and cabling administration Drawings, cabling administration Drawings, and field testing program development by an RCDD a Technician.
2. Installation Supervision: As directed, Installation shall be under the direct supervision of Technician or Level 2 Commercial Installer, who shall be present at all times when Work of this Section is performed at Project site.
3. Testing Supervisor: Currently certified by BICSI as an RCDD a Technician to supervise on-site testing.

B. Testing Agency Qualifications: Certified by BICSI. Testing agency must have personnel certified by BICSI on staff.

1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

1.8 PROJECT CONDITIONS

A. Environmental Conditions: Capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

1. Altitude: Sea level to 4000 feet (1220 m).
2. Master Control Unit: Rated for continuous operation in an ambient of 60 to 85 deg F (16 to 29 deg C) and a relative humidity of 20 to 80 percent, noncondensing.
3. Interior, Controlled Environment: As directed, system components, except master control unit, installed in air-conditioned or temperature-controlled interior environments shall be rated for continuous operation in ambients of 36 to 122 deg F (2 to 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing.
4. Interior, Uncontrolled Environment: As directed, system components installed in non-air-conditioned or non-temperature-controlled interior environments shall be rated for continuous operation in ambients of 0 to 122 deg F (minus 18 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing.
5. Exterior Environment: System components installed in locations exposed to weather shall be rated for continuous operation in ambients of minus 30 to plus 122 deg F (minus 34 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, condensing. Comply with UL 294 and UL 639 for outdoor-use equipment. Rate for continuous operation when exposed to rain as specified in NEMA 250, winds up to 85 mph (137 km/h) and snow cover up to 24 inches (610 mm) thick.
6. Hazardous Environment: System components located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers or flyings shall be rated, listed, and installed according to NFPA 70.

1.9 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer and Installer agree to repair or replace components of intrusion detection devices and equipment that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 FUNCTIONAL DESCRIPTION OF SYSTEM

A. Description: Hard-wired or Multiplexed, modular, microprocessor-based controls, intrusion sensors and detection devices, and communication links to perform monitoring, alarm, and control functions.

B. Supervision: System components shall be continuously monitored for normal, alarm, supervisory, and trouble conditions. Indicate deviations from normal conditions at any location in system. Indication includes identification of device or circuit in which deviation has occurred and whether deviation is an alarm or malfunction.

1. Alarm Signal: Display at master control unit and actuate audible and visual alarm devices.
2. Trouble Condition Signal: Distinct from other signals, indicating that system is not fully functional. Trouble signal shall indicate system problems such as battery failure, open or shorted transmission line conductors, or control-unit failure.
3. Supervisory Condition Signal: Distinct from other signals, indicating an abnormal condition as specified for the particular device or control unit.

C. System Control: Master control unit shall directly monitor intrusion detection units and connecting wiring.

D. System shall automatically reboot program without error or loss of status or alarm data after any system disturbance.

E. Operator Commands:

1. Help with System Operation: Display all commands available to operator. Help command, followed by a specific command, shall produce a short explanation of the purpose, use, and system reaction to that command.
2. Acknowledge Alarm: To indicate that alarm message has been observed by operator.
3. Place Protected Zone in Access: Disable all intrusion-alarm circuits of a specific protected zone. Tamper circuits may not be disabled by operator.
4. Place Protected Zone in Secure: Activate all intrusion-alarm circuits of a protected zone.
5. Protected Zone Test: Initiate operational test of a specific protected zone.
6. System Test: Initiate system-wide operational test.
7. Print reports.

F. Timed Control at Master Control Unit: Allow automatically timed "secure" and "access" functions of selected protected zones.

G. Automatic Control of Related Systems: Alarm or supervisory signals from certain intrusion detection devices control the following functions in related systems:

1. Switch selected lights.
2. Shift elevator control to a different mode.
3. Open a signal path between certain intercommunication stations.
4. Shift sound system to "listening mode" and open a signal path to certain system speakers.
5. Switch signal to selected monitor from CCTV camera in vicinity of sensor signaling an alarm.

H. Printed Record of Events: Print a record of alarm, supervisory, and trouble events on system printer. Sort and report by protected zone, device, and function. When master control unit receives a signal, print a report of alarm, supervisory, or trouble condition. Report type of signal (alarm, supervisory, or trouble), protected zone description, date, and time of occurrence. Differentiate alarm signals from other indications. When system is reset, report reset event with the same information concerning device, location, date, and time. Commands shall initiate the reporting of a list of current alarm, supervisory, and trouble conditions in system or a log of past events.

I. Response Time: Two seconds between actuation of any alarm and its indication at master control unit.

J. Circuit Supervision: Supervise all signal and data transmission lines, links with other systems, and sensors from master control unit. Indicate circuit and detection device faults with both protected zone and trouble signals, sound a distinctive audible tone, and illuminate an LED. Maximum permissible elapsed time between occurrence of a trouble condition and indication at master control unit is 20 seconds. Initiate an alarm in response to opening, closing, shorting, or grounding of a signal or data transmission line.

K. Programmed Secure-Access Control: System shall be programmable to automatically change status of various combinations of protected zones between secure and access conditions at scheduled times. Status changes may be preset for repetitive, daily, and weekly; specially scheduled operations may be preset up to a year in advance. Manual secure-access control stations shall override programmed settings.

L. Manual Secure-Access Control: Coded entries at manual stations shall change status of associated protected zone between secure and access conditions.

2.2 SYSTEM COMPONENT REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Control Units, Devices, and Communications with Monitoring Station: Listed and labeled by a qualified testing agency for compliance with SIA CP-01.

C. FM Global Compliance: FM-Approved and -labeled intrusion detection devices and equipment.

D. Comply with NFPA 70.

E. Surge Protection: Protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads. Include surge protection for external wiring of each conductor entry connection to components.

1. Minimum Protection for Power Lines 120 V and More: Auxiliary panel suppressors complying with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."
2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Lines: Listed and labeled by a qualified testing agency for compliance with NFPA 731.

F. Intrusion Detection Units: Listed and labeled by a qualified testing agency for compliance with UL 639.

G. Interference Protection: Components shall be unaffected by radiated RFI and electrical induction of 15 V/m over a frequency range of 10 to 10,000 MHz and conducted interference signals up to 0.25-V rms injected into power supply lines at 10 to 10,000 MHz.

H. Tamper Protection: Tamper switches on detection devices, control units, annunciators, pull boxes, junction boxes, cabinets, and other system components shall initiate a tamper-alarm signal when unit is opened or partially disassembled and when entering conductors are cut or disconnected. Master control-unit alarm display shall identify tamper alarms and indicate locations.

I. Self-Testing Devices: Automatically test themselves periodically, but not less than once per hour, to verify normal device functioning and alarm initiation capability. Devices transmit test failure to master control unit.

J. Antimasking Devices: Automatically check operation continuously or at intervals of a minute or less, and use signal-processing logic to detect blocking, masking, jamming, tampering, or other operational dysfunction. Devices transmit detection of operational dysfunction to master control unit as an alarm signal.

K. Addressable Devices: Transmitter and receivers shall communicate unique device identification and status reports to master control unit.

L. Remote-Controlled Devices: Individually and remotely adjustable for sensitivity and individually monitored at master control unit for calibration, sensitivity, and alarm condition.

2.3 ENCLOSURES

A. Interior Sensors: Enclosures that protect against dust, falling dirt, and dripping noncorrosive liquids.

B. Interior Electronics: NEMA 250, Type 12.

C. Exterior Electronics: NEMA 250, Type 4X, fiberglass or stainless steel.

D. Corrosion Resistant: NEMA 250, Type 4X, PVC or stainless steel.

E. Screw Covers: Where enclosures are readily accessible, secure with security fasteners of type appropriate for enclosure.

2.4 SECURE AND ACCESS DEVICES

A. Keypad and Display Module: Arranged for entering and executing commands for system-status changes and for displaying system-status and command-related data.

B. Key-Operated Switch: Change protected zone between secure and access conditions.

2.5 DOOR AND WINDOW SWITCHES

A. Description: Balanced-magnetic switch, complying with UL 634, installed on frame with integral overcurrent device to limit current to 80 percent of switch capacity. As directed, bias magnet and minimum of two or three encapsulated reed switches shall resist compromise from introduction of foreign magnetic fields.

B. Flush-Mounted Switches: Unobtrusive and flush with surface of door and window frame.

C. Overhead Door Switch: Balanced-magnetic type, listed for outdoor locations, and having door-mounted magnet and floor-mounted switch unit.

2.6 PIR SENSORS

A. Listed and labeled by a qualified testing agency for compliance with SIA PIR-01.

B. Description: Sensors detect intrusion by monitoring infrared wavelengths emitted from a human body within their protected zone and by being insensitive to general thermal variations.

1. Wall-Mounted Unit Maximum Detection Range: 125 percent of indicated distance for individual units and not less than 50 feet (15 m). Provide adjustable coverage pattern as indicated.
2. Ceiling-Mounted Unit Spot-Detection Pattern: Full 360-degree conical.
3. Ceiling-Mounted Unit Pattern Size: 84-inch (2135-mm) diameter at floor level for units mounted 96 inches (2440 mm) above floor; 18-foot (5.5-m) diameter at floor level for units mounted 25 feet (7.6 m) above floor.

C. Device Performance:

1. Sensitivity: Adjustable pattern coverage to detect a change in temperature of 2 deg F (1 deg C) or less, and standard-intruder movement within sensor's detection patterns at any speed between 0.3 to 7.5 fps (0.09 to 2.3 m/s) across two adjacent segments of detector's field of view.
2. Test Indicator: LED test indicator that is not visible during normal operation. When visible, indicator shall light when sensor detects an intruder. Locate test enabling switch under sensor housing cover.

2.7 MICROWAVE INTRUSION DETECTORS (INTERIOR)

A. Device Performance: Microwave transmitter establishes an electromagnetic field in an adjustable detection pattern and detects intrusion by monitoring changes in that pattern.

1. Sensitivity: Adjustable, able to detect standard-intruder movement within sensor's detection pattern at any speed between 0.3 to 7.5 fps (0.09 to 2.3 m/s). Sensor sensitivity adjustments shall be accessible only when sensor housing is removed, and sensors shall comply with 47 CFR 15.
2. Activation Indicator: LED indicator shall not be visible during normal operation. Indicator shall light when sensor detects a standard intruder. Locate test-enabling switch under sensor housing cover.

2.8 ACOUSTIC-TYPE, GLASS-BREAK SENSORS

A. Listed and labeled by a qualified testing agency for compliance with SIA GB-01.

B. Device Performance: Detect unique, airborne acoustic energy spectrum caused by breaking glass.

1. Sensor Element: Microprocessor-based, digital device to detect breakage of plate, laminate, tempered, and wired glass while rejecting common causes of false alarms. Detection pattern shall be at least a 20-foot (6-m) range.
2. Hookup Cable: Factory installed, not less than 72 inches (1830 mm).
3. Activation Indicator: LED on sensor housing that lights when responding to vibrations, remaining on until manually reset at sensor control unit or at master control unit.
4. Control Unit: Integral with sensor housing or in a separate assembly, locally adjustable by control under housing cover.
5. Glass-Break Simulator: A device to induce frequencies into protected glass pane that simulate breaking glass without causing damage to glass.

2.9 PIEZOELECTRIC-TYPE, GLASS-BREAK SENSORS

A. Listed and labeled by a qualified testing agency for compliance with SIA GB-01.

B. Device Performance: Detect unique, high-frequency vibrations caused by breaking glass.

1. Sensor Element: Piezoelectric crystals in a housing designed to mount directly to glass surface with adhesive provided by element manufacturer. Circular detection pattern, with at least a 60-inch (1525-mm) radius on a continuous glass pane. Sensor element shall not be larger than 4 sq. in. (25.80 sq. cm).
2. Hookup Cable: Factory installed, not less than 72 inches (1830 mm).
3. Activation Indicator: LED on sensor housing that lights when responding to vibrations, remaining on until manually reset at sensor control unit or at master control unit.
4. Control Unit: Integral with sensor housing or in a separate assembly, locally adjustable by control under housing cover.
5. Glass-Break Simulator: A device to induce frequencies into protected glass pane that simulate breaking glass without causing damage to glass.

2.10 PHOTOELECTRIC SENSORS

A. Device Performance: Detect an interruption of a pulsed, infrared, light beam that links transmitter and receiver.

1. Sensitivity: Detect standard-intruder movement within sensor's detection patterns at any speed of less than 7.5 fps (2.3 m/s) though the beam. Allow installation of multiple sensors within same protected zone that will not interfere with each other.
2. Activation Indicator: LED indicator shall not be visible during normal operation. Indicator shall light when sensor detects a standard intruder. Locate test enabling switch under sensor housing cover.

2.11 MICROWAVE-PIR DUAL-TECHNOLOGY SENSORS

A. Description: Single unit combining a sensor that detects changes in microwave signals and a PIR sensor that detects changes in ambient level of infrared emissions caused by standard-intruder movement within detection pattern.

B. Listed and labeled by a qualified testing agency for compliance with SIA PIR-01.

C. Device Performance: An alarm is transmitted when either sensor detects a standard intruder within a period of three to eight seconds from when the other sensor detects a standard intruder.

1. Minimum Detection Pattern: A room 20 by 30 feet (6 by 9 m).
2. PIR Sensor Sensitivity: Adjustable pattern coverage to detect a change in temperature of 2 deg F (1 deg C) or less, and standard-intruder movement within sensor's detection patterns at any speed between 0.3 to 7.5 fps (0.09 to 2.3 m/s) across two adjacent segments of detector's field of view.
3. Microwave Sensor Sensitivity: Adjustable, able to detect standard-intruder movement within sensor's detection pattern at any speed between 0.3 to 7.5 fps (0.09 to 2.3 m/s). Sensor sensitivity adjustments shall be accessible only when sensor housing is removed, and sensors shall comply with 47 CFR 15.
4. Activation Indicator: LED indicator shall not be visible during normal operation. Indicator shall light when sensor detects a standard intruder. Locate test enabling switch under sensor housing cover.

2.12 VIDEO MOTION SENSORS (INTERIOR)

A. Device Performance: Detect changes in video signal within a user-defined protected zone. Provide an alarm output for each video input.

1. Detect movement within protected zone of standard intruders wearing clothing with a reflectivity that differs from that of background scene by a factor of 2. Reject all other changes in video signal.
2. Modular design that allows for expansion or modification of number of inputs.
3. Controls:

    a. Number of detection zones.
    b. Size of detection zones.

c. Sensitivity of detection of each protected zone.

4. Mounting: Standard 19-inch (480-mm) rack as described in EIA/ECA 310-E.

2.13 MASTER CONTROL UNIT

A. Description: Supervise sensors and detection subsystems and their connecting communication links, status control (secure or access) of sensors and detector subsystems, activation of alarms and supervisory and trouble signals, and other indicated functions.

1. System software and programs shall be held in flash electrically erasable programmable read-only memory (EEPROM), retaining the information through failure of primary and secondary power supplies.
2. Include a real-time clock for time annotation of events on the event recorder and printer.
3. Addressable initiation devices that communicate device identity and status.
4. Control circuits for operation of mechanical equipment in response to an alarm.

B. Construction: As directed, freestanding equipment rack or Desk-mounted console, modular, with separate and independent alarm and supervisory system modules. Alarm-initiating protected zone boards shall be plug-in cards. Arrangements that require removal of field wiring for module replacement are unacceptable.

C. Comply with UL 609, UL 1023 or UL 1076 as directed.

D. Console Controls and Displays: Arranged for interface between human operator at master control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.

1. Annunciator and Display: LCD, one, two or three line(s) of 40 or 80 characters, minimum, as directed
2. Keypad: Arranged to permit entry and execution of programming, display, and control commands.
3. Control-Unit Network: Automatic communication of alarm, status changes, commands, and other communications required for system operation. Communication shall return to normal after partial or total network interruption such as power loss or transient event. Total or partial signaling network failures shall identify the failure and record the failure at the annunciator display and at the system printer.
4. Field Device Network: Communicate between the control unit and field devices of the system. Communications shall consist of alarm, network status, and status and control of field-mounted processors. Each field-mounted device shall be interrogated during each interrogation cycle.
5. Operator Controls: Manual switches and push-to-test buttons that do not require a key to operate. Prevent resetting of alarm, supervisory, or trouble signals while alarm or trouble condition persists. Include the following:

a. Acknowledge alarm.
b. Silence alarm.
c. System reset.

d. LED test.

6. Timing Unit: Solid state, programmable, 365 days.
7. Confirmation: Relays, contactors, and other control devices shall have auxiliary contacts that provide confirmation signals to system for their on or off status. Software shall interpret such signals, display equipment status, and initiate failure signals.
8. Alarm Indication: As directed, audible signal sounds and an LED lights at master control unit identifying the protected zone or addressable detector originating the alarm. Annunciator panel displays a common alarm light and sounds an audible tone.
9. Alarm Indication: As directed, audible signal sounds and a plain-language identification of the protected zone or addressable detector originating the alarm appears on LED or LCD display at master control unit. Annunciator panel displays a common alarm light and sounds an audible tone.
10. Alarm Indication: Audible signal sounds and a plain-language identification of the protected zone or addressable detector originating the alarm appears on LED, LCD or cathode-ray-tube display at master control unit. Annunciator panel alarm light and audible tone identify protected zone signaling an alarm.
11. Alarm activation sounds a bell, siren, strobe, bell or siren and strobe.

E. Protected Zones: Quantity of alarm and supervisory zones as indicated, with capacity for expanding number of protected zones by a minimum of 25 percent.

F. Power Supply Circuits: Master control units shall provide power for remote power-consuming detection devices. Circuit capacity shall be adequate for at least a 25 percent increase in load.

G. UPS: Comply with Section 263353 "Static Uninterruptible Power Supply." UPS shall be sized to provide a minimum of six hours of master control-unit operation.

H. Cabinet: Lockable, steel enclosure arranged so operations required for testing, normal operation, and maintenance are performed from front of enclosure. If more than a single cabinet is required to form a complete control unit, provide exactly matching modular enclosures. Accommodate all components and allow ample gutter space for field wiring. Identify each enclosure by an engraved, laminated, phenolic-resin nameplate. Lettering on enclosure nameplate shall not be less than 1 inch (25 mm) high. Identify, with permanent labels, individual components and modules within cabinets.

I. Transmission to Monitoring Station: A communications device to automatically transmit alarm, supervisory, and trouble signals to the monitoring station, operating over a standard voice grade telephone leased line. Comply with UL 1635.

J. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print system reset event, including same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.

2.14 AUDIBLE AND VISUAL ALARM DEVICES

A. Bell: Master control unit 10 inches (254 mm) in diameter, rated to produce a minimum sound output of 84 dB at 10 feet (3 m) from master control unit.

1. Enclosure: Weather-resistant steel box equipped with tamper switches on cover and on back of box.

B. Klaxon Weatherproof Motor-Driven Hooter: UL listed, rated to produce a minimum sound output of 120 dB at 3 feet (1 m), plus or minus 3 dB, at a frequency of 470 Hz. Rated for intermittent use: two minutes on and five minutes off.

1. Designed for use in industrial areas and in high-noise, severe-weather marine environments.

C. Siren: 30-W speaker with siren driver, rated to produce a minimum sound output of 103 dB at 10 feet (3 m) from master control unit.

1. Enclosure: Weather-resistant steel box with tamper switches on cover and on back of box.

D. Strobe: Xenon light complying with UL 1638, with a clear polycarbonate lens.

1. Light Output: 115 cd, minimum.
2. Flash Rate: 60 per minute.

2.15 SECURITY FASTENERS

A. Operable only by tools produced for use on specific type of fastener by fastener manufacturer or other licensed fabricator. Drive system type, head style, material, and protective coating as required for assembly, installation, and strength.

B. Drive System Types: As directed, Pinned Torx-Plus, pinned Torx or pinned hex (Allen).

C. Socket Flat Countersunk Head Fasteners:

1. Heat-treated alloy steel, ASTM F835 (ASTM F835M).
2. Stainless steel, ASTM F879 (ASTM F879M), Group 1 CW.

D. Socket Button Head Fasteners:

1. Heat-treated alloy steel, ASTM F835 (ASTM F835M).
2. Stainless steel, ASTM F879 (ASTM F879M), Group 1 CW.

E. Socket Head Cap Fasteners:

1. Heat-treated alloy steel, ASTM A574 (ASTM A574M).
2. Stainless steel, ASTM F837 (ASTM F837M), Group 1 CW.

F. Protective Coatings for Heat-Treated Alloy Steel:

1. Zinc chromate, ASTM F1135, Grade 3 or Grade 4, for exterior applications and interior applications where indicated.
2. Zinc phosphate with oil, ASTM F1137, Grade I, or black oxide unless otherwise indicated.

PART 3 - EXECUTION

3.1 SYSTEM INSTALLATION

A. Comply with UL 681 and NFPA 731.

B. Equipment Mounting: Install master control unit on finished floor with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.

1. Comply with requirements for seismic-restraint devices specified in Section 270548.16 "Seismic Controls for Communications Systems."

C. Install wall-mounted equipment, with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.

1. Comply with requirements for seismic-restraint devices specified in Section 270548.16 "Seismic Controls for Communications Systems."

D. Connecting to Existing Equipment: Verify that existing perimeter security system is operational before making changes or connections.

1. Connect new equipment to existing control panel in existing part of the building.
2. Connect new equipment to existing monitoring equipment at the Supervising Station.
3. As directed, expand, modify, and supplement existing control or monitoring equipment as necessary to extend existing control or monitoring functions to the new points. New components shall be capable of merging with existing configuration without degrading the performance of either system.

E. Security Fasteners: Where accessible to inmates, install intrusion detection components using security fasteners with head style appropriate for fabrication requirements, strength, and finish of adjacent materials except that a maximum of two different sets of tools shall be required to operate security fasteners for Project. Provide stainless-steel security fasteners in stainless-steel materials.

3.2 WIRING INSTALLATION

A. Wiring Method: Install wiring in metal raceways according to Section 270528 "Pathways for Communications Systems." Conceal raceway except in unfinished spaces and as indicated. Minimum conduit size shall be 1/2 inch (13 mm). Control and data transmission wiring shall not share conduit with other building wiring systems.

B. Wiring Method: Install wiring in metal raceways according to Section 270528 "Pathways for Communications Systems," except in accessible indoor ceiling spaces and in interior hollow gypsum board partitions where cable may be used. Conceal raceways and wiring except in

unfinished spaces and as indicated. Minimum conduit size shall be 1/2 inch (13 mm). Control and data transmission wiring shall not share conduit with other building wiring systems.

C. Wiring Method: Cable, concealed in accessible ceilings, walls, and floors when possible.

D. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Use lacing bars and distribution spools. Separate power-limited and non-power-limited conductors as recommended in writing by manufacturer. Install conductors parallel with or at right angles to sides and back of enclosure. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with intrusion system to terminal blocks. Mark each terminal according to system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

E. Wires and Cables:

1. Conductors: Size as recommended in writing by system manufacturer unless otherwise indicated.
2. 120-V Power Wiring: Install according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables" unless otherwise indicated.
3. Control and Signal Transmission Conductors: Install unshielded, twisted-pair cable unless otherwise indicated or if manufacturer recommends shielded cable, according to Section 270513 "Conductors and Cables for Communications Systems."
4. Data and Television Signal Transmission Cables: Install according to Section 270513 "Conductors and Cables for Communications Systems."

F. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

G. Install power supplies and other auxiliary components for detection devices at control units unless otherwise indicated or required by manufacturer. Do not install such items near devices they serve.

H. Identify components with engraved, laminated-plastic or metal nameplate for master control unit and each terminal cabinet, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 270553 "Identification for Communications Systems."

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with identification requirements in Section 270553 "Identification for Communications Systems."

B. Install instructions frame in a location visible from master control unit.

3.4 GROUNDING

A. Ground the master control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to master control unit.

B. Ground system components and conductor and cable shields to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

C. Signal Ground Terminal: Locate at main equipment rack or cabinet. Isolate from power system and equipment grounding. Provide 5-ohm ground. Measure, record, and report ground resistance.

D. Install grounding electrodes of type, size, location, and quantity indicated. Comply with installation requirements in Section 270526 "Grounding and Bonding for Communications Systems."

3.5 FIELD QUALITY CONTROL

A. Pretesting: After installation, align, adjust, and balance system and perform complete pretesting to determine compliance of system with requirements in the Contract Documents. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new ones and retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.

1. Report of Pretesting: After pretesting is complete, provide a letter certifying that installation is complete and fully operable; include names and titles of witnesses to preliminary tests.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections: Comply with provisions in NFPA 731, Ch. 9, "Testing and Inspections."

1. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.
2. Test Methods: Intrusion detection systems and other systems and equipment that are associated with detection and accessory equipment shall be tested according to Table "Test Methods" and Table "Test Methods of Initiating Devices."

D. Documentation: Comply with provisions in NFPA 731, Ch. 4, "Documentation."

E. Tag all equipment, stations, and other components for which tests have been satisfactorily completed.

3.6 DEMONSTRATION

A. As directed, engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain the intrusion detection system. Comply with documentation provisions in NFPA 731, Ch. 4, "Documentation and User Training."

END OF SECTION 283100

SECTION 283121 - AREA AND PERIMETER INTRUSION DETECTION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Perimeter detection and alarm system.

B. Related Sections:

1. Section 271313 "Communications Copper Backbone Cabling" for Category 5e, 6, and 7 backbone (riser-rated) cabling.
2. Section 271323 "Communications Optical Fiber Backbone Cabling" for multi- and single-mode backbone (riser-rated) optical fiber.
3. Section 271513 "Communications Copper Horizontal Cabling" for Category 5e, 6, and 7 horizontal (general use, riser-, and plenum-rated) cabling.
4. Section 271523 "Communications Optical Fiber Horizontal Cabling" for multi- and single-mode horizontal (general use, riser-, and plenum-rated) optical fiber.
5. Section 270513 "Conductors and Cables for Communications Systems" for cabling between master control units and field-mounted devices and control units.
6. Section 283100 "Intrusion Detection" for indoor-type intrusion detection devices.
7. Section 282000 "Video Surveillance" for CCTV cameras that are used as devices for video motion detection.

C. Master Control Unit: System component that accepts inputs from other control units and may also perform control-unit functions. The unit has limited capacity for the number of protected zones and is installed at an unattended location or at a location where it is not the attendant's primary function to monitor the security system.

D. Monitoring Station: Facility that receives signals and has personnel in attendance at all times to respond to signals. A central station is a monitoring station that is listed.

E. Standard Intruder: A person who weighs 100 lb (45 kg) or less and whose height is 60 inches (1525 mm) or less; dressed in a long-sleeved shirt, slacks, and shoes unless environmental conditions at the site require protective clothing.

F. Standard-Intruder Movement: Any movement, such as walking, running, crawling, rolling, or jumping, of a "standard intruder" in a protected zone.

1.2 ACTION SUBMITTALS

A. Product Data: Components for sensing, detecting, and control.

B. Shop Drawings: Detail assemblies of standard components that are custom assembled for specific application on this Project.

1. Raceway Riser Diagrams: Detail raceway runs required for perimeter security. Include designation of devices connected by raceway, raceway type and size, and type and size of wire and cable fill for each raceway run.
2. UPS: Sizing calculations.
3. Site and Floor Plans: Indicate final outlet and device locations, routing of raceways, and cables inside and outside the building. Include room layout for master control-unit console, terminal cabinet, racks, and UPS.
4. Master Control-Unit Console Layout: Show required artwork and device identification.
5. Device Address List: Coordinate with final system programming.
6. System Wiring Diagrams: Include system diagrams unique to Project. Show connections for all devices, components, and auxiliary equipment. Include diagrams for equipment and for system with all terminals and interconnections identified.
7. Details of surge protection.
8. Sensor detection patterns and adjustment ranges.

C. Design Data: Include method of operation and supervision of each component and each type of circuit. Show sequence of operations for manually and automatically initiated system or equipment inputs. Description must cover this specific Project; manufacturer's standard descriptions for generic systems are unacceptable.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Product Warranty: Sample of special warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. One spare control-unit board(s) for strain-sensitive cable system and one cable repair and splice kit(s).
2. One of each spare sensor and PIR unit and one alignment telescope(s) for long-range PIR system.
3. Fuses: Three of each kind and size.
4. Tool Kit: Provide six sets of tools for use with security fasteners, each packaged in a compartmented kit configured for easy handling and storage.
5. Security Fasteners: Furnish no fewer than 1 box for every 50 boxes or fraction thereof, of each type and size of security fastener installed.

1.6 QUALITY ASSURANCE

A. Installer Qualifications:

1. An employer of workers, at least one of whom is a technician certified by the National Burglar & Fire Alarm Association.
2. Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
3. Layout Responsibility: Preparation of Shop Drawings and cabling administration Drawings, cabling administration Drawings, and field testing program development by an RCDD a Technician.
4. Installation Supervision: Installation shall be under the direct supervision of Technician or Level 2 Commercial Installer as directed, who shall be present at all times when Work of this Section is performed at Project site.
5. Testing Supervisor: Currently certified by BICSI as an RCDD or a Technician as directed, to supervise on-site testing.

B. Testing Agency Qualifications: Certified by BICSI.

1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

1.7 PROJECT CONDITIONS

A. Environmental Conditions: Capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

1. Altitude: Sea level to 4000 feet (1220 m).
2. Master Control Unit: Rated for continuous operation in an ambient of 60 to 85 deg F (16 to 29 deg C) and a relative humidity of 20 to 80 percent, noncondensing.
3. Exterior Environment: System components installed in locations exposed to weather shall be rated for continuous operation in ambients of minus 30 to plus 122 deg F (minus 34 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, condensing. Comply with UL 294 and UL 639 for outdoor-use equipment. Rate for continuous operation when exposed to rain as specified in NEMA 250, winds up to 85 mph (137 km/h) and snow cover up to 24 inches (610 mm) thick.
4. Hazardous Environment: System components located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers or flyings shall be rated, listed, and installed according to NFPA 70.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer and Installer agree to repair or replace components of perimeter security devices and equipment that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 FUNCTIONAL DESCRIPTION OF SYSTEM

A. Description: As directed, perimeter protection system with fence-mounted systems, buried sensors or volumetric detectors integrated into a single perimeter detection and alarm system.

B. Supervision: System components shall be continuously monitored for normal, alarm, supervisory, and trouble conditions. Indicate deviations from normal conditions at any location in system. Indication includes identification of device or circuit in which deviation has occurred and whether deviation is an alarm or malfunction.

1. Alarm Signal: Display at master control unit and actuate audible and visual alarm devices.
2. Trouble Condition Signal: Distinct from other signals, indicating that system is not fully functional. Trouble signal shall indicate system problems such as battery failure, open or shorted transmission line conductors, or control-unit failure.
3. Supervisory Condition Signal: Distinct from other signals, indicating an abnormal condition as specified for the particular device or control unit.

C. System Control: Master control unit shall directly monitor gate detection devices, perimeter detection units, and connecting wiring.

D. System Control: One or more remote, addressable control units operate under control of a master control-unit microcomputer in a multiplexed distributed control system or as part of a network. Control units shall receive programming by multiplexed signal transmission from the associated master control unit and hold data in nonvolatile memory. System shall automatically reboot program without error or loss of status or alarm data after any system disturbance.

E. Operator Commands:

1. Help with System Operation: Display all commands available to operator. Help command, followed by a specific command, shall produce a short explanation of the purpose, use, and system reaction to that command.
2. Acknowledge Alarm: To indicate that alarm message has been observed by operator.
3. Place Protected Zone in Access: Disable all intrusion-alarm circuits of a specific protected zone. Tamper circuits may not be disabled by operator.
4. Place Protected Zone in Secure: Activate all intrusion-alarm circuits of a protected zone.
5. Protected Zone Test: Initiate operational test of a specific protected zone.
6. System Test: Initiate system-wide operational test.

F. Timed Control at Master Control Unit: Allow automatically timed "secure" and "access" functions of selected protected zones.

G. Automatic Control of Related Systems: Alarm or supervisory signals from certain perimeter security devices control the following functions in related systems:

1. Switch selected lights.
2. Open a signal path between certain intercommunication stations.
3. Shift sound system to "listening mode" and open a signal path to certain system speakers.

4. Switch signal to selected monitor from CCTV camera in vicinity of sensor signaling an alarm.

H. Response Time: Two seconds between actuation of any alarm and its indication at master control unit.

I. Circuit Supervision: Supervise all signal and data transmission lines, links with other systems, control units, and sensors from master control unit. Indicate circuit and detection device faults with both protected zone and trouble signals, sound a distinctive audible tone, and illuminate an LED. Maximum permissible elapsed time between occurrence of a trouble condition and indication at master control unit is 20 seconds. Initiate an alarm in response to opening, closing, shorting, or grounding of a signal or data transmission line.

J. Programmed Secure-Access Control: System shall be programmable to automatically change status of various combinations of protected zones between secure and access conditions at scheduled times. Status changes may be preset for repetitive, daily, and weekly; specially scheduled operations may be preset up to a year in advance. Manual secure-access control stations shall override programmed settings.

K. Manual Secure-Access Control: Coded entries at manual stations shall change status of associated protected zone between secure and access conditions.

2.2 SYSTEM COMPONENT REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Control Units, Devices, and Communications to Monitoring Station: Listed and labeled by a qualified testing agency for compliance with SIA CP-01.

C. FM Global Compliance: FM-Approved and -labeled perimeter security devices and equipment.

D. Comply with NFPA 70.

E. Perimeter Security Units: Listed and labeled by a qualified testing agency for compliance with UL 639.

F. Surge Protection: Protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads. Include surge protection for external wiring of each conductor entry connection to components.

1. Minimum Protection for Power Lines 120 V and More: Auxiliary panel suppressors complying with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."
2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Lines: Listed and labeled by a qualified testing agency for compliance with NFPA 731.

G. Interference Protection: Components shall be unaffected by radiated RFI and electrical induction of 15 V/m over a frequency range of 10 to 10,000 MHz and conducted interference signals up to 0.25-V rms injected into power supply lines at 10 to 10,000 MHz.

H. Tamper Protection: Tamper switches on detection devices, control units, annunciators, pull boxes, junction boxes, cabinets, and other system components shall initiate a tamper-alarm signal when unit is opened or partially disassembled and when entering conductors are cut or disconnected. Master control-unit alarm display shall identify tamper alarms and indicate locations.

I. Self-Testing Devices: Automatically test themselves periodically, but not less than once per hour, to verify normal device functioning and alarm initiation capability. Devices transmit test failure to master control unit.

J. Antimasking Devices: Automatically check operation continuously or at intervals of a minute or less, and use signal-processing logic to detect blocking, masking, jamming, tampering, or other operational dysfunction. Devices transmit detection of operational dysfunction to master control unit as an alarm signal.

K. Addressable Devices: Transmitter and receivers shall communicate unique device identification and status reports to master control unit.

L. Remote-Controlled Devices: Individually and remotely adjustable for sensitivity and individually monitored at master control unit for calibration, sensitivity, and alarm condition.

2.3 ENCLOSURES

A. Interior Electronics: NEMA 250, Type 12.

B. Exterior Electronics: NEMA 250, Type 4X, fiberglass or stainless steel.

C. Corrosion Resistant: NEMA 250, Type 4X, PVC or stainless steel as directed.

D. Terminal cabinets in handholes and manholes shall be NEMA 250, Type 6 or Type 6P as directed.

E. Screw Covers: Where enclosures are readily accessible, secure with security fasteners of type appropriate for enclosure.

2.4 SECURE AND ACCESS DEVICES

A. Keypad and Display Module: Arranged for entering and executing commands for system-status changes and for displaying system-status and command-related data.

B. Key-Operated Switch: Change protected zone between secure and access conditions.

2.5 STRAIN-SENSITIVE CABLE

A. Description: Fence-mounted strain-sensitive, coaxial transducer cable shall monitor chain-link-type and welded-mesh-type fence and generate an alarm when a standard intruder attempts to climb over, cut through, or lift fence fabric.

B. Environment: Suitable for exterior installation and the following conditions:

1. Ambient Temperatures: Ranging from minus 22 to plus 158 deg F (minus 30 to plus 70 deg C).

C. Transducer Cable:

1. UV-resistant cable furnished by system manufacturer.
2. Suitable for up to 1000 feet (300 m) of sensor cable per single-zone control unit and up to 2000 feet (600 m) of sensor cable per dual-zone processor.
3. Sensitivity shall be uniform throughout its entire length, requiring only one variable sensitivity adjustment throughout its entire length.

D. Control Unit:

1. Field mounted, with tamper switch at control-unit board.
2. Electronic circuitry shall discriminate between acceptable fence movement and intrusion-related disturbances.
3. Sensitivity, count control, and climb-over processors shall be adjustable with a minimum of five individual count-control and climb-over adjustments.
4. Control-unit output shall have adjustable pulse width to adjust the time the alarm relay will activate per detected intrusion attempt.

E. System Performance:

1. Immune to RFI and EMI environments; interference shall have no effect on normal operational characteristics.
2. Trouble and Tamper: Entire sensor system shall be fully supervised with individually monitored tamper and supervision alarms. Disconnecting, cutting, or shorting of strain-sensitive cable results in supervisory alarm.
3. Intrusion Simulation: Each zone shall have a self-test feature that, when activated by a signal from master control unit will produce an intrusion alarm and verify operation of sensor.

2.6 LONG-RANGE PIR DETECTORS

A. Description: Volumetric passive infrared detection system.

B. Listed and labeled by a qualified testing agency for compliance with SIA PIR-01.

C. Environment: Suitable for exterior installation and the following conditions:

1. Ambient Temperatures: Ranging from minus 30 to plus 150 deg F (minus 34 to plus 65 deg C).

D. System Performance: Detect an interruption of dual-infrared light beams that link transmitters and receivers. Generate an alarm when signal is interrupted due to presence of an object that interrupts both beams.

1. Sensitivity: Field adjustable to allow adjustment of range from 25 to 500 feet (7.6 to 152 m), generating an alarm within 20 to 50 ms when both beams are interrupted.

2. Detection system shall adjust automatically to compensate for weather, including fog, rain, snow, blowing dust, and rapid temperature changes.
3. Motion Detection: Detect standard-intruder movement at rates from 0.1 to 50 fps (0.03 to 15.2 m/s).
4. Supervision: Generate supervisory alarm if any portion of system is tampered with.
5. Remote Test: When initiated by master control unit, start a test sequence for each detector element that simulates standard-intruder movement within sensor's detection patterns, causing an alarm.

2.7 GEOPHONE FENCE DETECTION

A. Description: Fence-mounted system to detect attempts to cut or climb the protected fence, using geophone sensors that respond to specific shock or vibrations.

B. Environment: Suitable for exterior installation and the following conditions:

1. Ambient Temperatures: Ranging from minus 30 to plus 150 deg F (minus 34 to plus 65 deg C).

C. System Performance:

1. Control Unit: 10 zone capacity for processing geophone generated analog signals. Each zone shall consist of not more than 10 sensors.

   a. Adjustments: For each zone, provide stepped gain control for sensitivity and switches for geophone signal filters to minimize nuisance alarms. System shall adjust automatically to compensate for weather, including fog, rain, snow, blowing dust, and rapid temperature changes.
   b. Trouble Condition Signal: Generate when any zone fails.
   c. Supervisory Condition Signal: Generate on interference with control-unit operation or when detecting a break-in into an enclosure housing electronics.

2. Sensors: Fence mounted 20 feet (6 m) o.c.
3. Cable for Interconnection of System Components: Shielded, PVC jacketed and armored, as supplied by system manufacturer.
4. Test each zone simulating an alarm condition. As directed, Test by command from master control or test switch at control unit inside the enclosure.

2.8 VIDEO MOTION SENSOR

A. Description: Video-surveillance-based detection system.

B. Device Performance: Detect changes in video signal within a user-defined protected zone. Provide an alarm output for each video input.

1. Detect movement within protected zone of standard intruders wearing clothing with a reflectivity that differs from that of background scene by a factor of 2. Reject all other changes in video signal.
2. Modular design that allows for expansion or modification of number of inputs.

3. Adjustable Controls:

   a. Number of detection zones.
   b. Size of detection zones.
   c. Sensitivity of detection of each protected zone.

4. Mounting: Standard 19-inch (480-mm) rack as described in EIA/ECA 310-E.

C. Environment: Suitable for installation in interior air-conditioned spaces.

2.9 GATE UNITS

A. Description: Fence-mounted gate-movement detectors, balanced-magnetic type, and UL listed for outdoor locations. Units shall be designed for mounting on single- or double-leaf swinging or rolling gates and have armored jumper cables between switch and stationary junction box for wiring to master control unit and tamper switches in junction box.

B. Device Performance: Bias magnet and at least three encapsulated-reed switches that resist compromise from introduction of foreign magnetic fields, with integral overcurrent protective device to limit current to 80 percent of switch capacity.

C. Remote Test: Simulate movement of actuating magnet from master control unit.

2.10 FIELD-MOUNTED CONTROL UNITS

A. Field-mounted control units shall include the power supply and detector specific functions, and provide for communications with the master control unit. Control unit shall include read-only resident software needed for startup, a time clock, and all automatic operations. Software shall be downloaded from the master control unit.

B. Battery Backup: UPS, providing six hours of run time during a power outage, with two-rate automatic battery charger to fully recharge batteries within 12 hours after normal power is restored.

1. Batteries: Rechargeable, valve-regulated, recombinant, sealed, lead-acid type with nominal 10-year life expectancy.
2. Battery Charger: Solid-state, fully automatic, variable-charging-rate type. Charger shall recharge fully discharged battery within 24 hours.

C. Annunciation: Indicate a change in system condition and switching of system or component to backup power.

2.11 MASTER CONTROL UNIT

A. Description: Supervise sensors and detection subsystems and their connecting communication links, status control (secure or access) of sensors and detector subsystems, activation of alarms and supervisory and trouble signals, and other indicated functions.

1. System software and programs shall be held in flash electrically erasable programmable read-only memory (EEPROM), retaining the information through failure of primary and secondary power supplies.
2. Include a real-time clock for time annotation of events on the event recorder.
3. Addressable initiation devices that communicate device identity and status.
4. Control circuits for operation of mechanical equipment in response to an alarm.

B. Construction: Freestanding equipment rack, Desk-mounted console, modular, with separate and independent alarm and supervisory system modules as directed. Alarm-initiating protected zone boards shall be plug-in cards. Arrangements that require removal of field wiring for module replacement are unacceptable.

C. Comply with UL 609, UL 681 or UL 1076 as directed.

D. Console Controls and Displays: Arranged for interface between human operator at master control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.

1. Annunciator and Display: LCD type, quantity of line(s) as directed, of 40 or 80 characters, minimum as directed.
2. Keypad: Arranged to permit entry and execution of programming, display, and control commands
3. Control-Unit Network: Automatic communication of alarm, status changes, commands, and other communications required for system operation. Communication shall return to normal after partial or total network interruption such as power loss or transient event. Total or partial signaling network failures shall identify the failure and record the failure at the annunciator display.
4. Field Device Network: Communicate between the control unit and field devices of the system. Communications shall consist of alarm, network status, and status and control of field-mounted processors. Each field-mounted device shall be interrogated during each interrogation cycle.
5. Operator Controls: Manual switches and push-to-test buttons that do not require a key to operate. Prevent resetting of alarm, supervisory, or trouble signals while alarm or trouble condition persists. Include the following:

    a. Acknowledge alarm.
    b. Silence alarm.
    c. System reset.
    d. LED test.

6. Timing Unit: Solid state, programmable, 365 days.
7. Confirmation: Relays, contactors, and other control devices shall have auxiliary contacts that provide confirmation signals to system for their on or off status. Software shall interpret such signals, display equipment status, and initiate failure signals.
8. Alarm Indication: An audible signal sounds and an LED lights at master control unit identifying the protected zone, addressable detector originating the alarm as directed. Annunciator panel displays a common alarm light and sounds an audible tone.
9. Alarm Indication: As directed, an audible signal sounds and a plain-language identification of the protected zone or addressable detector originating the alarm appears

on LED or LCD display at master control unit. Annunciator panel displays a common alarm light and sounds an audible tone.

10. Alarm Indication: As directed, an audible signal sounds and a plain-language identification of the protected zone or addressable detector originating the alarm appears on LED, LCD or cathode-ray-tube display at master control unit. Annunciator panel alarm light and audible tone identify protected zone signaling an alarm.
11. As directed, alarm activation sounds a bell, siren, strobe or bell or siren and strobe.

E. Protected Zones: Quantity of alarm and supervisory zones as indicated, with capacity for expanding number of protected zones by a minimum of 25 percent.

F. Power Supply Circuits: Master control units shall provide power for remote power-consuming detection devices. Circuit capacity shall be adequate for at least a 25 percent increase in load.

G. UPS: Comply with Section 263353 "Static Uninterruptible Power Supply." UPS shall be sized to provide a minimum of six hours of master control-unit operation.

H. Cabinet: Lockable, steel enclosure arranged so operations required for testing, normal operation, and maintenance are performed from front of enclosure. If more than a single cabinet is required to form a complete control unit, provide exactly matching modular enclosures. Accommodate all components and allow ample gutter space for field wiring. Identify each enclosure by an engraved, laminated, phenolic-resin nameplate. Lettering on enclosure nameplate shall not be less than 1 inch (25 mm) high. Identify, with permanent labels, individual components and modules within cabinets.

I. Transmission to Monitoring Station: A communications device to automatically transmit alarm, supervisory, and trouble signals to the monitoring station, operating over a standard voice grade telephone leased line. Comply with UL 1635.

2.12 AUDIBLE AND VISUAL ALARM DEVICES

A. Bell: 10 inches (254 mm) in diameter, rated to produce a minimum sound output of 84 dB at 10 feet (3 m) from master control unit.

1. Enclosure: Weather-resistant steel box equipped with tamper switches on cover and on back of box.

B. Klaxon Weatherproof Motor-Driven Hooter: UL listed, rated to produce a minimum sound output of 120 dB at 3 feet (1 m), plus or minus 3 dB, at a frequency of 470 Hz. Rated for intermittent use: two minutes on, five minutes off.

1. Designed for use in industrial areas and in high-noise, severe-weather marine environments.

C. Siren: 30-W speaker with siren driver, rated to produce a minimum sound output of 103 dB at 10 feet (3 m) from master control unit.

1. Enclosure: Weather-resistant steel box with tamper switches on cover and on back of box.

D. Strobe: Xenon light complying with UL 1638, with a clear polycarbonate lens.

1. Light Output: 115 cd, minimum.
2. Flash Rate: 60 per minute.

2.13 SECURITY FASTENERS

A. Operable only by tools produced for use on specific type of fastener by fastener manufacturer or other licensed fabricator. Drive system type, head style, material, and protective coating as required for assembly, installation, and strength.

B. Drive System Types: Pinned Torx-Plus, pinned Torx or pinned hex (Allen) as directed.

C. Socket Flat Countersunk Head Fasteners:

1. Heat-treated alloy steel, ASTM F835 (ASTM F835M).
2. Stainless steel, ASTM F879 (ASTM F879M), Group 1 CW.

D. Socket Button Head Fasteners:

1. Heat-treated alloy steel, ASTM F835 (ASTM F835M).
2. Stainless steel, ASTM F879 (ASTM F879M), Group 1 CW.

E. Socket Head Cap Fasteners:

1. Heat-treated alloy steel, ASTM A574 (ASTM A574M).
2. Stainless steel, ASTM F837 (ASTM F837M), Group 1 CW.

F. Protective Coatings for Heat-Treated Alloy Steel:

1. Zinc chromate, ASTM F1135, Grade 3 or Grade 4, for exterior applications and interior applications where indicated.
2. Zinc phosphate with oil, ASTM F1137, Grade I, or black oxide unless otherwise indicated.

PART 3 - EXECUTION

3.1 SYSTEM INSTALLATION

A. Comply with UL 681 and NFPA 731.

B. Equipment Mounting: Install master control unit on finished floor with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.

1. Comply with requirements for seismic-restraint devices specified in Section 270548.16 "Seismic Controls for Communications Systems."

C. Install wall-mounted equipment, with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.

1. Comply with requirements for seismic-restraint devices specified in Section 270548.16 "Seismic Controls for Communications Systems."

D. Connecting to Existing Equipment: Verify that existing perimeter security system is operational before making changes or connections.

1. Connect new equipment to existing control panel in existing part of the building.
2. Connect new equipment to existing monitoring equipment at the Supervising Station.
3. Expand, modify, and supplement existing control or monitoring equipment as necessary to extend existing control or monitoring functions to the new points as directed. New components shall be capable of merging with existing configuration without degrading the performance of either system.

E. Security Fasteners: Where accessible to public, install perimeter security components using security fasteners with head style appropriate for fabrication requirements, strength, and finish of adjacent materials except that a maximum of two different sets of tools shall be required to operate security fasteners for Project. Provide stainless-steel security fasteners in stainless-steel materials.

F. Wiring Method: Install power, signal, and data transmission wire and cable in metal raceways according to Section 270543 "Underground Pathways and Structures for Communications Systems" and Section 270528 "Pathways for Communications Systems." Minimum conduit size shall be 1/2 inch (13 mm). Control and data transmission wiring shall not share conduit with other building wiring systems.

G. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Use lacing bars and distribution spools. Separate power-limited and non-power-limited conductors as recommended in writing by manufacturer. Install conductors parallel with or at right angles to sides and back of enclosure. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with perimeter security system to terminal blocks. Mark each terminal according to system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

H. Wires and Cables:

1. Conductors: Size as recommended in writing by system manufacturer unless otherwise indicated.
2. 120-V Power Wiring: Install according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables" unless otherwise indicated.
3. Cable for Low-Voltage Control and Signal Circuits: Install unshielded, twisted-pair cable unless otherwise indicated or if manufacturer recommends shielded cable, according to Section 270513 "Conductors and Cables for Communications Systems."
4. Data and Television Signal Transmission Cables: Install according to Section 270513 "Conductors and Cables for Communications Systems."

I. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

J. Install power supplies and other auxiliary components for detection devices at control units unless otherwise indicated or required by manufacturer. Do not install such items near devices they serve.

K. Stain-Sensitive Transducer Cable: Attached to fence at 12-inch (300-mm) intervals with tie wraps.

3.2 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with identification requirements in Section 270553 "Identification for Communications Systems."

B. Install instructions frame in a location visible from master control unit.

3.3 GROUNDING

A. Ground the master control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to master control unit.

B. Ground system components and conductor and cable shields to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

C. Signal Ground Terminal: Locate at main equipment rack or cabinet. Isolate from power system and equipment grounding. Provide 5-ohm ground. Measure, record, and report ground resistance.

D. Install grounding electrodes of type, size, location, and quantity indicated. Comply with installation requirements in Section 270526 "Grounding and Bonding for Communications Systems."

3.4 FIELD QUALITY CONTROL

A. Pretesting: After installation, align, adjust, and balance system and perform complete pretesting to determine compliance of system with requirements in the Contract Documents. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new ones and retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.

1. Report of Pretesting: After pretesting is complete, provide a letter certifying that installation is complete and fully operable; include names and titles of witnesses to preliminary tests.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections: Comply with provisions in NFPA 731, Ch. 9, "Testing and Inspections."

1. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.

2. Test Methods: Perimeter security systems and other systems and equipment that are associated with detection and accessory equipment shall be tested according to Table "Test Methods" and Table "Test Methods of Initiating Devices."
3. Geophone System Tests: Test each zone at a minimum of two different locations. Test each zone as follows:

    a. Horizontal Movement: Adjust sensitivity to screen out alarms from wind.
    b. Vertical Climb: 100 percent detection required. Set count at three occurrences within 90-second window.
    c. Cut Test: 100 percent detection required. Set count at two occurrences within 120-second window.
    d. Set sensitivity to value as low as possible, consistent with reliable detection.
    e. If performance tests fail, make adjustments to sensors to comply with requirements. Retest failing and adjacent zones to comply with test.

4. Strain-Sensitive Cable System Tests: Adjust sensitivity and count control to value as low as possible, consistent with reliable detection.
5. Long-Range PIR System Tests: Adjust sensitivity and hold time between activity duration to value as low as possible, consistent with reliable detection.

D. Documentation: Comply with provisions in NFPA 731, Ch. 4, "Documentation."

E. Tag all equipment, stations, and other components at which tests have been satisfactorily completed.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain the perimeter security system as directed. Comply with documentation provisions in NFPA 731, Ch. 4, "Documentation and User Training."

END OF SECTION 283121

SECTION 284400 - REFRIGERANT DETECTION AND ALARM

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes refrigerant monitors and notification appliances.

1.2 ACTION SUBMITTALS

A. Product Data:

1. For each type of refrigerant monitor, include refrigerant sensing range in ppm, temperature and humidity range, alarm outputs, display range, furnished specialties, installation requirements, and electric power requirement.

B. Shop Drawings:

1. Air-Sampling Tubing: Size, routing, and termination including elevation above finished floor.
2. Wiring Diagrams: Power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control test reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PIR REFRIGERANT MONITOR

A. Description: Sensor shall be factory tested, calibrated, and certified to continuously measure and display the specific gas concentration and shall be capable of indicating, alarming, shutting down fuel-fired equipment, and automatically activating ventilation system.

B. Standard: Monitoring system shall comply with ASHRAE 15 and ASHRAE 147.

C. Performance:

1. Refrigerant to Be Monitored: As directed.
2. Range: 0 to 1000 ppm.

3. Sensitivity:

    a. Minimum Detectability: 1 ppm.
    b. Accuracy: 0 to 50 ppm; plus or minus 1 ppm. 51 to 1000 ppm; plus or minus 10 percent of reading.
    c. Repeatability: Plus or minus 1 percent of full scale.
    d. Response: Maximum 10 seconds per sample.
    e. Detection Level Set Points:

        1) Detection Level 1: 1 ppm.
        2) Detection Level 2 or Level 1: 10 or 50 ppm as directed.
        3) Detection Level 3 or Level 2: 50 or 250 ppm as directed.

4. Sensitivity:

    a. Minimum Detectability: 20 ppm.
    b. Accuracy: 0 to 100 ppm; plus or minus 20 ppm, 100 to 1000 ppm; plus or minus 5 percent of reading.
    c. Repeatability: Plus or minus 1 percent of full scale.
    d. Response: 50 percent of a step change in 60 seconds.
    e. Detection Level Set Points:

        1) Detection Level 1: 20 ppm.
        2) Detection Level 2 or Level 1 as directed: 50 ppm.
        3) Detection Level 3 or Level 2 as directed: 250 ppm.

5. Operating Temperature: 32 to 104 deg F (0 to 40 deg C).
6. Relative Humidity: 20 to 95 percent, noncondensing over the operating temperature range. Compensate sensor for relative humidity.
7. Site Elevation: Maximum 6560 feet (2000 m).

D. Input/Output Features:

1. Maximum Power Input: 120-V ac, 60 Hz, 75 W.
2. Number of Air-Sampling Points: As directed.
3. Air-Sampling Point Inlet Filter: 0.10-micron filter element for each sampling point.
4. Air-Sampling Point Analog Output: 0- to 10-V dc into 2k ohms, or 4- to 20-mA into 1k ohms matched to sensor output.
5. Alarm Relays: Minimum 3 or 4 relays at a minimum of 5-A resistive load each as directed.
6. Alarm Set Points: Displayed and adjustable through keypad on front of meter.
7. Alarm Silence Switch: Mount in the front panel of the monitor to stop audible and visual notification appliances, but alarm LED remains illuminated.
8. Alarm Manual Reset: Momentary-contact push button in the front panel of the monitor stops audible and visual notification appliances, extinguishes alarm LED, and returns monitor to detection mode at current detection levels.
9. Display: Alphanumeric LCD, LED indicating lights for each detection level; acknowledge switch and test switch mounted on front panel; alarm status LEDs and service fault/trouble LEDs.
10. Audible Output: Minimum 75 dB at 10 feet (3 m).
11. Visible Output: Strobe light.

12. Sensor Analog Output: 0- to 10-V dc into 2k ohms, or 4- to 20-mA into 1k ohms.
13. Serial Output: RS-232 or RS-485 compatible with HVAC controls.
14. Enclosure: NEMA 250, Type 1 or Type 12, with locking quarter-turn latch and key.

2.2 MONITOR ALARM SEQUENCE

A. Detection Level 1: Notify HVAC control workstation of detection in the refrigeration equipment room on a rise or fall of refrigerant concentration to this level. Start ventilation system at low speed to allow occupancy by maintenance technicians to identify leaks. Cycle blue strobe lights.

B. Detection Level 2 or Level 1 as directed: Notify the HVAC control workstation of the detection in the refrigeration equipment room on a rise or fall of refrigerant concentration to this level. Run ventilation system at high speed on a rise in concentration to this level, and change to low speed on a reduction in concentration below this level. Operate the ventilation system at high speed for a minimum of five minutes. Cycle amber strobe lights.

C. Detection Level 3 or Level 2 as directed: Notify the HVAC control workstation of the detection in the refrigeration equipment room on a rise or fall of refrigerant concentration to this level. Sound alarm horns and cycle red strobe lights inside and outside refrigeration equipment room. Terminate operation of any combustion-process equipment located in the refrigeration equipment room. Provide manual reset for this detection level.

D. Sensor Fault/Trouble: Notify HVAC control workstation of fault/trouble detection in monitor.

2.3 NOTIFICATION APPLIANCES

A. Horns: Comply with UL 464; electric-vibrating-polarized type, listed by a qualified testing agency with provision for housing the operating mechanism behind a grille. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet (3 m) from the horn.

B. Visible Alarm Devices: Comply with UL 1971; three color xenon strobe lights, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The words "REFRIGERANT DETECTION" printed in minimum 1/2-inch- (13-mm-) high letters on the lens. Rated light output is 75 or 110 candela as directed.

2.4 AIR-SAMPLING TUBING

A. Annealed-Temper Copper Tubing: ASTM B88, Type L (ASTM B88M, Type B).

B. Polyethylene Tubing: ASTM D2737, flame-retardant, nonmetallic tubing rated for ambient temperature range of 10 to 150 deg F (minus 13 to plus 65 deg C).

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with ASHRAE 15 and ASHRAE 147.

B. Install air-sampling inlets, or diffusion type monitors in pits, tunnels, or trenches in machinery room that are accessible to personnel.

C. Floor mount diffusion-type monitor, sensor/transmitters, or air-sampling inlets on slotted channel frame 12 to 18 inches (300 to 450 mm) above the floor in a location near the refrigerant source or between the refrigerant source and the ventilation duct inlet.

D. Wall mount air-sampling multiple-point monitors with top of unit 60 inches (1525 mm) above finished floor.

E. Run air-sampling tubing from monitor to air-sampling point, in size as required by monitor manufacturer. Install tubing with maximum unsupported length of 36 inches (915 mm), for tubing exposed to view. Terminate air-sampling tubing at sampling point with filter recommended by monitor manufacturer.

F. Install air-sampling tubing with sufficient slack and flexible connections to allow for vibration of tubing and movement of equipment.

G. Purge air-sampling tubing with dry, oil-free compressed air before connecting to monitor.

H. Number-code or color-code air-sampling tubing for future identification and service of air-sampling multiple-point monitors.

I. Extend air-sampling tubing from exhaust part of multiple-point monitors to outside.

J. Install warning signs, labels, and nameplates to identify detection devices according to Section 230553 "Identification for HVAC Piping and Equipment."

K. Place warning signs inside and outside each door to the refrigeration equipment room. Sample wording: "AUDIBLE AND VISUAL ALARM SOUNDING INDICATES REFRIGERANT DETECTION - ENTRY REQUIRES SELF-CONTAINED BREATHING APPARATUS."

L. Audible Alarm-Indicating Devices: Install at each entry door to refrigeration equipment room, and position not less than 6 inches (150 mm) below the ceiling. Install horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille.

M. Visible Alarm-Indicating Devices: Install adjacent to each alarm horn at each entry door to refrigeration equipment room, and position at least 6 inches (150 mm) below the ceiling.

3.2 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

B. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. Inspect field-assembled components, equipment installation, and electrical connections for compliance with requirements.
2. Test and adjust controls and safeties.
3. Test Reports: Prepare a written report to record the following:

a. Test procedures used.
b. Test results that comply with requirements.
c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

D. Repair or replace malfunctioning units and retest as specified above.

END OF SECTION 284400

SECTION 284621.11 - ADDRESSABLE FIRE-ALARM SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fire-alarm control unit.
2. Manual fire-alarm boxes.
3. System smoke detectors.
4. Nonsystem smoke detectors.
5. Heat detectors.
6. Notification appliances.
7. Magnetic door holders.
8. Remote annunciator.
9. Addressable interface device.
10. Digital alarm communicator transmitter.

B. Related Requirements:

1. Section 271513 "Communications Copper Horizontal Cabling" for cables and conductors for fire-alarm systems.

1.2 ACTION SUBMITTALS

A. General Submittal Requirements:

1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.
2. Shop Drawings shall be prepared by persons with the following qualifications:

    a. Trained and certified by manufacturer in fire-alarm system design.
    b. NICET-certified, fire-alarm technician; Level III or Level IV minimum as directed.
    c. Licensed or certified by authorities having jurisdiction.

B. Product Data: For each type of product, including furnished options and accessories.

C. Shop Drawings: For fire-alarm system.

1. Comply with recommendations and requirements in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
2. Include plans, elevations, sections, details, and attachments to other work.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.
4. Detail assembly and support requirements.

5. Include voltage drop calculations for notification-appliance circuits.
6. Include battery-size calculations.
7. Include input/output matrix.
8. Include statement from manufacturer that all equipment and components have been tested as a system and meet all requirements in this Specification and in NFPA 72.
9. Include performance parameters and installation details for each detector.
10. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
11. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale; coordinate location of duct smoke detectors and access to them.

    a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.
    b. Show field wiring required for HVAC unit shutdown on alarm.
    c. Locate detectors according to manufacturer's written recommendations.

12. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits and point-to-point wiring diagrams.

D. Delegated-Design Submittal: For notification appliances and smoke and heat detectors, in addition to submittals listed above, indicate compliance with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Drawings showing the location of each notification appliance and smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the device.
2. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72. Calculate spacing and intensities for strobe signals and sound-pressure levels for audible appliances.
3. Indicate audible appliances required to produce square wave signal per NFPA 72.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Seismic Qualification Data: Certificates, for fire-alarm control unit, accessories, and components, from manufacturer.

C. Field quality-control reports.

D. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following and deliver copies to authorities having jurisdiction:

    a. Comply with the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
    b. Provide "Fire Alarm and Emergency Communications System Record of Completion Documents" according to the "Completion Documents" Article in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
    c. Complete wiring diagrams showing connections between all devices and equipment.
    d. Riser diagram.
    e. Record copy of site-specific software.
    f. Provide "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:

        1) Equipment tested.
        2) Frequency of testing of installed components.
        3) Frequency of inspection of installed components.
        4) Requirements and recommendations related to results of maintenance.
        5) Manufacturer's user training manuals.

    g. Manufacturer's required maintenance related to system warranty requirements.
    h. Abbreviated operating instructions for mounting at fire-alarm control unit and each annunciator unit.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm technician level as directed.

C. NFPA Certification: Obtain certification according to NFPA 72 by an NRTL (nationally recognized testing laboratory).

D. NFPA Certification: Obtain certification according to NFPA 72 by a UL-listed alarm company.

E. NFPA Certification: Obtain certification according to NFPA 72 in the form of a placard by an FM Global-approved alarm company.

F. NFPA Certification: Obtain certification according to NFPA 72 as directed.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail in materials or workmanship within specified warranty period.

1. Warranty Extent: All equipment and components not covered in the Maintenance Service Agreement.
2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Source Limitations for Fire-Alarm System and Components: Components shall be compatible with, and operate as an extension of, existing system. Provide system manufacturer's certification that all components provided have been tested as, and will operate as, a system.

B. Noncoded, UL-certified or FM Global-placarded addressable system as directed, with multiplexed signal transmission and horn/strobe evacuation.

C. Automatic sensitivity control of certain smoke detectors.

D. All components provided shall be listed for use with the selected system.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices and systems:

1. Manual stations.
2. Heat detectors.
3. Smoke detectors.
4. Duct smoke detectors.
5. Carbon monoxide detectors.
6. Automatic sprinkler system water flow.
7. Fire-extinguishing system operation.
8. Fire standpipe system.
9. Dry system pressure flow switch.

B. Fire-alarm signal shall initiate the following actions:

1. Continuously operate alarm notification appliances.
2. Identify alarm and specific initiating device at fire-alarm control unit and remote annunciators.
3. Transmit an alarm signal to the remote alarm receiving station.
4. Unlock electric door locks in designated egress paths.

5. Release fire and smoke doors held open by magnetic door holders.
6. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
7. Close smoke dampers in air ducts of designated air-conditioning duct systems.
8. Activate preaction system.
9. Recall elevators to primary or alternate recall floors.
10. Activate elevator power shunt trip.
11. Activate emergency lighting control.
12. Activate emergency shutoffs for gas and fuel supplies.
13. Record events in the system memory.
14. Insert signal-initiating actions.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:

1. Valve supervisory switch.
2. High- or low-air-pressure switch of a dry-pipe or preaction sprinkler system.
3. Elevator shunt-trip supervision.
4. Loss of communication with any panel on the network.

D. System trouble signal initiation shall be by one or more of the following devices and actions:

1. Open circuits, shorts, and grounds in designated circuits.
2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3. Loss of communication with any addressable sensor, input module, relay, control module, or remote annunciator.
4. Loss of primary power at fire-alarm control unit.
5. Ground or a single break in internal circuits of fire-alarm control unit.
6. Abnormal ac voltage at fire-alarm control unit.
7. Break in standby battery circuitry.
8. Failure of battery charging.
9. Abnormal position of any switch at fire-alarm control unit or annunciator.

E. System Supervisory Signal Actions:

1. Initiate notification appliances.
2. Identify specific device initiating the event at fire-alarm control unit and remote annunciators.
3. After a time delay of 200 seconds, transmit a trouble or supervisory signal to the remote alarm receiving station.

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Fire-alarm control unit and raceways shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.4 FIRE-ALARM CONTROL UNIT

A. General Requirements for Fire-Alarm Control Unit:

1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864.
2. Addressable Initiation Device Circuits: The FACP shall indicate which communication zones have been silenced and shall provide selective silencing of alarm notification appliance by building communication zone.
3. Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: The FACP shall be listed for releasing service.

B. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.

1. Annunciator and Display: Liquid-crystal type, 80 characters, minimum.
2. Keypad: Arranged to permit entry and execution of programming, display, and control commands.

C. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits:

1. Pathway Class Designations: NFPA 72, class as directed.
2. Pathway Survivability: Level 0 or Level 1 as directed.

D. Notification-Appliance Circuit:

1. Audible appliances shall sound in a three-pulse temporal pattern, as defined in NFPA 72.
2. Where notification appliances provide signals to sleeping areas, the alarm signal shall be a 520-Hz square wave with an intensity 15 dB above the average ambient sound level or 5 dB above the maximum sound level, or at least 75 dBA, whichever is greater, measured at the pillow.
3. Visual alarm appliances shall flash in synchronization where multiple appliances are in the same field of view, as defined in NFPA 72.

E. Elevator Recall:

1. Elevator recall shall be initiated only by one of the following alarm-initiating devices:

    a. Elevator lobby detectors except the lobby detector on the designated floor.
    b. Smoke detector in elevator machine room.
    c. Smoke detectors in elevator hoistway.

2. Elevator controller shall be programmed to move the cars to the alternate recall floor if lobby detectors located on the designated recall floors are activated.
3. Water-flow alarm connected to sprinkler in an elevator shaft and elevator machine room shall shut down elevators associated with the location without time delay.

    a. Water-flow switch associated with the sprinkler in the elevator pit may have a delay to allow elevators to move to the designated floor.

F. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke-barrier walls shall be or not be connected to fire-alarm system.

G. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory.

H. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.

I. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory signals, supervisory and digital alarm communicator transmitters and digital alarm radio transmitters shall be powered by 24-V dc source.

1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.

J. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.

2.5 MANUAL FIRE-ALARM BOXES

A. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38.

1. Single-action mechanism, breaking-glass or plastic-rod or pull-lever type as directed; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
2. Station Reset: Key- or wrench-operated switch.

2.6 SYSTEM SMOKE DETECTORS

A. General Requirements for System Smoke Detectors:

1. Comply with UL 268; operating at 24-V dc, nominal.
2. Detectors shall be four or two-wire type as directed.
3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
4. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
6. Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.

7. Remote Control: Unless otherwise indicated, detectors shall be digital-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.

    a. Rate-of-rise temperature characteristic of combination smoke- and heat-detection units shall be selectable at fire-alarm control unit for 15 or 20 deg F (8 or 11 deg C) per minute.
    b. Fixed-temperature sensing characteristic of combination smoke- and heat-detection units shall be independent of rate-of-rise sensing and shall be settable at fire-alarm control unit to operate at 135 or 155 deg F (57 or 68 deg C).
    c. Multiple levels of detection sensitivity for each sensor.
    d. Sensitivity levels based on time of day.

B. Photoelectric Smoke Detectors:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

    a. Primary status.
    b. Device type.
    c. Present average value.
    d. Present sensitivity selected.
    e. Sensor range (normal, dirty, etc.).

C. Ionization Smoke Detector:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

    a. Primary status.
    b. Device type.
    c. Present average value.
    d. Present sensitivity selected.
    e. Sensor range (normal, dirty, etc.).

D. Duct Smoke Detectors: Photoelectric type complying with UL 268A.

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

    a. Primary status.
    b. Device type.
    c. Present average value.
    d. Present sensitivity selected.

e. Sensor range (normal, dirty, etc.).

3. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector for smoke detection in HVAC system ducts.
4. Each sensor shall have multiple levels of detection sensitivity.
5. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
6. Relay Fan Shutdown: Fully programmable relay rated to interrupt fan motor-control circuit.

2.7 CARBON MONOXIDE DETECTORS

A. General: Carbon monoxide detector listed for connection to fire-alarm system.

1. Mounting: Adapter plate for outlet box mounting.
2. Testable by introducing test carbon monoxide into the sensing cell.
3. Detector shall provide alarm contacts and trouble contacts.
4. Detector shall send trouble alarm when nearing end-of-life, power supply problems, or internal faults.
5. Comply with UL 2075.
6. Locate, mount, and wire according to manufacturer's written instructions.
7. Provide means for addressable connection to fire-alarm system.
8. Test button simulates an alarm condition.

2.8 NONSYSTEM SMOKE DETECTORS

A. General Requirements for Non-system Smoke Detectors:

1. Non-system smoke detectors shall be listed as compatible with the fire-alarm equipment installed or shall have a contact closure interface listed for the connected load.
2. Non-system smoke detectors shall meet the monitoring for integrity requirements in NFPA 72.

B. Single-Station Smoke Detectors:

1. Comply with UL 217; suitable for NFPA 101, residential occupancies; operating at 120-V ac with 9-V dc battery as the secondary power source. Provide with "low" or "missing" battery chirping-sound device.
2. Auxiliary Relays: One Form C, rated at 0.5 A or Form A and one Form C, both rated at 0.5 A as directed.
3. Audible Notification Appliance: Piezoelectric sounder rated at 90 dBA at 10 feet (3 m) according to UL 464.
4. Visible Notification Appliance: 177-cd strobe.
5. Heat sensor, 135 deg F (57 deg C) combination rate-of-rise and fixed temperature.
6. Test Switch: Push to test; simulates smoke at rated obscuration.
7. Tandem Connection: Allow tandem connection of number of indicated detectors; alarm on one detector shall actuate notification on all connected detectors.

8. Plug-in Arrangement: Detector and associated electronic components shall be mounted in a plug-in module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
9. Self-Restoring: Detectors shall not require resetting or readjustment after actuation to restore them to normal operation.
10. Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.

C. Single-Station Duct Smoke Detectors:

1. Comply with UL 268A; operating at 120-V ac.
2. Sensor: LED or infrared light source with matching silicon-cell receiver.

    a. Detector Sensitivity: Smoke obscuration between 2.5 and 3.5 percent/foot (0.008 and 0.011 percent/mm) when tested according to UL 268A.

3. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. The fixed base shall be designed for mounting directly to air duct. Provide terminals in the fixed base for connection to building wiring.

    a. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; listed for use with the supplied detector.

4. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
5. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

2.9 HEAT DETECTORS

A. General Requirements for Heat Detectors: Comply with UL 521.

1. Temperature sensors shall test for and communicate the sensitivity range of the device.

B. Heat Detector, Combination Type: Actuated by either a fixed temperature or a rate of rise.

1. Mounting: Adapter plate for outlet box mounting or Twist-lock base interchangeable with smoke-detector bases as directed.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

C. Heat Detector, Fixed-Temperature Type: Actuated by temperature that exceeds a fixed temperature.

1. Mounting: Adapter plate for outlet box mounting or Twist-lock base interchangeable with smoke-detector bases as directed.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.10 NOTIFICATION APPLIANCES

A. General Requirements for Notification Appliances: Connected to notification-appliance signal circuits, zoned as indicated, equipped for mounting as indicated, and with screw terminals for system connections.

1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.

B. Chimes: Vibrating type.

C. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464.

D. Visible Notification Appliances: Xenon strobe lights complying with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch- (25-mm-) high letters on the lens.

1. Mounting: Wall mounted unless otherwise indicated.
2. Flashing shall be in a temporal pattern, synchronized with other units.
3. Strobe Leads: Factory connected to screw terminals.
4. Mounting Faceplate: Factory finished, red or white as directed.

2.11 MAGNETIC DOOR HOLDERS

A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.

1. Electromagnets: Require no more than 3 W to develop 25-lbf (111-N) holding force.
2. Wall-Mounted Units: Flush mounted unless otherwise indicated.
3. Rating: 24-V ac or dc.
4. Rating: 120-V ac.

B. Material and Finish: Match door hardware.

2.12 REMOTE ANNUNCIATOR

A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.

1. Mounting: Flush or Surface cabinet, NEMA 250, Type 1 as directed.

B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.13 ADDRESSABLE INTERFACE DEVICE

A. General:

1. Include address-setting means on the module.
2. Store an internal identifying code for control panel use to identify the module type.
3. Listed for controlling HVAC fan motor controllers.

B. Monitor Module: Microelectronic module providing a system address for alarm-initiating devices for wired applications with normally open contacts.

C. Integral Relay: Capable of providing a direct signal to elevator controller to initiate elevator recall or to circuit-breaker shunt trip for power shutdown as directed.

1. Allow the control panel to switch the relay contacts on command.
2. Have a minimum of two normally open and two normally closed contacts available for field wiring.

D. Control Module:

1. Operate notification devices.
2. Operate solenoids for use in sprinkler service.

2.14 DIGITAL ALARM COMMUNICATOR TRANSMITTER

A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632.

B. Functional Performance: As directed, unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture one or two telephone line(s) and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on either line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.

C. Local functions and display at the digital alarm communicator transmitter shall include the following:

1. Verification that both telephone lines are available.
2. Programming device.
3. LED display.
4. Manual test report function and manual transmission clear indication.
5. Communications failure with the central station or fire-alarm control unit.

D. Digital data transmission shall include the following:

1. Address of the alarm-initiating device.
2. Address of the supervisory signal.

3. Address of the trouble-initiating device.
4. Loss of ac supply.
5. Loss of power.
6. Low battery.
7. Abnormal test signal.
8. Communication bus failure.

E. Secondary Power: Integral rechargeable battery and automatic charger.

F. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

A. Comply with NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install all electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."

B. Connecting to Existing Equipment: Verify that existing fire-alarm system is operational before making changes or connections.

C. Equipment Mounting: Install fire-alarm control unit on finished floor.

1. Comply with requirements for seismic-restraint devices specified in Section 270548.16 "Seismic Controls for Communications Systems."

D. Install wall-mounted equipment, with tops of cabinets not more than 78 inches (1980 mm) above the finished floor.

1. Comply with requirements for seismic-restraint devices specified in Section 270548.16 "Seismic Controls for Communications Systems."

E. Manual Fire-Alarm Boxes:

1. Install manual fire-alarm box in the normal path of egress within 60 inches (1520 mm) of the exit doorway.
2. Mount manual fire-alarm box on a background of a contrasting color.
3. The operable part of manual fire-alarm box shall be between 42 inches (1060 mm) and 48 inches (1220 mm) above floor level. All devices shall be mounted at the same height unless otherwise indicated.

F. Smoke- or Heat-Detector Spacing: Comply with NFPA 72.

G. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches (9100 mm) long shall be supported at both ends.

H. Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location. Do not install smoke detectors in sprinklered elevator shafts.

I. Single-Station Smoke Detectors: Where more than one smoke alarm is installed within a dwelling or suite, they shall be connected so that the operation of any smoke alarm causes the alarm in all smoke alarms to sound.

J. Remote Status and Alarm Indicators: Install in a visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.

K. Audible Alarm-Indicating Devices: Install not less than 6 inches (150 mm) below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Install all devices at the same height unless otherwise indicated.

L. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches (150 mm) below the ceiling. Install all devices at the same height unless otherwise indicated.

M. Device Location-Indicating Lights: Locate in public space near the device they monitor.

3.2 PATHWAYS

A. Pathways above recessed ceilings and in non-accessible locations may be routed exposed.

1. Exposed pathways located less than 96 inches (2440 mm) above the floor shall be installed in EMT.

B. Pathways shall be installed in EMT.

C. Exposed EMT shall be painted red enamel.

3.3 CONNECTIONS

A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Section 087100 "Door Hardware." Connect hardware and devices to fire-alarm system.

1. Verify that hardware and devices are listed for use with installed fire-alarm system before making connections.

B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 36 inches (910 mm) from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.

1. Smoke dampers in air ducts of designated HVAC duct systems.
2. Magnetically held-open doors.
3. Electronically locked doors and access gates.
4. Alarm-initiating connection to elevator recall system and components.
5. Alarm-initiating connection to activate emergency lighting control.
6. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.
7. Supervisory connections at valve supervisory switches.

8. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.
9. Supervisory connections at elevator shunt-trip breaker.
10. Supervisory connections at fire-extinguisher locations.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."

B. Install framed instructions in a location visible from fire-alarm control unit.

3.5 GROUNDING

A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

B. Ground shielded cables at the control panel location only. Insulate shield at device location.

3.6 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by Architect or authorities having jurisdiction as directed.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Visual Inspection: Conduct visual inspection prior to testing.
    a. Inspection shall be based on completed record Drawings and system documentation that is required by NFPA 72 in its "Completion Documents, Preparation" table in the "Documentation" section of the "Fundamentals" chapter.
    b. Comply with the "Visual Inspection Frequencies" table in the "Inspection" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.
2. System Testing: Comply with the "Test Methods" table in the "Testing" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
4. Test audible appliances for the private operating mode according to manufacturer's written instructions.
5. Test visible appliances for the public operating mode according to manufacturer's written instructions.
6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" section of the "Fundamentals" chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

C. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

D. Fire-alarm system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

F. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

G. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

3.7 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

C. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule access to system and to upgrade computer equipment if necessary.

3.8 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system.

END OF SECTION 284621.11

SECTION 284621.13 - CONVENTIONAL FIRE-ALARM SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fire-alarm control unit.
2. Manual fire-alarm boxes.
3. System smoke detectors.
4. Non-system smoke detectors.
5. Heat detectors.
6. Notification appliances.
7. Magnetic door holders.
8. Remote annunciator.
9. Digital alarm communicator transmitter.

B. Related Requirements:

1. Section 270513 "Conductors and Cables for Communications Systems" for cables and conductors for fire-alarm systems.

1.2 ACTION SUBMITTALS

A. General Submittal Requirements: As directed.

1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.
2. Shop Drawings shall be prepared by persons with the following qualifications:

    a. Trained and certified by manufacturer in fire-alarm system design.
    b. NICET-certified fire-alarm technician; Level III or Level IV minimum as directed.
    c. Licensed or certified by authorities having jurisdiction.

B. Product Data: For each type of product, including furnished options and accessories.

C. Shop Drawings: For fire-alarm system.

1. Comply with recommendations and requirements in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
2. Include plans, elevations, sections, details, and attachments to other work.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.
4. Detail assembly and support requirements.
5. Include voltage drop calculations for notification-appliance circuits.

6. Include battery size calculations.
7. Include input/output matrix.
8. Include statement from manufacturer that all equipment and components have been tested as a system and meet all requirements in this Specification and in NFPA 72.
9. Include performance parameters and installation details for each detector.
10. Verify that each duct smoke detector is listed for the complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
11. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale; coordinate location of duct smoke detectors and access to them.

    a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.
    b. Show field wiring required for HVAC unit shutdown on alarm.
    c. Locate detectors according to manufacturer's written recommendations.

12. Include floor plans to indicate final outlet locations showing zone designation of each device. Show size and route of cable and conduits and point-to-point wiring diagrams.

D. Delegated-Design Submittal: For notification appliances and smoke and heat detectors, in addition to submittals listed above, indicate compliance with performance requirements and design criteria, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation.

1. Drawings showing the location of each smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the device.
2. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72. Calculate spacing and intensities for strobe signals and sound-pressure levels for audible appliances.
3. Indicate audible appliances required to produce square wave signal per NFPA 72.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Seismic Qualification Data: Certificates, for fire-alarm control unit, accessories, and components, from manufacturer.

C. Field quality-control reports.

D. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following and deliver copies to authorities having jurisdiction:

a. Comply with the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
b. Provide the "Fire Alarm and Emergency Communications System Record of Completion Documents" according to the "Completion Documents" article in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
c. Complete wiring diagrams showing connections between all devices and equipment.
d. Riser diagram.
e. Record copy of site-specific software.
f. Provide the "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:

    1) Equipment tested.
    2) Frequency of testing of installed components.
    3) Frequency of inspection of installed components.
    4) Requirements and recommendations related to results of maintenance.
    5) Manufacturer's user training manuals.

g. Manufacturer's required maintenance related to system warranty requirements.
h. Abbreviated operating instructions for mounting at fire-alarm control unit and each annunciator unit.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level II, Level III, Level IV technician as directed.

C. NFPA Certification: Obtain certification according to NFPA 72 by an NRTL (nationally recognized testing laboratory).

D. NFPA Certification: Obtain certification according to NFPA 72 by a UL-listed alarm company.

E. NFPA Certification: Obtain certification according to NFPA 72 in the form of a placard by an FM Global-approved alarm company.

F. NFPA Certification: Obtain certification according to NFPA 72 as directed.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail in materials or workmanship within specified warranty period.

1. Warranty Extent: All equipment and components not covered in the Maintenance Service Agreement.
2. Warranty Period: five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Source Limitations for Fire-Alarm System and Components: Components shall be compatible with and operate as an extension of existing system. Provide system manufacturer's certification that all components provided have been tested as, and will operate as, a system.

B. Noncoded system dedicated to fire-alarm service only.

C. All components provided shall be listed for use with the selected system.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices and systems:

1. Manual stations.
2. Heat detectors.
3. Smoke detectors.
4. Duct smoke detectors.
5. Carbon monoxide detectors.
6. Automatic sprinkler system water flow.
7. Fire-extinguishing system operation.
8. Fire standpipe system.
9. Dry system pressure flow switch.

B. Fire-alarm signal shall initiate the following actions:

1. Continuously operate alarm notification appliances.
2. Identify alarm zone at fire-alarm control unit and remote annunciators.
3. Transmit an alarm signal to the remote alarm receiving station.
4. Unlock electric door locks in designated egress paths.
5. Release fire and smoke doors held open by magnetic door holders.
6. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
7. Close smoke dampers in air ducts of designated air-conditioning duct systems.
8. Activate elevator power shunt trip.
9. Activate emergency lighting control.
10. Activate emergency shutoffs for gas and fuel supplies.
11. Record events in the system memory.

C. Supervisory signal initiation shall be by one or more of the following devices and systems:

1. Valve supervisory switch.
2. Elevator shunt-trip supervision.
3. Loss of communication with any panel on the network.

D. System trouble signal initiation shall be by one or more of the following devices and actions:

1. Open circuits, shorts, and grounds in designated circuits.
2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3. Loss of primary power at fire-alarm control unit.
4. Ground or a single break in internal circuits of fire-alarm control unit.
5. Abnormal ac voltage at fire-alarm control unit.
6. Break in standby battery circuitry.
7. Failure of battery charging.
8. Abnormal position of any switch at fire-alarm control unit or annunciator.

E. System Trouble and Supervisory Signal Actions:

1. Initiate notification appliances.
2. Annunciate at fire-alarm control unit and remote annunciators.
3. After a time delay of 200 seconds, transmit a trouble or supervisory signal to the remote alarm receiving station.

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Fire-alarm control unit and raceways shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.4 FIRE-ALARM CONTROL UNIT

A. General Requirements for Fire-Alarm Control Unit:

1. Modular, power-limited design with electronic modules, UL 864 listed.

a. Include a real-time clock for time annotation of events.
b. The FACP shall be listed for connection to a central-station signaling system service.

B. Alphanumeric Display and System Controls: Display alarm, supervisory, and component status messages and the programming and control menu.

1. Annunciator and Display: Liquid-crystal type, one line or two lines of 40 or 80 characters, minimum as directed.

C. Circuits:

1. No Fewer Than Five Initiating-Device Circuits:

a. Four circuits, NFPA 72, Class B.

b. One circuit(s), NFPA 72, Class A.

2. No Fewer Than Two Notification-Appliance Circuits: NFPA 72, Class B.
3. Pathway Survivability: Level 0 or Level 1 as directed.
4. Serial Interfaces:

a. One RS 485 port for remote annunciators.
b. One RS 232 port for personal computer configuration.

D. Notification-Appliance Circuit: Operation shall sound as directed.

E. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke-barrier walls shall be or not be connected to fire-alarm system as directed.

F. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.

G. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory signals or and supervisory and digital alarm communicator transmitters shall be powered by the 24-V dc source.

1. Alarm current draw of the entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.

H. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.

2.5 MANUAL FIRE-ALARM BOXES

A. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38.

1. As directed, Single-action mechanism, breaking-glass or plastic-rod or pull-lever type.
2. As directed, Double-action mechanism requiring two actions to initiate an alarm, breaking-glass or plastic-rod or pull-lever type.
3. Station Reset: Key- or wrench-operated switch.

2.6 SYSTEM SMOKE DETECTORS

A. General Requirements for System Smoke Detectors:

1. Operating at 24-V dc, nominal.
2. Detectors shall be four or two-wire type as directed.
3. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
4. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
5. Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.

6. Provide multiple levels of detection sensitivity for each sensor, with alarm-verification feature.

B. Photoelectric Smoke Detectors: Comply with UL 268.

C. Ionization Smoke Detector: Comply with UL 268.

D. Duct Smoke Detectors: Photoelectric type complying with UL 268A.

1. Remote indication and test station. Operating key switch initiates an alarm test.
2. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector for smoke detection in HVAC system ducts.
3. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
4. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

2.7 CARBON MONOXIDE DETECTORS

A. Description: Listed for connection to fire-alarm system.

1. Mounting: Adapter plate for outlet box mounting.
2. Detector shall provide a means to test by introducing test carbon monoxide into the sensing cell.
3. Detector shall provide alarm contacts and trouble contacts.
4. Detector shall send trouble alarm when nearing end-of-life, power supply problems, or internal faults.
5. Detector shall be listed to comply with UL 2075.
6. Detectors shall be located, mounted, and wired according to manufacturer's written instructions.
7. Test button simulates an alarm condition.

2.8 NONSYSTEM SMOKE DETECTORS

A. General Requirements for Non-system Smoke Detectors:

1. Non-system smoke detectors shall be listed as compatible with the fire-alarm equipment installed or shall have a contact closure interface listed for the connected load.
2. Non-system smoke detectors shall meet the monitoring for integrity requirements in NFPA 72.

B. Single-Station Smoke Detectors:

1. Comply with UL 217; suitable for NFPA 101, residential occupancies; operating at 120-V ac with 9-V dc battery as the secondary power source. Provide with "low" or "missing" battery chirping-sound device.
2. Auxiliary Relays: One Form C, rated at 0.5 A or Form A and one Form C, both rated at 0.5 A as directed.
3. Audible Notification Appliance: Piezoelectric sounder rated at 90 dBA at 10 feet (3 m) according to UL 464.

4. Visible Notification Appliance: 177-cd strobe.
5. Heat sensor, 135 deg F (57 deg C) combination rate-of-rise and fixed temperature.
6. Test Switch: Push to test; simulates smoke at rated obscuration.
7. Tandem Connection: Allow tandem connection of number of indicated detectors; alarm on one detector shall actuate notification on all connected detectors.
8. Plug-in Arrangement: Detector and associated electronic components shall be mounted in a plug-in module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
9. Self-Restoring: Detectors shall not require resetting or readjustment after actuation to restore them to normal operation.
10. Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.

C. Single-Station Duct Smoke Detectors:

1. Comply with UL 268A; operating at 120-V ac.
2. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. The fixed base shall be designed for mounting directly to air duct. Provide terminals in the fixed base for connection to building wiring.

    a. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; listed for use with the supplied detector.

3. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
4. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

2.9 HEAT DETECTORS

A. General Requirements for Heat Detectors: Comply with UL 521.

B. Heat Detector, Combination Type: Actuated by either a fixed temperature or a rate of rise.

1. Mounting: Adapter plate for outlet box mounting or twist-lock base interchangeable with smoke-detector bases.

C. Heat Detector, Fixed-Temperature Type: Actuated by temperature that exceeds a fixed temperature.

1. Mounting: Adapter plate for outlet box mounting or twist-lock base interchangeable with smoke-detector bases.

2.10 NOTIFICATION APPLIANCES

A. General Requirements for Notification Appliances: Connected to notification-appliance signal circuits, zoned as indicated, equipped for mounting as indicated, and with screw terminals for system connections.

1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.

B. Chimes, High-Level Output: Vibrating type.

C. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464.

D. Visible Notification Appliances: Xenon strobe lights complying with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch- (25-mm-) high letters on the lens.

1. Mounting: Wall mounted unless otherwise indicated.
2. Flashing shall be in a temporal pattern, synchronized with other units.
3. Strobe Leads: Factory connected to screw terminals.
4. Mounting Faceplate: Factory finished, red or white as directed.

2.11 MAGNETIC DOOR HOLDERS

A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.

1. Electromagnets: Require no more than 3 W to develop 25-lbf (111-N) holding force.
2. Wall-Mounted Units: Flush mounted unless otherwise indicated.
3. Rating: 24-V ac or dc.
4. Rating: 120-V ac.

B. Material and Finish: Match door hardware.

2.12 REMOTE ANNUNCIATOR

A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.

1. Mounting: Flush or Surface cabinet, NEMA 250, Type 1 as directed.

B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.13 DIGITAL ALARM COMMUNICATOR TRANSMITTER

A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632.

B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture one or two telephone line(s) and dial a preset

number for a remote central station as directed. When contact is made with central station(s), signals shall be transmitted. If service on either line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.

C. Local functions and display at the digital alarm communicator transmitter shall include the following:

1. Verification that both telephone lines are available.
2. Programming device.
3. LED display.
4. Manual test report function and manual transmission clear indication.
5. Communications failure with the central station or fire-alarm control unit.

D. Digital data transmission shall include the following:

1. Zone of the alarm initiating device.
2. Zone of the supervisory signal.
3. Zone of the trouble initiating device.
4. Loss of ac supply.
5. Loss of power.
6. Low battery.
7. Abnormal test signal.
8. Communication bus failure.

E. Secondary Power: Integral rechargeable battery and automatic charger.

F. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

A. Comply with NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install all electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."

B. Connecting to Existing Equipment: Verify that existing fire-alarm system is operational before making changes or connections.

C. Install wall-mounted equipment, with tops of cabinets not more than 78 inches (1980 mm) above the finished floor.

1. Comply with requirements for seismic-restraint devices specified in Section 260548.16 "Seismic Controls for Communications Systems."

D. Manual Fire-Alarm Boxes:

1. Install manual fire-alarm box in the normal path of egress within 60 inches (1520 mm) of the exit doorway.
2. Mount manual fire-alarm box on a background of a contrasting color.
3. The operable part of manual fire-alarm box shall be between 42 inches (1060 mm) and 48 inches (1220 mm) above floor level. All devices shall be mounted at the same height unless otherwise indicated.

E. Smoke- or Heat-Detector Spacing: Comply with NFPA 72.

F. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches (9100 mm) long shall be supported at both ends.

G. Elevator Shafts: Install a heat detector within 24 inches (610 mm) of each sprinkler head. Coordinate temperature rating and location with sprinkler rating and location. Do not install smoke detectors in sprinklered elevator shafts.

H. Single-Station Smoke Detectors: Where more than one smoke alarm is installed within a dwelling or suite, they shall be connected so that the operation of any smoke alarm causes the alarm in all smoke alarms to sound.

I. Remote Status and Alarm Indicators: Install in a visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.

J. Audible Alarm-Indicating Devices: Install not less than 6 inches (150 mm) below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Install all devices at the same height unless otherwise indicated.

K. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches (150 mm) below the ceiling. Install all devices at the same height unless otherwise indicated.

L. Device Location-Indicating Lights: Locate in public space near the device they monitor.

3.2 PATHWAYS

A. Pathways above recessed ceilings and in non-accessible locations may be routed exposed.

1. Exposed pathways located less than 96 inches (2440 mm) above the floor shall be installed in EMT.

B. Pathways shall be installed in EMT.

C. Exposed EMT shall be painted red enamel.

3.3 CONNECTIONS

A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Section 087100 "Door Hardware." Connect hardware and devices to fire-alarm system.

1. Verify that hardware and devices are listed for use with installed fire-alarm system before making connections.

B. Connect supervised interface devices to the following devices and systems. Install the interface device less than 36 inches (910 mm) from the device controlled.

1. Smoke dampers in air ducts of designated HVAC duct systems.
2. Magnetically held-open doors.
3. Electronically locked doors and access gates.
4. Supervisory connections at valve supervisory switches.
5. Supervisory connections at fire-pump power failure including a dead-phase or phase-reversal condition.
6. Supervisory connections at fire-pump engine control panel.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install framed instructions in a location visible from fire-alarm control unit.

3.5 GROUNDING

A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

B. Ground shielded cables at the control panel location only. Insulate shield at device location.

3.6 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by Architect or authorities having jurisdiction as directed.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Visual Inspection: Conduct the visual inspection prior to testing.

a. Inspection shall be based on completed record Drawings and system documentation that is required by NFPA 72 in Chapter 10 "Fundamentals," Section 10.18.21 "Completion Documents, Preparation."
b. Comply with NFPA 72, Chapter 14, "Inspection, Testing, and Maintenance," Section 14.3 "Inspection" and the "Visual Inspection Frequencies" Table; retain the "Initial/Reacceptance" column and list only the installed components.

2. System Testing: Comply with NFPA 72, Chapter 14, "Inspection, Testing, and Maintenance," Section 14.4 "Testing" and the "Test Methods" Table.
3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
4. Test visible appliances for the public operating mode according to manufacturer's written instructions.
5. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" section of the "Fundamentals" chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

C. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

D. Fire-alarm system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

F. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

G. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with the visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system.

END OF SECTION 284621.13

SECTION 284700 - MASS NOTIFICATION SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. MNS wiring, raceways, terminal cabinets, outlets, and mounting boxes.
2. Control equipment.
3. Notification appliances.
4. Accessories.

B. Related Requirements:

1. Section 284621.11 "Addressable Fire-Alarm Systems" for fire alarm system that interfaces with the equipment of this Section.

1.2 DEFINITIONS

A. ATP: Acceptance Test Procedure.

B. LOC: Local operating console.

C. MNS: Mass notification system.

D. NICET: National Institute for Certification in Engineering Technologies.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Prepare Shop Drawings by persons with the following qualifications:

   a. Trained and certified by manufacturer in MNS design.
   b. NICET-certified technician; Level III or Level IV minimum as directed.
   c. Licensed or certified according to the requirements of the authorities having jurisdiction.

2. Include plans, elevations, sections, and mounting details.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
4. Detail fabrication and assembly of the following:

a. Speaker clusters on poles.
b. Racks with amplifiers and terminations.
c. Control panels.

5. Include diagrams for power, signal, and control wiring.

C. Delegated-Design Submittal: For items listed below, indicate compliance with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Speaker placement.
2. Speaker dB output.
3. Amplifier output.
4. Remote power booster rating and locations.
5. Battery sizing calculations.
6. Voltage drop calculations.
7. Seismic mounting and supports.

1.4 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for amplifiers, speakers, racks, accessories, and components, from manufacturer.

B. Product test reports.

C. Source quality-control reports.

D. Field quality-control reports.

E. Sample warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

B. Computer-generated instruction card mounted behind a Lexan plastic or glass cover in a stainless steel or aluminum frame. The card shall indicate those steps to be taken by an operator when a signal is received as well as the functional operation of the system under all conditions: normal, alarm, supervisory, and trouble.

C. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: As directed. Device address list.
3. Printout of software application and graphic screens.

D. Proprietary equipment and software required to implement future changes to the MNS.

E. System documentation to the owner, including but not limited to the following:

1. System record Drawings and wiring details, including one set of full-size printed Drawings, and a CD ROM with copies of the record Drawings in PDF format and DXF format for use in AutoCAD drafting program, 2012 version.
2. Documentation of all component and wiring identification, including a copy of each equipment nameplate.
3. System matrix showing interaction of all input signals with output commands.
4. Documentation of system voltage, current, and resistance readings taken during the installation, testing, and ATP phases of the system installation.
5. System program showing control devices and operations, and system functions of equipment and devices.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer for installation of units required for this Project.

1. Personnel certified by NICET as Audio Systems Level II or Level III Technician as directed.

B. Testing Agency Qualifications: An NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NICET at Level III to supervise on-site testing.

1.7 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of the MNS that fail(s) in materials or workmanship within specified warranty period.

1. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Source Limitations: Obtain MNS from single source or producer.

2.2 PERFORMANCE REQUIREMENTS

A. Comply with UL 2572.

B. Mass Notification Messaging System:

1. Software-operated, network-based communications system with wired and wireless access points for control interface. Designated operators shall be able to log in via a web browser and have complete access to their own portion of the MNS.

2. An autonomous voice notification control unit shall monitor and control the notification appliance network and provide consoles for local operation. Authorized personnel shall be able to use a console to initiate delivery of pre-recorded voice messages, provide live voice messages and instructions, and initiate visual strobe and optional textual message notification appliances. The autonomous voice notification control unit shall temporarily override audible fire alarm notification while delivering mass notification messages to ensure they are intelligible.
3. The MNS messaging system shall be capable of the following:

    a. Communicating through the use of wired or wireless networks for one- or two-way communications and control between a building or area and emergency personnel.
    b. Automatically distribute at least 100 simultaneous and unique messages to the appropriate notification appliances.
    c. Allow multiple operators to send messages simultaneously.
    d. Grant access for control to another control station if the location in control becomes inoperable and/or the authorized operator at that control station can no longer operate the control station.
    e. Send voice messages and text messages with an indication of the source of the message that can only be sent from the message source.
    f. Send alert messages to end users (recipients) via multiple delivery methods, including but not limited to the following:

        1) Audio-visual network alerts to computers via desktop pop-up.
        2) Text alerts to mobile phones and pagers.
        3) Text alerts to email clients.
        4) Text alerts to textual visible appliances.
        5) Alerts to visible appliances.
        6) Audio alerts to phones.
        7) Audio alerts to speakers.
        8) Audio alerts to existing wide-area or building voice and/or other MNS.
        9) Network alerts to any other IP-connected devices via standard XML and CAP protocols.

    g. Suppress contact information for other end users with messages or in message headers.

4. Live announcements or prerecorded messages. Live messages shall take precedence over prerecorded messages.
5. Notification appliance network shall consist of speakers and visual notification devices located to provide intelligible instructions at areas as indicated.
6. Interface with the fire alarm system to utilize the voice modules, visual alarms, and speakers of the fire alarm system.
7. Give priority to MNS announcements over other audible announcements of the system including fire alarm system in a normal or alarm state. When an announcement is activated during a fire alarm, fire alarm system functions shall continue in an alarm state, except for the output signals of the fire alarm audible and visual notification appliances.
8. Comply with speech intelligibility requirements of NFPA 72 as measured according to ANSI/ASA S3.2.
9. Capable of overriding local control of speaker volume levels for emergency communications. Local controls shall be permitted to adjust volume levels of non-

emergency signals only, such as, but not limited to, background music and convenience paging.

10. Capable of providing separate messages to one individual building or to multiple buildings at any given time if the MNS serves more than one building.
11. Capable of monitoring emergency notifications from multiple data sources (National Weather Service, Emergency Managers Weather Information Network, Naval Meteorology and Oceanography, and others as determined locally) and automatically send out notifications to designated facilities and personnel based on pre-defined rules.
12. Capable of centrally tracking, in real-time, all alerting activities for each individual recipient, including sending, receiving, and responding to alerts, and of generating reports based on tracked information.
13. Capable of operating remote printer via a USB output. Provide matching printer listed and labeled as part of the MNS.

C. Seismic Performance: MNS speakers, equipment mountings, poles, racks, pathways, conductors, and amplification and control components shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the system will remain in place without separation of any parts when subjected to the seismic forces specified and the system will be fully operational after the seismic event."
2. Component Importance Factor is 1.5.

D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 MASTER CONTROL PANEL

A. Description:

1. Fully enclosed in a lockable steel cabinet with access for testing, and maintenance from the front of the enclosure.
2. Solid-state, modular components, internally mounted and arranged for easy access for power, supervision, control, and logic for the system.
3. 120 V ac, 60 Hz power supply.
4. An indicator for each message source shall indicate which sources are available and which are selected.
5. Indicators for broadcast media used to convey the selected message to selected audience shall indicate which sources are available and which are selected.
6. Capable of confirming the receipt of a message. If the message was not confirmed received, the system shall be capable of using other means of contact until receipt of confirmation or until a preset time period.
7. Capable of automatically sending another message after the receipt of a message or messages.

8. Operator Access Functions:

    a. Select prerecorded message for transmission.
    b. Select microphone for live broadcast.
    c. Initiate message broadcast.
    d. Terminate message broadcast.

9. Supervisory Access Functions:

    a. Reset time and date.
    b. Enable or disable event-initiated programs, printouts, and initiators.
    c. Enable or disable individual message sources and broadcast media.
    d. Supervisory level functions shall not require computer programming skills. MNS shall record changes to program functions, to be maintained in the control panel for a minimum of one year. The control panel shall maintain the ID of the supervisor making the change.

10. System operator level access functions:

    a. Clear supervisory trouble alarms.
    b. Revise programming.
    c. Revise prerecorded messages.
    d. Assign access rights to all levels.
    e. MNS shall record changes at system operator level in the control panel, to be maintained for a minimum of one year. The control panel shall maintain the ID of the system operator making the change.

11. Capable of at least 1000 or 5000 users as directed, with each user having its own log-in and password credentials and at least four contact methods.
12. Capable of storing users in one or multiple groups and able to create a minimum of 10 or 20 groups.
13. Each panel shall have supervisory functions for power failure, internal component failure, and operation.
14. MNS shall have a complete set of self-diagnostics for controller and appliance network, and local diagnostic information display, local diagnostic information, and system event log.
15. Printed records of changes, supervisory functions, message transmission, and operator actions shall be maintained for a minimum of one year.

2.4 NOTIFICATION COMPONENTS

A. Voice/Alarm Signaling Service:

1. One-way, multichannel voice notification system incorporating at least eight distinct sounds selectable by user for tone signaling and incorporating a voice module for delivery of prerecorded messages.
2. Redundant microphones, preamplifiers, amplifiers, and tone generators provided in separate main and remote cabinets.
3. Voice notification system shall support facility public address paging.

4. Audible appliances shall produce a code 3 temporal tone for three cycles followed by a voice message that is repeated until the control panel is reset or silenced.
5. Automatic messages shall be broadcast through speakers throughout the building or facility, but not in stairs or elevators.
6. When using microphones, live messages shall be broadcast throughout a selected floor or floors or all call, including stairs and elevators.
7. Live voice message shall override automatic or recorded audible output through use of a microphone input at the main control panel or the remote cabinet.
8. Number of alarm channels shall be indicated for automatic, simultaneous transmission of different announcements to different zones or for manual transmission of announcements by use of the central-control microphone.

    a. Allow sending an evacuation signal to selected zones and, at the same time, allow voice paging to the other zones selectively or in any combination.
    b. Programmable tone and message sequence selection.
    c. Standard digitally recorded messages for "Evacuation" and "All Clear."

B. Audible Notification System: Comply with the requirements of NFPA 72 and ISO 7240-16 for Emergency Voice/Alarm Communications System, except where more stringent requirements are specified. Voice intelligibility shall be evaluated according to IEC 60268-16.

1. Amplifiers:

    a. Comply with UL 1711.
    b. Audio output shall be selectable for line level. Minimum amplifier output shall be 100 W rms.
    c. Capable of operating all speakers at the same time.
    d. Loss of operating power, supervisory power, or any other malfunction that could render the voice module inoperative shall automatically cause the code 3 temporal tone to take over all functions assigned to the failed unit in the event an alarm is activated.

2. Audible Notification Devices:

    a. Handheld push-to-talk microphone shall be supervised and a key shall be required to enable remote microphone use.
    b. Microprocessor shall actively integrate circuitry, field wiring, and digital coding necessary for the immediate and accurate rebroadcasting of stored voice data into appropriate amplifier input.

C. Voice/Tone Notification Appliances:

1. Comply with UL 1480.
2. Indoor Speakers for Voice Notification:

    a. Construction: High-efficiency, sealed back; for maximum output at minimum power across a frequency range of 150 Hz to 10,000 Hz.
    b. Standard: UL 1480.
    c. Speaker Locations: Comply with NFPA 72, "Notification Appliances" and "Emergency Communications Systems" chapters.

d. High-Range Units: Rated 2 to 15 W.
e. Low-Range Units: Rated 1 to 2 W.
f. Mounting: Flush, Semi-recessed or Surface mounted and bidirectional as directed.
g. Matching Transformers: Tap range matched to acoustical environment of speaker location.

3. Outdoor Speakers for Voice Notification:

a. As directed, high-powered, 1600-W or 3200-W speaker arrays with acoustic performance and intelligibility features complying with NFPA 72.
b. Control panel providing signal processing, amplification, gain control, battery backup, and antenna surge protection.
c. Pole designed for the speaker array with 100 mph (160 km/h) or 110 mph (177 km/h) wind load as directed.

D. Text Displays:

1. Programmable, digital text displays having a minimum of 4-inch (100-mm) high letters for hearing-impaired occupants displaying the content of the voice message being played.
2. Capable of sending static, flashing, or scrolling messages to textual visible appliances.
3. Mass notification control panel shall interface with and control the programmable display controller to activate the proper message.
4. Textual visible notification shall be primary notification when it is the only method used to convey emergency MNS information to the general public or to specific individuals.

E. Visual Notification Appliances:

1. As directed, strobes used solely for MNS shall be amber, clear or nominal white complying with UL 1971 and with the word "ALERT" factory printed on the trim.
2. Strobes used in combination systems where the same strobe is used for both MNS and fire notification shall be clear or nominal white complying with UL 1971.
3. Strobes used for MNS shall be synchronized.

F. Web Interfaces:

1. Capable of utilizing dedicated or existing IP networks to send alert messages. System shall be able to communicate with multiple modalities to include but not limited to pop-up alerts on personal computers, text messages to cellular phones, email messaging to IP-capable computers or devices, and recorded voice messages to voice-over-IP (VoIP) telephones and PCs.
2. Capable of activating, through a single interface, non-IP alerting systems such as wide-area alerting systems, fire alarm systems, PA systems, handheld radio systems, radio broadcast systems, personal pager systems, nurse call systems, and traditional dial-up telephone alerting systems.
3. Capable of accessing user screens via multiple web browsers such as MS Explorer, Mozilla Firefox, or Apple Safari.
4. Capable of sending live video stream from an IP-based camera or security camera system to any PC or video display.

G. Primary Power:

1. 24-V dc obtained from 120-V ac service and a power-supply module.

    a. Power supplies shall be sized to furnish a minimum of 125% of the total connected load in a worst-case condition.

2. Devices Powered by 24-V dc:

    a. Control panels.
    b. Notification appliances.
    c. Text displays.
    d. Trouble signals.
    e. Supervisory signals.
    f. Supervisory and digital alarm communicator transmitters.
    g. Digital alarm radio transmitters.

H. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.

1. Batteries: Sealed lead calcium.
2. Batteries: Sealed, valve-regulated, recombinant lead acid.
3. Batteries: Sealed lead calcium, valve-regulated, recombinant lead acid.
4. Battery size shall be a minimum of 125% of the calculated requirement.

I. Overvoltage and Surge Protection:

1. Signaling Line Circuit Surge Protection: Protected against surges induced on any signaling line circuit located outdoors, and complying with IEEE C62.41.1 and IEEE C62.41.2.
2. Protect cables and conductors that serve as communications links with surge protection devices installed at each end that meet the following waveforms:

    a. 10 by 1000 mic.sec. waveform with a peak of 1500 V and a peak current of 60 A.
    b. 8 by 20 mic.sec. waveform with a peak of 1000 V and a peak current of 500 A. Protection shall be provided at the equipment. Additional surge protectors, rated for the application, shall be installed on each circuit within 36 inches (900 mm) of the cable entrance to the building.
    c. Fuses shall not be used for surge protection.

3. Sensor Wiring Surge Protection: Digital and analog inputs and outputs shall be protected against surges induced by sensor wiring. The inputs and outputs shall be tested with the following waveforms:

    a. 10 by 1000 mic.sec. waveform with a peak of 1500 V and a peak current of 60 A.
    b. 8 by 20 mic.sec. waveform with a peak of 1000 V and a peak current of 500 A.
    c. Fuses shall not be used for surge protection.

2.5 ACCESSORIES

A. Operator's Console:

1. Capable of initiating recorded messages and displays, and for delivering live voice messages.
2. Capacity for at least eight pre-recorded messages and the ability to automatically repeat pre-recorded messages.
3. Having a microphone for delivering live messages.

B. LOC:

1. LOC shall provide redundant control of the notification system control panel.
2. When an installation has more than one LOC, they shall be programmed to allow only one LOC to be available for messaging at a time. Once one LOC becomes active, all other LOC will have an indication that the system is busy (Amber Busy Light) and cannot be used at that time.
3. LOC shall be capable of being locked out or overridden from the Master Control Panel according to NFPA 72.

C. Fire Alarm Interface: Adequate discrete outputs to temporarily deactivate the fire alarm audible notification appliances while delivering voice messages.

2.6 SOFTWARE

A. Control Units and Control Panels: PC-based equipment that is field programmable for control, notification, and supervisory functions; menu-driven program configuration; is password protected.

B. Operational Capability:

1. Loading and editing instructions and operating sequences as necessary.
2. Storing and downloading while the system is in operation.
3. A second set of operating software shall reside in control panels as backup in case primary operating software is corrupted.

C. Memory: Software operations shall be stored in a nonvolatile programmable memory within the MNS control unit. Loss of primary and secondary power shall not erase nonvolatile programmable memory.

2.7 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect assembled equipment as directed. Affix standards organization's certification or label.

B. MNS will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with installation requirements in NFPA 70, NFPA 72, and NECA 1.

B. Install remote amplification and control units in terminal cabinets. Power each remote amplification and control unit from a wiring riser specifically for that use or from a local emergency power panel located on the same floor as the remote unit.

C. Equipment Installation: Install MNS cabinets with seismic rated anchors and mounting apparatus. Comply with requirements for seismic-restraint devices specified in Section 270548.16 "Seismic Controls for Communications Systems."

D. Comply with requirements in Section 270513 "Conductors and Cables for Communications Systems" for cables and conductors for mass notification systems.

E. Do not install cable through structural members or in contact with pipes, ducts, or other potentially damaging items.

F. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.

G. Cold-Weather Installation: Bring cable to room temperature before dereeling. The use of heat lamps is prohibited.

H. Weatherproof Equipment: For units that are mounted outdoors, in damp locations, or where exposed to weather, install consistent with requirements of weatherproof rating.

I. Separation of Wires: Separate speaker-microphone, line-level, speaker-level, and power wiring runs. Install MNS wiring in separate raceways or, where exposed or in same enclosure, separate conductors at least 12 inches (300 mm) apart for speaker-microphone wiring and adjacent parallel power and telephone wiring. Separate other intercommunication equipment conductors as recommended by equipment manufacturer.

J. Connections:

1. Make all terminations on numbered terminal strips in terminal cabinets or equipment enclosures. No splices or butt joints will be accepted.
2. Terminate all conductors; no cable shall contain unterminated elements.
3. Crimp-on type spade lugs shall be used for terminations of stranded conductors to binder screw or stud type terminals. Spade lugs shall have upset legs and insulation sleeves sized for the conductors.

K. Mount all devices and appliances to or in an approved electrical box.

L. Install operating instruction placard on the interior of the mass notification control panel.

M. Install operating instruction placard on the frame in a location acceptable to the Architect and observable from the mass notification control panel.

N. Cybersecurity:

1. Software:

a. Coordinate security requirements with IT department or CIO as directed.
b. Ensure that latest stable software release is installed and properly operating.
c. Disable or change default passwords to password using a combination of uppercase and lower letters, numbers, and symbols at least 8 characters in length. Record passwords and turn over to party responsible for system operation and administration.

2. Hardware:

a. Coordinate location and access requirements with IT department or CIO as directed.
b. Enable highest level of wireless encryption that is compatible with Owner's ICT network.
c. Disable dual network connections.

3.2 GROUNDING

A. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

B. Signal Ground Terminal: Locate at main equipment cabinet. Connect to instrument ground system and isolate from power system and equipment grounding.

3.3 FIELD QUALITY CONTROL

A. Prepare a written ATP for testing the MNS components and installation according to NFPA 72 and this Section. Demonstrate specified function of the system and verify the correct operation of all system components, circuits, and programming.

1. Prepare a complete listing of device labels for alphanumeric annunciator displays prior to the ATP.

B. Testing Agency: Owner will engage or Engage a qualified testing agency to perform tests and inspections as directed.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Take resistance, current, and voltage readings as work progresses.
2. Signal Ground Test: Measure and report ground resistance at public address equipment signal ground. Comply with testing requirements specified in Section 280526 "Grounding and Bonding for Electronic Safety and Security."
3. Verify that wiring for each device is terminated at the properly identified terminals.
4. Test wiring runs for continuity, short circuits, and grounds before system is energized.

5. All test equipment, instruments, tools, and labor required to conduct the system tests shall be made available by the installing Contractor.
6. Schedule tests with at least seven days' advance notice of test performance.
7. After installing MNS and after electrical circuitry has been energized, test for compliance with requirements.
8. Perform the following tests in 50 percent of or 25 percent of all zones and rooms as directed.
9. Perform indoor sound tests in a single test location in rooms less than 20 ft. (6 m) by 20 ft. (6 m). Tests shall be made on a 20 ft. (6 m) by 20 ft. (6 m) grid for larger rooms.
10. Sound test measurements shall be taken at a worst-case location within each room or grid, not near any speaker.
11. Operational Test: Perform tests that include originating messages at microphone outlets, prerecorded messages, remote wired and non-wired inputs, telephone or cellular and other inputs as directed. Verify proper routing and volume levels and that system is free of noise and distortion.
12. Signal-to-Noise Ratio Test: Measure signal-to-noise ratio of complete system at normal gain settings as follows:

    a. Disconnect microphone at connector or jack closest to it and replace it in the circuit with a signal generator using a 1000-Hz signal. Measure signal-to-noise ratio.
    b. Repeat test for each separately controlled zone of loudspeakers.
    c. Minimum acceptance ratio is 50 dB.

13. Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 50, 200, 400, 1000, 3000, 8000, and 12,000 Hz into each preamplifier channel. For each frequency, measure distortion in the paging and all-call amplifier outputs. Maximum acceptable distortion at any frequency is 3 percent total harmonics.
14. Intelligibility Test: Test for intelligibility in accordance with ANSI/ASA S3.2.
15. Power Output Test: Measure electrical power output of each power amplifier at normal gain settings of 50, 1000, and 12,000 Hz. Maximum variation in power output at these frequencies shall not exceed plus or minus 1 dB. Outdoor sound levels where personnel may be present shall not exceed 120 dB when measured on the A-scale of a standard sound level meter at slow response. Sound levels shall not exceed 85 dB at any local microphone of the MNS under the same conditions.
16. System notification appliances shall be demonstrated as follows:

    a. All alarm notification appliances actuate as programmed.
    b. Audibility and visibility at required levels.

17. System indications shall be demonstrated as follows:

    a. Correct message display at MNS control panel for each alarm input.
    b. Correct message display at remote panels and annunciators for each alarm input.
    c. Correct history logging for all system activity.

18. System off-site reporting functions shall be demonstrated as follows:

    a. Correct zone transmitted for each alarm input.
    b. Trouble signals received.

D. MNS will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.4 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train or Train Owner's maintenance personnel to adjust, operate, and maintain units as directed.

1. Train a minimum of four employees of the Owner.

END OF SECTION 284700

SECTION 285211 - DETENTION MONITORING AND CONTROL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes detention monitoring and control operating system, based on PLC technology with hard-control panel operator interface.

1.2 ACTION SUBMITTALS

A. Product Data: For components for detention monitoring and control and systems integration. Include dimensions and data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: Detail assemblies of standard components that are custom assembled for specific application on this Project.

1. Outline Drawings: Indicate dimensions, weights, arrangement of components, and clearance and access requirements.
2. Control Panel Layout: At full scale, show required artwork and device identification.
3. Wiring Diagrams: Detail specific power, control, signal, communication, and data wiring and cabling. Coordinate nomenclature and presentation with block diagram.
4. Raceway Riser Diagrams: Detail raceway runs required for detention monitoring and control and for systems integration. Include designation of devices connected by raceway, raceway type and size, and type and size of wire and cable fill for each raceway run.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certification that fabrication for completed equipment rack and control panel assemblies will withstand seismic forces defined in Section 270548.16 "Seismic Controls for Communications Systems."

B. Field quality-control reports.

C. Program documentation, software licenses, and backup copies of software used on Project.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 SERVICE CONDITIONS

A. Environmental Service Conditions: Systems, equipment, and components shall be capable of operating continuously in the following conditions without mechanical or electrical damage or degradation of operating capability:

1. Ambient Temperature: 140 deg F (60 deg C).
2. Relative Humidity: 10 to 95 percent, noncondensing.

B. Electrical Service Conditions: Equipment shall operate continuously in the following conditions without damage or degradation of operating capability:

1. Voltage Range for Equipment with a Nominal Rating of 120-V AC: 88 to 132 V.
2. Voltage Range for Equipment with a Nominal Rating of 24-V DC: 22 to 85 V.
3. Frequency Range for Equipment with a Nominal Frequency Rating of 60 Hz: 45 to 63 Hz.

PART 2 - PRODUCTS

2.1 FUNCTIONAL DESCRIPTION OF SYSTEM

A. Control Panels for Monitoring and Control Operator Interface: Hard control panels.

B. Normal System and Device Programming Equipment: Dedicated administrative management computer.

C. Interconnection of PLCs with Each Other and with Control Panels: Through a PLC network.

D. Interface between PLC System and Controlled and Monitored Devices: Relay assemblies.

E. Systems Integration: Detention monitoring and control system shall be integrated with features and functions of the following systems and equipment:

1. Lighting controls specified in Section 260943 "Network Lighting Controls."
2. Fire alarm system specified in Section 284621.11 "Addressable Fire-Alarm Systems" or Section 284621.13 "Conventional Fire-Alarm Systems" as directed.
3. Intercommunication and paging specified in Section 275123.20 "Commercial Intercommunications and Program Systems."
4. Closed-circuit television specified in Section 282000 "Video Surveillance."

F. Reliability: Components, arrangement, assembly, construction, wiring, connections, integration, adjustments, and system programming shall have a reliability such that no single malfunction or equipment failure can impair the normal operational control function of more than 20 percent of doors and associated components controlled by the overall system.

G. Independent Operation: System equipment, software, operation, controls, and communications shall provide, as an optional emergency control mode, totally independent operation for the primary local control panel for each operational area.

H. System Response Time: For indicated items, shall be within the following limits:

1. Mechanical Locking and Unlocking of Doors: Within one second of operator action at control panel.
2. As directed, initiate Mechanical Movement of Electrically Controlled Doors or Doors and Gates or Gates: Within one second of operator action at control panel.
3. Initiate Audible and Visual Indications at Control Panels: Within one second of change of state of monitored field devices, or of alarm or intercom call-in events.
4. Initiate Automatic Switching and Start of Automatic Countdown Cycles: Within one second of occurrence of specified triggering event.

I. Automatic Logging of System Events: As directed.

1. Stores, processes, and reports on logged data using an approved software package designed for the purpose.
2. Events to Be Logged: System shall be capable of logging any combination of events that may be registered on the system. Provide logging of the following events in initial programming of the system:

    a. Operator log-on and log-off.
    b. Alarms and alarm responses.
    c. Door interlock overrides.
    d. Gate operation.

3. Data to be Logged for Each Event:

    a. Date and time of occurrence.
    b. Action-point identification.
    c. Operator name (for operator actions).

J. Audible Tone: A distinctive, audible, confirmation signal tone shall sound locally for 0.25 second each time an operator performs a switching, selection, acknowledgment, silence, reset, or other similar operation at a control panel.

2.2 COMPONENT PROTECTION

A. Surge Protection: Protect components from voltage surges originating external to equipment housings and entering through power, communication, signal, control, and sensing leads. Include surge protection for external wiring of each conductor entry connecting to components.

1. Minimum Protection for AC Power Circuits 120 V and More: Multistage surge suppressors, listed under UL 1449, using a combination of inductors and silicon avalanche diodes or equivalent, and with 300-V suppression level and 5-nanosecond maximum response time.

    a. Silicon Avalanche Diodes: Bipolar, Grade A, plus or minus 5 percent tolerance.
    b. Discrete SPD Units External to Protected Equipment: Enclosed modules with indicating lights labeled "power on" and "failure."

2. Minimum Protection for Communication, Signal, Data, Control, and Low-Voltage Power Circuits: As directed.

B. Interference Protection: Component function shall be unaffected by radiated-radio-frequency interference and electrical induction of 15 V/m over a frequency range of 10 to 10,000 MHz, or by conducted interference signals up to 0.25-V RMS injected into power supply lines at 10 to 10,000 MHz.

2.3 PERFORMANCE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.4 HARD CONTROL PANELS

A. Electromechanical-Switch Control Panels: Flat-panel type with LED indicating lights and electromechanical switches.

1. Panel Configuration: Switches and LEDs shall be arranged on a scaled graphic replication of floor plan or in a tabular functional layout as directed.

B. Construction: Devices, media, and work surface shall be assembled on a subbase consisting of a flat aluminum plate as follows:

1. Minimum Aluminum Subbase Thickness: 1/8 inch (3.2 mm) or 3/16 inch (4.8 mm) as directed.
2. Minimum Plexiglass Subbase Thickness: 1/4 inch (6.4 mm) or 5/16 inch (8 mm) as directed.
3. Top for Electromechanical-Switch Panels: As directed.
4. Plastic Materials: Nontoxic and flame retardant.
5. Scale for Graphic Floor Plan: So switches and LEDs are within the lines enclosing the spaces they control or monitor.
6. Device Mounting: Removable from bottom of subpanel.

    a. Electromechanical Switches and Associated LEDs: Secured to subpanel with operating parts exposed at work surface and sealed around exposed parts with bezel.
    b. Terminal Strips and Auxiliary Components: Mounted to underside of control panel.

C. Mounting: Secure control panel to console base or turret as directed.

1. Panel shall be hinged at top with heavy-duty, continuous metal hinges arranged so devices and their wiring connections become fully accessible when panel is opened.
2. Panel shall be secured to base in closed position with listed, high-security-rated, locking assemblies. Locks shall have bolts that latch top panel assembly to base at each front corner.
3. Console Base: Internally reinforced to resist panel movement during a seismic event when base is anchored to building structure.

D. Wiring: Factory wired, with multiconductor cable secured to underside of panel with straps at 1-inch (25-mm) maximum intervals and extra straps and cable sheath reinforcing sleeve where conductors break out for connections.

1. Circuits: Power limited, 12-V dc, maximum.
2. Connections to Control Panel Devices and Components: Solderless, quick-disconnect, plug or sleeve connectors.

E. Control Panel LEDs:

1. Description: Miniature socket-mounting, high-intensity type; colors as indicated; sealed against moisture and dust.
2. Rating: 20 mA, with overload capacity up to 70 mA without affecting life expectancy.
3. Operating Life: 100,000 hours minimum.
4. Viewing Angle: 90 degrees.
5. Body and Lens Material: High-impact polycarbonate.
6. Socket Wiring Terminations: Quick-disconnect sockets.

F. Control Panel Switches, Electromechanical Type:

1. Description: Sealed units rated for a minimum of 5-A inductive load at 28-V dc.
2. Rated Life: 250,000 cycles minimum, at rated voltage and current.

G. Operational Performance of Control Panels: Include the following control, monitoring, and performance functions by hard control panels and associated equipment and circuits:

1. Audible and Visual Alarm Indications and Controls: Red alarm LED flashes and a distinctive tone pulses continuously at control panel when an alarm condition or uncontrolled change of state occurs in controlled or monitored circuits or equipment.

    a. Tone is silenced by momentary-contact silence switch, and LED becomes steady.
    b. Depressing the momentary-contact reset switch extinguishes LED for alarms that can be locally reset.

2. Door Status Visual Indications: Denoted by LEDs at door control switches as follows:

    a. Nonsecure: Red LED.
    b. Secure: Green LED.
    c. Alarm (Door Position or Lock Status Inconsistent with Control Position or Status): Flashing red LED.

3. Panel-Controlled, Unlocking and Automatic-Locking, Single Swing Doors:

    a. Operation of control switch unlocks door for a period programmable from 1/2 to 10 seconds.
    b. Switch: Momentary contact.

4. Electrically or Pneumatically Operated Door, Gate or Door and Gate as directed: Single switch for each unit for open and close control. Operation of switch applies power, initiating opening or closing. Limit switch supplied with mechanism stops unit at end of

its travel. If switch is operated during opening or closing cycle, mechanism stops for one second before reversing.

a. Switch: Two-position, maintained-contact paddle or Single-pole, momentary contact as directed.

5. Individually Controlled Cell Doors: Two momentary-contact switches. One switch locks door, and the other unlocks door.
6. Group-Controlled or Individually Controlled Doors:

a. Switch: Two momentary-contact switches. Depressing one switch locks or unlocks door, depending on current status. Second switch, when operated simultaneously with the panel group door assign and unassign switch, either assigns or unassigns door for group operation, depending on current status.
b. Indications: Yellow LED at individual door assign and unassign switch is lighted when door is assigned for group operation.

7. Group Door Assign and Unassign Switch: Momentary-contact switch.

a. Depressing and holding this switch lights the red LED at control switch for each door that is currently assigned for group operation and permits unassigning any of those doors by momentarily depressing the associated lock and unlock switch.
b. Doors not currently assigned are assigned for group operation by momentarily depressing the associated lock and unlock switch while the group assign and unassign switch continues to be depressed.
c. Assigning and unassigning operations shall not lock or unlock doors.

8. Group Door Locking and Unlocking:

a. Two momentary-contact switches; one for locking and the other for unlocking.
b. Locking or unlocking of group doors is performed individually at one-second intervals.

9. Cell Door Inmate-Access Lockout: One switch on control panel for each cell door.

a. As directed, depressing a momentary-contact inmate-access switch enables an inmate-operated local electric key or push-button, inmate door-control switch that locks and unlocks cell door. Local electric keys or Push-button, inmate door-control switches are specified in Section 087163 "Detention Door Hardware" as directed
b. Depressing the switch again disables operation of inmate access when provided by operation of group inmate-access switch.
c. When inmate access is enabled, orange LED at switch is lighted; otherwise, LED is not lighted.

10. Group Inmate-Access Switch: Controls on-off status of inmate access for cells in group that have this function enabled.

a. Depressing the momentary-contact switch turns function on or off, depending on current condition.

b. When cell group is in inmate-access mode, orange LED at switch is lighted; otherwise, LED is not lighted.

11. Door Interlocking: Interlocks designated groups of doors and gates.

a. Effect: When one door in a group is unlocked or open, the others in the group are prevented from being unlocked or opened.
b. Override When One Door of an Interlocked Group Is Nonsecure: Simultaneous momentary operation of interlock override switch and unlock or open switches for secured interlocked doors to be opened overrides the interlocking for those doors.
c. Override When One Door of an Interlocked Group Is Nonsecure: Simultaneous momentary operation of two interlock override switches and the unlock or open control for secured interlocked doors to be opened overrides the interlocking for those doors.
d. Indications When in Override Mode: Additional yellow LEDs at locking switch for each interlocked door and at override switch, and a distinctive audible tone.

1) All Doors in Group Secure: LEDs, tone for doors in group, and override switch are off.
2) One Door of Interlocked Group Nonsecure: Red LED for nonsecure door is lighted; yellow LEDs for doors in group are on continuously; there is no tone.
3) Two or More Doors in Group Nonsecure: LEDs flash for doors in group, tone pulses, and momentary operation of silence switch silences tone.

12. Operator-Controlled Emergency Door Release - Two-Switch Control: Simultaneous operation of two momentary-contact, emergency-release switches unlocks designated doors.

a. Second simultaneous operation of the two switches returns locks to normal operation.
b. Locking or unlocking of doors is performed individually at one-second intervals.
c. Indications: Red LED at the pair of emergency-release switches is lighted and sounds a distinctive tone.

1) When emergency-release switches unlock doors, LED flashes continuously five times per second, and audible alarm pulses.
2) Silence switch silences audible alarm.
3) When doors are relocked or alarm-reset switch is operated, LED is extinguished and alarm is silenced.

13. Automatic Fire-Door Release: A signal from fire alarm control panel triggers automatic, sequential, timed release of doors in a specific zone. Fire alarm system determines which doors are to be released.

a. Doors in egress path are released first, after a timed countdown period.
b. When doors in egress path are unlocked, a countdown period for release of cell doors begins.
c. Countdown periods are of programmable duration.
d. Countdown may be stopped during either period by actuating an abort switch at control panel.

e. If there is an additional fire alarm signal from the same zone after countdown has been aborted but before smoke detectors have been cleared and fire alarm system reset, system shall restart the countdown; the restarted countdown shall have the same time remaining as remained when cycle was aborted.
f. If there is an additional fire alarm signal from a different zone before original initiating smoke detectors are cleared and fire alarm system is reset, countdown shall begin in new zone with same time remaining as remained for original alarm zone at time of second alarm.
g. Locking or unlocking of doors is performed individually at one-second intervals.
h. Indications: One LED and a distinctive audible tone for each countdown cycle.

1) While cycle is in progress, LED for that cycle shall flash five times per second, and tone shall pulse once for each second of countdown.
2) When doors are released, nonsecure LEDs for those doors shall flash continuously.
3) During each countdown cycle, digital clock in control panel shall count down the time remaining before release of doors in that cycle.

14. Intercommunication Control:

a. Incoming Intercom Call: When staff or inmate station initiates a call to control panel station, a distinctive tone sounds and a yellow or green LED at station switch flashes as directed.
b. Operator acknowledges call by depressing the momentary-contact intercom switch associated with calling station or momentary-contact acknowledge switch. LED is lighted steadily, and tone ceases.
c. Acknowledgment of call opens an audio path to calling station and permits two-way conversation using push-to-talk switch and microphone or handset.
d. Operating the switch again, or selecting another station, terminates the connection; LED at first station switch is extinguished.
e. Listening or Outgoing-Call Function: Operator selects staff or inmate station by operating the station switch. Operator may listen or proceed with two-way conversation using push-to-talk switch and microphone or handset. Selecting station again, or selecting another station, terminates the connection.

15. Paging: Operator transmits paging announcements by operating a momentary-contact paging or paging zone switch as directed, closing a momentary-contact push-to-talk switch, and using microphone or handset. As directed, yellow or Green LED lights at paging or paging zone switch until it is operated again to terminate the connection. Multiple zones may be paged simultaneously by operating more than one paging zone switch before transmitting.
16. Audio-Level Alarm: Depressing the momentary-contact, audio-level-alarm switch shall place intercom system in monitoring mode for cell noise level.

a. Red LED at audio-level-alarm switch is lighted when system is in alarm mode.
b. When in alarm mode, system alarms when noise level in any cell exceeds an adjustable preset threshold. Green LED flashes at control panel intercom station switch for the cell originating the alarm, and an audible alarm tone pulses.
c. Depressing the silence switch silences audible alarm and causes green LED to light steadily.

d. When reset switch is operated, green LED is extinguished.

17. Video Switching Control:

    a. Signal from assigned camera is automatically switched to spot monitor at control panel when the following occurs:

        1) Operator selects associated intercommunication station by operating the selector switch for the station, by acknowledging incoming intercom call, or by operating the camera switch.
        2) A staff-duress alarm is initiated in the vicinity of camera.

    b. Video signal from assigned camera is manually switched to spot monitor at control station when operator operates momentary-contact camera switch.
    c. Green LED on the graphic control panel identifies and locates video camera currently providing the signal for spot monitor at control panel location.

18. Cell Lighting Control: Two momentary-contact switches for each cell provide individual on, off, and inmate control of lights and receptacles.

    a. Depressing the inmate switch energizes receptacles and permits or removes local control of lights within cell, depending on current status.
    b. Depressing the light switch turns lights and receptacles on or off, depending on current status.
    c. Indications: As directed, Green or Orange LED at light switch is lighted when lighting is and power are on; otherwise, LED is not lighted. Green or Orange LED at inmate switch is lighted when inmate control is enabled as directed.

19. Electrical Circuit On-Off Switching Control for Designated Outlets: As directed

    a. Selecting the on position or switch turns circuit on. Selecting the off position or switch turns circuit off.
    b. Indications: As directed, Green or Orange LED at switch indicates when circuit is on.

20. Fire Alarm System Status Indications:

    a. Red fire alarm LED flashes when alarm occurs.
    b. Red LED for each zone flashes when alarm occurs for that zone.
    c. Red LED for each detection device and each manual station flashes when that device or station is in an alarm state.
    d. Audible alarm tone pulses when alarm signal occurs.
    e. Depressing the silence switch silences audible tone and causes LED to light steadily. After fire alarm system is reset, operating the reset switch extinguishes LED.

21. Smoke Control: Operating the smoke-control switch initiates a signal to HVAC system controls to start preestablished smoke-control operating mode for local zone. Yellow LED at switch flashes continuously to verify that HVAC system is operating in smoke-control mode.

22. Duress-Status Indications: When staff-duress device for a zone is activated, red staff-duress LED for that zone flashes and audible alarm tone pulses. Operating the silence switch silences audible alarm and causes LED to light steadily. Operating the reset switch extinguishes LED.
23. Elevator Security Controls: As directed
24. Override of Normal Control for Operation of Exhaust Fans:

    a. Depressing the momentary-contact, exhaust-fan switch starts designated fans for an operating cycle of programmable duration. Fans turn off automatically when cycle ends.
    b. Indications: Yellow LED at switch is lighted steadily when fans are on; otherwise, LED is not lighted.

25. Water-Flow Control: On-off control at central control panel as directed.

    a. Depressing the momentary-contact, water-on switch opens solenoid valve in supply line. Depressing the switch again closes valve.
    b. Indications: Yellow LED at switch is lighted when water is on; otherwise, LED is not lighted.

26. Trouble Alarm Indications for Auxiliary and Utility Systems: Audible and visual indications providing a single nondifferentiated alarm for certain systems and equipment.

    a. Monitored Conditions:

        1) Failure of normal electrical utility supply.
        2) Malfunction of generator set and standby power supply.
        3) UPS malfunction.
        4) Compressed-air system malfunction.
        5) HVAC system malfunction.
        6) Network malfunction.
        7) PLC fault.

    b. Red alarm LED is normally not lighted. When failure or malfunction occurs, light flashes and alarm tone pulses.
    c. Depressing the silence switch silences audible tone and causes LED to light steadily.
    d. If a second malfunction occurs while alarm is silenced but before reset, light flashes and alarm tone pulses again.
    e. After alarm condition is corrected, operating the reset switch extinguishes LED.

27. Panel Control-Power Switch: Key-operated switch turns power to control panel on and off and enables operation.

    a. Indications: Green LED is lighted when panel is enabled; otherwise, LED is not lighted.

28. Remote-Panel Enable Switch: Guarded momentary-contact switch turns control power on and off as directed

a. Indications: Green LED is lighted when satellite panel is enabled; otherwise, LED is not lighted.

2.5 ADMINISTRATIVE MANAGEMENT COMPUTER

A. Description: IBM-compatible microcomputer housed in a standard tower enclosure or an industrial chassis as directed. Minimum features, components, and capabilities shall be same as specified for touchscreen video control panel central-processing unit, with the following exceptions:

1. Peripheral Components:

a. Keyboard: As directed
b. Mouse: Two or Three-button model as directed.
c. Monitor: 17 inches (432 mm). With 1280 by 1024 resolution.

1) On-Screen Colors: 256.
2) Video Card Capacity: VRAM with capture.

d. Speakers: Two amplified computer speakers.
e. Printer: Comply with "Printer" Article.

B. Operational Performance: Same as specified for touchscreen video control panel with the following exceptions and additions:

1. On-Screen Switching and Selection Functions: Performed by mouse-initiated pointing and clicking instead of by touching the screen.
2. Station Capability:

a. Can assume the detention monitoring and control functions of any other touchscreen or any graphic control panel.
b. Can assign the functional performance of any other touchscreen or any graphic control panel to any other touchscreen control panel.
c. Configures, generates, and prints administrative and activity reports, using automatically logged event data.
d. Edits and updates programs, databases, system operating variables, point descriptions, help and operating protocol screens, and icon designations.
e. Edits maps.

2.6 PLC SYSTEM

A. General-Purpose PLCs:

B. "Proprietary" PLCs Designed Specifically for Detention Facility Application:

C. Description: Modular, general-purpose PLCs manufactured specifically for detention facility applications; complete with controllers, power supplies, I/O modules, communication links, and housings. Minimum features and functionality include the following:

1. Characteristics: Adequate memory, software, I/O connections, communication capabilities, power capacity, and logic and timing functions to meet indicated requirements.
2. Controller and I/O Uniformity: Manufacturer's different models shall be compatible, sharing common mounting centers, commands, control language, instruction code, and I/O structure.
3. I/O Modules: Same manufacturer as PLCs and applicable within the full range of manufacturer's controller models.
4. Controller Output Capacity: Adequate to drive local I/O within 50 feet (15 m) of controller without interface modules or additional power supplies. Adequate to drive remote I/O within 1640 feet (503 m) of controller using remote I/O interface modules and a high-speed data link.
5. Expandability: Include a minimum of 25 percent spare capacity and operational capability for future expansion without performance degradation.
6. Controller EPROM: Stores system application program, operating software, and fixed database.
7. Controller General-Purpose RAM: Provides operational memory and storage for operating database. RAM is backed up by lithium battery of adequate capacity for a 12-month outage.
8. Controller Communication Capability: Serial RS 232, RS 422, or RS 485, plus standard Ethernet LAN, using nonproprietary protocol and copper or fiber-optic media.
9. Diagnostics and Failure Response: Controllers and associated I/O devices shall be self-monitoring and self-diagnostic. They shall also monitor their communication links. Failure of any type shall be indicated by LED on the unit, and occurrence of failure shall be communicated to applicable control panel, where it shall result in a failure indication. An analysis of failure shall be registered in PLC memory and shall be remotely software accessible.
10. Redundant Controllers: If installed to meet indicated reliability requirements, a failure of controlling PLC shall be sensed by the redundant unit, which shall assume control and transmit a controller malfunction signal within one second.
11. PLC and Local I/O Power Supply: Regulated dc unit located in the same rack enclosure as units it serves; with 24-V output. Include the following features:

    a. Capacity: 150 percent of load.
    b. Voltage Control and Protection: Remote sensing of voltage at load and internal overvoltage protection.
    c. Fault Protection: Fuses and inherent design protect against short circuit and overload, including shorting of either leg of dc output to conductive material energized intentionally or through malfunction at 120 V.
    d. Surge Protection: Protect the power supply and its I/O circuits in all modes of operation.

12. PLC and Local I/O Device Mounting: Rack mounting in ventilated enclosures.

2.7 RELAYS

A. Description: Plug-in, electromagnetic, solid-state electronic or electromagnetic or solid-state electronic units as directed. Arrange in relay assemblies that have the following features:

1. Fuse and SPD protection.

2. Indicating LED for each relay.
3. Optical isolation of input circuits to V as directed.

B. Rating: A minimum of 125 or 150 percent of the inrush current of controlled device, but not less than 6 A as direc.

2.8 PRINTER

A. Laser: As directed, capable of a certain number of pages per minute minimum nominal printing rate in draft mode.

2.9 DEDICATED UPS

A. Description: Single-phase units, rated 120 V, 60-Hz input and output, complying with requirements for UPS-type central battery inverters in Section 263323.11 "Central Battery Equipment for Emergency Lighting" and with the following:

1. Capacity: Adequate to supply full connected load for a minimum of four hours.
2. SPD: Comply with UL 1449. Provide let-through voltage of 300 V or less.
3. Annunciation of UPS malfunction at control panel.
4. Connected Loads: PLCs and I/O modules both local and remote; operating, control, and indicating power supplies for control panels; and UPS loads as directed.

2.10 COMPONENT ENCLOSURES

A. Description: Metal cabinets, racks, and consoles, with welded frames, complying with UL 1610.

B. Doors, Covers, and Other Access Provisions:

1. Hinged Type: Flanged, with locks and nonremovable pins in hinges.
2. Screw Covers: Secure with security fasteners of type indicated or, if not indicated, flat-head (countersunk) security fasteners.
3. Locks: Pick-resistant, flush-tumbler type; three-point latching device for hinged doors or covers with latch edge more than 24 inches (610 mm) long.
4. Keys: Identical, unless otherwise indicated. Removable only when lock is locked.

C. Seismic Hardening: Increase rigidity of frames with additional welding and grinding of seams and addition of gussets at corners. Reinforce mounting and attachment provisions to resist seismic forces.

D. Mounting and Anchoring Provisions: Accessible only when doors or covers are open. Comply with applicable seismic criteria.

2.11 CABLES

A. Twisted-Pair Signal and Data Cable: Comply as directed.

B. Fiber-Optic Cables and Connectors: Comply as directed.

2.12 ACCESSORIES

A. Interfaces with equipment specified in other sections include accessories, adapters, electronic interface units, and connections required for functional performance indicated.

2.13 SECURITY FASTENERS

A. Description: Operable only by tools produced by fastener manufacturer or other licensed fabricator for use on specific type of fastener. Drive system type, head style, material, and protective coating as required for assembly, installation, and strength.
   1. Drive System Types: Pinned Torx-Plus, pinned Torx or pinned hex (Allen) as directed.
   2. Socket Flat Countersunk Head Fasteners:
      a. Heat-treated alloy steel, ASTM F835 (ASTM F835M).
      b. Stainless steel, ASTM F879 (ASTM F879M), Group 1 CW.
   3. Socket Button Head Fasteners:
      a. Heat-treated alloy steel, ASTM F835 (ASTM F835M).
      b. Stainless steel, ASTM F879 (ASTM F879M), Group 1 CW.
   4. Protective Coatings for Heat-Treated Alloy Steel:
      a. Zinc chromate, ASTM F1135, Grade 3 or 4; for exterior applications and interior applications where indicated.
      b. Zinc chromate with oil, ASTM F1137, Grade 1, or black oxide; unless otherwise indicated.

2.14 SLEEVES FOR RACEWAYS AND CABLES

A. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch (1.3- or 3.5-mm) thickness as indicated and of length to suit application.

C. Coordinate sleeve selection and application with selection and application of firestopping specified in Section 078413 "Penetration Firestopping."

PART 3 - EXECUTION

3.1 SYSTEMS INTEGRATION

A. Integrate installations and connections of equipment and systems specified in this Section with those specified in the following Sections:

1. Section 087163 "Detention Door Hardware" for detention hardware controlled by detention monitoring and control system.
2. Section 275123 "Intercommunications and Program Systems" for intercommunication and paging equipment.
3. Section 284621.11 "Addressable Fire-Alarm Systems" and Section 284621.13 "Conventional Fire-Alarm Systems" for fire alarm equipment and devices.
4. Section 282000 "Video Surveillance" for closed-circuit television equipment.
5. Section 323113 "Chain Link Fences and Gates" for gate operators and locking devices.

3.2 INSTALLATION

A. Comply with NECA 1.

B. Anchor equipment to building structural elements and support according to requirements in Section 270529 "Hangers and Supports for Communications Systems."

C. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounted items.

D. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

E. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

F. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

G. Right of Way: Give to raceways and piping systems installed at a required slope.

H. Security Fasteners: Where accessible to inmates, install detention monitoring and control components using security fasteners with head style appropriate for fabrication requirements, strength, and finish of adjacent materials, except that a maximum of two different sets of tools shall be required to operate security fasteners for Project. Provide stainless-steel security fasteners in stainless-steel materials.

I. AC Power and Lighting Circuits: Comply with Section 270526 "Grounding and Bonding for Communications Systems" for materials and installation requirements.

J. Class 2 Power - Limited Power, Signal, and Control Circuits: Ground systems and equipment according to manufacturer's written instructions.

K. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Comply with requirements in Section 078413 "Penetration Firestopping."

L. Cybersecurity:

1. Software:

    a. Coordinate security requirements with IT department or CIO as directed.
    b. Ensure that latest stable software release is installed and properly operating.
    c. Disable or change default passwords to password using a combination of uppercase and lower letters, numbers, and symbols at least 8 characters in length. Record passwords and turn over to party responsible for system operation and administration.

2. Hardware:

    a. Coordinate location and access requirements with IT department or CIO as directed.
    b. Enable highest level of wireless encryption that is compatible with Owner's ICT network.
    c. Disable dual network connections.

3.3 WIRE AND CABLE INSTALLATION

A. Network and Data-Line Twisted-Pair Circuits: Install wiring as specified in Section 270513 "Conductors and Cables for Communications Systems."

B. Fiber-Optic Cable: Install and terminate as specified in Section 270513 "Conductors and Cables for Communications Systems."

C. Bundle, train, and support wire and cable in enclosures.

D. Connections: Make connections according to manufacturer's wiring diagrams, unless otherwise indicated.

E. Wiring Method: Install wire and cable in metal raceway except where another wiring method is indicated.

3.4 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

B. Coordinate sleeve selection and application with selection and application of firestopping specified in Section 078413 "Penetration Firestopping."

C. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

D. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

E. Rectangular Sleeve Minimum Metal Thickness:

1. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side greater than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
2. For sleeve cross-section rectangle perimeter equal to, or greater than, 50 inches (1270 mm) and 1 or more sides equal to, or greater than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

F. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

G. Cut sleeves to length for mounting flush with both surfaces of walls.

H. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.

I. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed or unless seismic criteria require a different clearance.

J. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Refer to Section 079200 "Joint Sealants" for materials and installation.

K. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with Section 078413 "Penetration Firestopping."

L. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage or Engage a qualified testing agency to perform tests and inspections as directed.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Schedule visual and mechanical inspections and electrical tests with at least seven days' advance notice.
2. Inspect detention monitoring and control components for defects and physical damage, labeling of testing laboratory, and nameplate compliance with the Contract Documents.
3. Inspect interiors of enclosures, including the following:

    a. Integrity of mechanical and electrical connections.
    b. Component type and labeling verification.

c. Ratings of installed components.

4. Electrical Tests: Use caution when testing devices containing solid-state components. Perform the following according to manufacturer's written instructions:

   a. Continuity tests of circuits.
   b. Operational Tests: Set and operate controls at each control panel and at each monitored and controlled device to demonstrate their functions and capabilities. Use a methodical sequence that cues and reproduces actual operating functions as recommended by manufacturer. Record response to each test command and operation, including logging and printout of events. Record time intervals between initiation of alarm conditions and registration of alarms at control (panel), and between initiation of commands and execution at controlled equipment.

      1) Coordinate testing required by this Section with that required by Sections specifying equipment being monitored and controlled and systems to be integrated with detention monitoring and control work.
      2) Simulate malfunctions to verify protective features and appropriate alarm indications.

5. Correct deficiencies make necessary adjustments, and retest. Verify that specified requirements are met.

D. Prepare test and inspection reports.

END OF SECTION 285211

SECTION 311000 - SITE CLEARING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Protecting existing vegetation to remain.
2. Removing existing vegetation.
3. Clearing and grubbing.
4. Stripping and stockpiling topsoil.
5. Removing above- and below-grade site improvements.
6. Disconnecting, capping, or sealing site utilities.
7. Temporary erosion and sedimentation control.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 MATERIAL OWNERSHIP

A. Except for materials indicated to be stockpiled or otherwise remain Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

1.4 FIELD CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
2. Provide alternate routes around closed or obstructed trafficways if required by Owner or authorities having jurisdiction.

B. Salvageable Improvements: Carefully remove items indicated to be salvaged and store on Owner's premises where indicated.

C. Utility Locator Service: Notify utility locator service for area where Project is located before site clearing.

D. Do not commence site clearing operations until temporary erosion- and sedimentation-control and plant-protection measures are in place.

E. Tree- and Plant-Protection Zones: Protect according to requirements in Section 015639 "Temporary Tree and Plant Protection."

PART 2 - PRODUCTS

2.1 MATERIALS

A. Satisfactory Soil Material: Requirements for satisfactory soil material are specified in Section 312000 "Earth Moving."

1. Obtain approved borrow soil material off-site when satisfactory soil material is not available on-site.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect and maintain benchmarks and survey control points from disturbance during construction.

B. Verify that trees, shrubs, and other vegetation to remain or to be relocated have been flagged and that protection zones have been identified and enclosed according to requirements in Section 015639 "Temporary Tree and Plant Protection."

C. Protect existing site improvements to remain from damage during construction.

1. Restore damaged improvements to their original condition, as acceptable to Owner.

3.2 TEMPORARY EROSION AND SEDIMENTATION CONTROL

A. Provide temporary erosion- and sedimentation-control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to erosion- and sedimentation-control Drawings and requirements of authorities having jurisdiction.

B. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross protection zones.

C. Inspect, maintain, and repair erosion- and sedimentation-control measures during construction until permanent vegetation has been established.

D. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

3.3 TREE AND PLANT PROTECTION

A. Protect trees and plants remaining on-site according to requirements in Section 015639 "Temporary Tree and Plant Protection."

B. Repair or replace trees, shrubs, and other vegetation indicated to remain or be relocated that are damaged by construction operations according to requirements in Section 015639 "Temporary Tree and Plant Protection."

3.4 EXISTING UTILITIES

A. Locate, identify, disconnect, and seal or cap utilities indicated to be removed or abandoned in place.

1. Arrange with utility companies to shut off indicated utilities.

B. Interrupting Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others, unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify Architect not less than two days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without Architect's written permission.

C. Removal of underground utilities is included in earthwork sections; in applicable fire suppression, plumbing, HVAC, electrical, communications, electronic safety and security, and utilities sections; and in Section 024116 "Structure Demolition" and Section 024119 "Selective Demolition."

3.5 CLEARING AND GRUBBING

A. Remove obstructions, trees, shrubs, and other vegetation to permit installation of new construction.

1. Grind down stumps and remove roots larger than 3 inches (75 mm) in diameter, obstructions, and debris to a depth of 18 inches (450 mm) below exposed subgrade.
2. Use only hand methods or air spade for grubbing within protection zones.

B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.

1. Place fill material in horizontal layers not exceeding a loose depth of 8 inches (200 mm) and compact each layer to a density equal to adjacent original ground.

3.6 TOPSOIL STRIPPING

A. Remove sod and grass before stripping topsoil.

B. Strip topsoil to depth indicated on Drawings or of 6 inches (150 mm) as directed, in a manner to prevent intermingling with underlying subsoil or other waste materials.

C. Stockpile topsoil away from edge of excavations without intermixing with subsoil or other materials. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust and erosion by water.

3.7 SITE IMPROVEMENTS

A. Remove existing above- and below-grade improvements as indicated and necessary to facilitate new construction.

3.8 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property.

B. Separate recyclable materials produced during site clearing from other nonrecyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities.

END OF SECTION 311000

SECTION 312000 - EARTH MOVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Excavating and filling for rough grading the Site.
2. Preparing subgrades for slabs-on-grade, walks, pavements, turf and grasses and plants as directed.
3. Excavating and backfilling for buildings and structures.
4. Drainage course for concrete slabs-on-grade.
5. Subbase course for concrete walks or pavements as directed.
6. Subbase course and base course for asphalt paving.
7. Excavating and backfilling trenches for utilities and pits for buried utility structures.

1.2 DEFINITIONS

A. Backfill: Soil material used to fill an excavation.

1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
2. Final Backfill: Backfill placed over initial backfill to fill a trench.

B. Base Course: Aggregate layer placed between the subbase course and hot-mix asphalt paving.

C. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.

D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.

E. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water.

F. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.

1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Architect. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.
2. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Architect. Unauthorized excavation, as well as remedial work directed by Architect, shall be without additional compensation.

G. Fill: Soil materials used to raise existing grades.

H. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.

I. Subbase Course: Aggregate layer placed between the subgrade and base course for hot-mix asphalt pavement, or aggregate layer placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.

J. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.

K. Utilities: On-site underground pipes, conduits, ducts, and cables as well as underground services within buildings.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct pre-excavation conference at Project site.

1.4 INFORMATIONAL SUBMITTALS

A. Material test reports.

1.5 FIELD CONDITIONS

A. Utility Locator Service: Notify utility locator service for area where Project is located before beginning earth-moving operations.

B. Do not commence earth-moving operations until plant-protection measures specified in Section 015639 "Temporary Tree and Plant Protection" are in place.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.

B. Satisfactory Soils: As directed, Soil Classification Groups GW, GP, GM, SW, SP, and SM according to ASTM D2487 or Groups A-1, A-2-4, A-2-5, and A-3 according to AASHTO M 145, or a combination of these groups; free of rock or gravel larger than 3 inches (75 mm) in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.

1. Liquid Limit: Value as directed.
2. Plasticity Index: Value as directed.

C. Unsatisfactory Soils: Soil Classification Groups GC, SC, CL, ML, OL, CH, MH, OH, and PT according to ASTM D2487 or Groups A-2-6, A-2-7, A-4, A-5, A-6, and A-7 according to AASHTO M 145, or a combination of these groups.

1. Unsatisfactory soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.

D. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940/D2940M; with at least 90 percent passing a 1-1/2-inch (37.5-mm) sieve and not more than 12 percent passing a No. 200 (0.075-mm) sieve.

E. Base Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940/D2940M; with at least 95 percent passing a 1-1/2-inch (37.5-mm) sieve and not more than 8 percent passing a No. 200 (0.075-mm) sieve.

F. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940/D2940M; with at least 90 percent passing a 1-1/2-inch (37.5-mm) sieve and not more than 12 percent passing a No. 200 (0.075-mm) sieve.

G. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940/D2940M; except with 100 percent passing a 1-inch (25-mm) sieve and not more than 8 percent passing a No. 200 (0.075-mm) sieve.

H. Drainage Course: Narrowly graded mixture of washed crushed stone or crushed or uncrushed gravel; ASTM D448; coarse-aggregate grading Size 57; with 100 percent passing a 1-1/2-inch (37.5-mm) sieve and zero to 5 percent passing a No. 8 (2.36-mm) sieve.

2.2 ACCESSORIES

A. Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, 6 inches (150 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of the utility; colored to comply with local practice or requirements of authorities having jurisdiction.

B. Detectable Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches (150 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches (750 mm) deep; colored to comply with local practice or requirements of authorities having jurisdiction.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth-moving operations.

B. Protect and maintain erosion and sedimentation controls during earth-moving operations.

C. Protect subgrades and foundation soils from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.

3.2 EXCAVATION, GENERAL

A. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions.

1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.

3.3 EXCAVATION FOR STRUCTURES

A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch (25 mm). If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.

1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.
2. Pile Foundations: Stop excavations 6 to 12 inches (150 to 300 mm) above bottom of pile cap before piles are placed. After piles have been driven, remove loose and displaced material. Excavate to final grade, leaving solid base to receive concrete pile caps.
3. Excavation for Underground Tanks, Basins, and Mechanical or Electrical Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus 1 inch (25 mm). Do not disturb bottom of excavations intended as bearing surfaces.

B. Excavations at Edges of Tree- and Plant-Protection Zones:

1. Excavate by hand or with an air spade to indicated lines, cross sections, elevations, and subgrades. If excavating by hand, use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.
2. Cut and protect roots according to requirements in Section 015639 "Temporary Tree and Plant Protection."

3.4 EXCAVATION FOR WALKS AND PAVEMENTS

A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

3.5 EXCAVATION FOR UTILITY TRENCHES

A. Excavate trenches to indicated gradients, lines, depths, and elevations.

B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches (300 mm) higher than top of pipe or conduit unless otherwise indicated.

1. Clearance: 12 inches (300 mm) each side of pipe or conduit or as indicated.

C. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits. Remove projecting stones and sharp objects along trench subgrade.

1. Excavate trenches 6 inches (150 mm) deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

D. Trenches in Tree- and Plant-Protection Zones:

1. Hand-excavate to indicated lines, cross sections, elevations, and subgrades. Use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.
2. Do not cut main lateral roots or taproots; cut only smaller roots that interfere with installation of utilities.
3. Cut and protect roots according to requirements in Section 015639 "Temporary Tree and Plant Protection."

3.6 SUBGRADE INSPECTION

A. Proof-roll subgrade below the building slabs and pavements with a pneumatic-tired dump truck to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

B. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Architect, without additional compensation.

3.7 UNAUTHORIZED EXCAVATION

A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill, with 28-day compressive strength of 2500 psi (17.2 MPa), may be used when approved by Architect.

1. Fill unauthorized excavations under other construction, pipe, or conduit as directed by Architect.

3.8 STORAGE OF SOIL MATERIALS

A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.

1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.9 UTILITY TRENCH BACKFILL

A. Place backfill on subgrades free of mud, frost, snow, or ice.

B. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

C. Trenches under Footings: Backfill trenches excavated under footings and within 18 inches (450 mm) of bottom of footings with satisfactory soil; fill with concrete to elevation of bottom of footings. Concrete is specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.

D. Trenches under Roadways: Provide 4-inch (100-mm) thick, concrete-base slab support for piping or conduit less than 30 inches (750 mm) below surface of roadways. After installing and testing, completely encase piping or conduit in a minimum of 4 inches (100 mm) of concrete before backfilling or placing roadway subbase course. Concrete is specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed.

E. Initial Backfill: Place and compact initial backfill of subbase material or satisfactory soil as directed, free of particles larger than 1 inch (25 mm) in any dimension, to a height of 12 inches (300 mm) over the pipe or conduit.

1. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.

F. Final Backfill: Place and compact final backfill of satisfactory soil to final subgrade elevation.

G. Warning Tape: Install warning tape directly above utilities, 12 inches (300 mm) below finished grade, except 6 inches (150 mm) below subgrade under pavements and slabs.

3.10 SOIL FILL

A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.

B. Place and compact fill material in layers to required elevations as follows:

1. Under grass and planted areas, use satisfactory soil material.

2. Under walks and pavements, use satisfactory soil material.
3. Under steps and ramps, use engineered fill.
4. Under building slabs, use engineered fill.
5. Under footings and foundations, use engineered fill.

3.11 SOIL MOISTURE CONTROL

A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.

1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
2. Remove and replace, or scarify and air dry, otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

3.12 COMPACTION OF SOIL BACKFILLS AND FILLS

A. Place backfill and fill soil materials in layers not more than 8 inches (200 mm) in loose depth for material compacted by heavy compaction equipment and not more than 4 inches (100 mm) in loose depth for material compacted by hand-operated tampers.

B. Place backfill and fill soil materials evenly on all sides of structures to required elevations and uniformly along the full length of each structure.

C. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D698 or ASTM D1557 as directed:

1. Under structures, building slabs, steps, and pavements, scarify and recompact top 12 inches (300 mm) of existing subgrade and each layer of backfill or fill soil material at 95 percent.
2. Under walkways, scarify and recompact top 6 inches (150 mm) below subgrade and compact each layer of backfill or fill soil material at 92 percent.
3. Under turf or unpaved areas, scarify and recompact top 6 inches (150 mm) below subgrade and compact each layer of backfill or fill soil material at 85 percent.
4. For utility trenches, compact each layer of initial and final backfill soil material at 85 percent.

3.13 GRADING

A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.

B. Site Rough Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to elevations required to achieve indicated finish elevations, within the following subgrade tolerances:

1. Turf or Unpaved Areas: Plus or minus 1-inch (25 mm).

2. Walks: Plus or minus 1-inch (25 mm).
3. Pavements: Plus or minus ½-inch (13 mm).

C. Grading inside Building Lines: Finish subgrade to a tolerance of 1/2 inch (13 mm) when tested with a 10-foot (3-m) straightedge.

3.14 SUBBASE AND BASE COURSES UNDER PAVEMENTS AND WALKS

A. Place subbase course and base course on subgrades free of mud, frost, snow, or ice.

B. On prepared subgrade, place subbase course and base course under pavements and walks as follows:

1. Shape subbase course and base course to required crown elevations and cross-slope grades.
2. Place subbase course and base course that exceeds 6 inches (150 mm) in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches (150 mm) thick or less than 3 inches (75 mm) thick.
3. Compact subbase course and base course at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 95 percent of maximum dry unit weight according to ASTM D698 or ASTM D1557 as directed.

3.15 DRAINAGE COURSE UNDER CONCRETE SLABS-ON-GRADE

A. Place drainage course on subgrades free of mud, frost, snow, or ice.

B. On prepared subgrade, place and compact drainage course under cast-in-place concrete slabs-on-grade as follows:

1. Place drainage course that exceeds 6 inches (150 mm) in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches (150 mm) thick or less than 3 inches (75 mm) thick.
2. Compact each layer of drainage course to required cross sections and thicknesses to not less than 95 percent of maximum dry unit weight according to ASTM D698.

3.16 FIELD QUALITY CONTROL

A. Special Inspections: Owner will engage a qualified special inspector to perform inspections:

B. Testing Agency: Owner will engage a qualified geotechnical engineering testing agency to perform tests and inspections.

C. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.

D. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing

subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Architect.

E. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

3.17 PROTECTION

A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.

C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.

1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.18 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus satisfactory soil and waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.

END OF SECTION 312000

SECTION 312319 - DEWATERING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes construction dewatering.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 FIELD CONDITIONS

A. Survey Work: Engage a qualified land surveyor or professional engineer to survey adjacent existing buildings, structures, and site improvements; establish exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Dewatering Performance: Design, furnish, install, test, operate, monitor, and maintain dewatering system of sufficient scope, size, and capacity to control hydrostatic pressures and to lower, control, remove, and dispose of ground water and permit excavation and construction to proceed on dry, stable subgrades.

PART 3 - EXECUTION

3.1 PREPARATION

A. Provide temporary grading to facilitate dewatering and control of surface water.

B. Protect and maintain temporary erosion and sedimentation controls, which are specified in Section 015000 "Temporary Facilities and Controls," Section 311000 "Site Clearing," during dewatering operations.

3.2 INSTALLATION

A. Install dewatering system utilizing wells, well points, or similar methods complete with pump equipment, standby power and pumps, filter material gradation, valves, appurtenances, water disposal, and surface-water controls.

1. Space well points or wells at intervals required to provide sufficient dewatering.
2. Use filters or other means to prevent pumping of fine sands or silts from the subsurface.

B. Place dewatering system into operation to lower water to specified levels before excavating below ground-water level.

C. Provide standby equipment on-site, installed and available for immediate operation, to maintain dewatering on continuous basis if any part of system becomes inadequate or fails.

3.3 OPERATION

A. Operate system continuously until drains, sewers, and structures have been constructed and fill materials have been placed or until dewatering is no longer required.

B. Operate system to lower and control ground water to permit excavation, construction of structures, and placement of fill materials on dry subgrades. Drain water-bearing strata above and below bottom of foundations, drains, sewers, and other excavations.

1. Do not permit open-sump pumping that leads to loss of fines, soil piping, subgrade softening, and slope instability.
2. Reduce hydrostatic head in water-bearing strata below subgrade elevations of foundations, drains, sewers, and other excavations.
3. Maintain piezometric water level a minimum of 24 inches (600 mm) or 60 inches (1500 mm) below bottom of excavation as directed.

C. Remove dewatering system from Project site on completion of dewatering. Plug or fill well holes with sand or cut off and cap wells a minimum of 36 inches (900 mm) below overlying construction.

3.4 FIELD QUALITY CONTROL

A. Survey-Work Benchmarks: Resurvey benchmarks regularly during dewatering and maintain an accurate log of surveyed elevations for comparison with original elevations. Promptly notify Architect if changes in elevations occur or if cracks, sags, or other damage is evident in adjacent construction.

END OF SECTION 312319

SECTION 313116 - TERMITE CONTROL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Soil treatment.
2. Bait-station system.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product. Include the EPA-Registered Label for termiticide products.

1.4 INFORMATIONAL SUBMITTALS

A. Product certificates.

B. Soil Treatment Application Report: Include the following:

1. Date and time of application.
2. Moisture content of soil before application.
3. Termiticide brand name and manufacturer.
4. Quantity of undiluted termiticide used.
5. Dilutions, methods, volumes used, and rates of application.
6. Areas of application.
7. Water source for application.

C. Bait-Station System Installation Report: Include the following:

1. Location of areas and sites conducive to termite feeding and activity.
2. Plan drawing showing number and locations of bait stations.
3. Dated report for each monitoring and inspection occurrence, indicating level of termite activity, procedure, and treatment applied before time of Substantial Completion.
4. Termiticide brand name and manufacturer.
5. Quantities of termiticide and nontoxic termite bait used.
6. Schedule of inspections for one year from date of Substantial Completion.

D. Sample Warranties: For special warranties.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: A specialist who is licensed according to regulations of authorities having jurisdiction to apply termite control treatment and products in jurisdiction where Project is located and who employs workers trained and approved by manufacturer to install manufacturer's products.

1.6 WARRANTY

A. Soil Treatment Special Warranty: Manufacturer's standard form, signed by Applicator and Contractor, certifying that termite control work consisting of applied soil termiticide treatment will prevent infestation of subterranean termites, including Formosan termites (Coptotermes formosanus). If subterranean termite activity or damage is discovered during warranty period, re-treat soil and repair or replace damage caused by termite infestation.

1. Warranty Period: As directed, Three or Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SOIL TREATMENT

A. Termiticide: EPA-Registered termiticide acceptable to authorities having jurisdiction, in an aqueous solution formulated to prevent termite infestation.
1. Service Life of Treatment: Soil treatment termiticide that is effective for not less than three or five years against infestation of subterranean termites as directed.

2.2 BAIT-STATION SYSTEM

A. Description: EPA-Registered system acceptable to authorities having jurisdiction. Provide bait stations based on the dimensions of building perimeter indicated on Drawings, according to product's EPA-Registered Label and manufacturer's written instructions.

PART 3 - EXECUTION

3.1 PREPARATION

A. Remove extraneous sources of wood cellulose and other edible materials, such as wood debris, tree stumps and roots, stakes, formwork, and construction waste wood from soil within and around foundations.

B. Soil Treatment Preparation: Remove foreign matter and impermeable soil materials that could decrease treatment effectiveness on areas to be treated.

3.2 APPLYING SOIL TREATMENT

A. Application: Mix soil treatment termiticide solution to a uniform consistency. Distribute treatment uniformly. Apply treatment at the product's EPA-Registered Label volume and rate for maximum specified concentration of termiticide to the following so that a continuous horizontal and vertical termiticidal barrier or treated zone is established around and under building construction.

1. Slabs-on-Grade and Basement Slabs: Underground-supported slab construction, including footings, building slabs, and attached slabs as an overall treatment. Treat soil materials before concrete footings and slabs are placed.
2. Foundations: Soil adjacent to and along the entire inside perimeter of foundation walls; along both sides of interior partition walls; around plumbing pipes and electric conduit penetrating the slab; around interior column footers, piers, and chimney bases; and along the entire outside perimeter, from grade to bottom of footing.
3. Crawlspaces: Soil under and adjacent to foundations. Treat adjacent areas, including around entrance platform, porches, and equipment bases. Apply overall treatment only where attached concrete platform and porches are on fill or ground.
4. Masonry: Treat voids.
5. Penetrations: At expansion joints, control joints, and areas where slabs and below-grade walls will be penetrated.

B. Post warning signs in areas of application.

C. Reapply soil treatment solution to areas disturbed by subsequent excavation, grading, landscaping, or other construction activities following application.

3.3 INSTALLING BAIT-STATION SYSTEM

A. Bait-Station System: Install during construction to determine areas of termite activity and after construction, including landscaping, is completed.

B. Place bait stations according to product's EPA-Registered Label and manufacturer's written instructions, in the following locations:

1. Conducive sites and locations indicated on Drawings.
2. In and around infested trees and stumps.
3. In mulch beds.
4. Where wood directly contacts soil.
5. Areas of high soil moisture.
6. Near irrigation sprinkler heads.
7. Each area where roof drainage system, including downspouts and scuppers, drains to soil.
8. Along driplines of roof overhangs without gutters.
9. Where condensate lines from mechanical equipment drip or drain to soil.
10. At plumbing penetrations through ground-supported slabs.
11. Other sites and locations as determined by licensed Installer.

END OF SECTION 313116

SECTION 315000 - EXCAVATION SUPPORT AND PROTECTION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes temporary excavation support and protection systems.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Shop Drawings: For excavation support and protection system, prepared by or under the supervision of a qualified professional engineer.

B. Delegated-Design Submittal: For excavation support and protection systems, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For the following:

1. Professional Engineer: Experience with providing delegated-design engineering services of the type indicated, including documentation that engineer is licensed in the jurisdiction or state as directed in which Project is located.

B. Contractor Calculations: For excavation support and protection system. Include analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

C. Existing Conditions: Using photographs or video recordings, show existing conditions of adjacent construction and site improvements that might be misconstrued as damage caused by inadequate performance of excavation support and protection systems. Submit before Work begins.

1.5 CLOSEOUT SUBMITTALS

A. Record Drawings: Identify locations and depths of capped utilities, abandoned-in-place support and protection systems, and other subsurface structural, electrical, or mechanical conditions.

1.6 FIELD CONDITIONS

A. Interruption of Existing Utilities: Do not interrupt any utility-serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility according to requirements indicated:

1. Notify Architect, Construction Manager or Owner as directed no fewer than two days in advance of proposed interruption of utility.
2. Do not proceed with interruption of utility without Architect's, Construction Manager's or Owner's written permission as directed.

B. Survey Work: Engage a qualified land surveyor or professional engineer to survey adjacent existing buildings, structures, and site improvements; establish exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design excavation support and protection systems to resist all lateral loading and surcharge, including but not limited to, retained soil, groundwater pressure, adjacent building loads, adjacent traffic loads, construction traffic loads, material stockpile loads, and seismic loads, based on the following:

1. Compliance with OSHA Standards and interpretations, 29 CFR 1926, Subpart P.
2. Compliance with AASHTO Standard Specification for Highway Bridges or AASHTO LRFD Bridge Design Specification, Customary U.S. Units.
3. Compliance with requirements of authorities having jurisdiction.
4. Compliance with utility company requirements.
5. Compliance with railroad requirements.

2.2 MATERIALS

A. Provide materials that are either new or in serviceable condition.

B. Structural Steel: ASTM A36/A36M, ASTM A690/A690M, or ASTM A992/A992M.

C. Steel Sheet Piling: ASTM A328/A328M, ASTM A572/A572M, or ASTM A690/A690M; with continuous interlocks.

1. Corners: Site-fabricated mechanical interlock or Roll-formed corner shape with continuous interlock as directed.

D. Wood Lagging: Lumber, mixed hardwood, nominal rough thickness of size and strength required for application 3 inches (75 mm) or 4 inches (100 mm) as directed.

E. Shotcrete: Comply with Section 033713 "Shotcrete" for shotcrete materials and mixes, reinforcement, and shotcrete application.

F. Cast-in-Place Concrete: ACI 301, of compressive strength required for application.

G. Reinforcing Bars: ASTM A615/A615M, Grade 60 (Grade 420), deformed.

H. Tiebacks: Steel bars, ASTM A722/A722M.

I. Tiebacks: Steel strand, ASTM A416/A416M.

PART 3 - EXECUTION

3.1 INSTALLATION - GENERAL

A. Locate excavation support and protection systems clear of permanent construction, so that construction and finishing of other work is not impeded.

B. Install excavation support and protection systems to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
2. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

C. Install excavation support and protection systems without damaging existing buildings, structures, and site improvements adjacent to excavation.

3.2 SOLDIER PILES AND LAGGING

A. Install steel soldier piles before starting excavation.

1. Extend soldier piles below excavation grade level to depths adequate to prevent lateral movement.
2. Space soldier piles at regular intervals not to exceed allowable flexural strength of wood lagging.
3. Accurately align exposed faces of flanges to vary not more than 2 inches (50 mm) from a horizontal line and not more than 1:120 out of vertical alignment.

B. Install wood lagging within flanges of soldier piles as excavation proceeds.

1. Trim excavation as required to install lagging.
2. Fill voids behind lagging with soil, and compact.

C. Install wales horizontally at locations indicated on Drawings and secure to soldier piles.

3.3 SHEET PILING

A. Before starting excavation, install one-piece sheet piling lengths and tightly interlock vertical edges to form a continuous barrier.

B. Accurately place the piling using templates and guide frames unless otherwise recommended in writing by the sheet piling manufacturer.

1. Limit vertical offset of adjacent sheet piling to 60 inches (1500 mm).
2. Accurately align exposed faces of sheet piling to vary not more than 2 inches (50 mm) from a horizontal line and not more than 1:120 out of vertical alignment.

C. Cut tops of sheet piling to uniform elevation at top of excavation.

3.4 TIEBACKS

A. Drill, install, grout, and tension tiebacks.

B. Test load-carrying capacity of each tieback and replace and retest deficient tiebacks.

1. Have test loading observed by a qualified professional engineer responsible for design of excavation support and protection system.

C. Maintain tiebacks in place until permanent construction is able to withstand lateral earth and hydrostatic pressures.

3.5 BRACING

A. Locate bracing to clear columns, floor framing construction, and other permanent work. If necessary to move brace, install new bracing before removing original brace.

1. Do not place bracing where it will be cast into or included in permanent concrete work unless otherwise approved by Architect.
2. Install internal bracing if required to prevent spreading or distortion of braced frames.
3. Maintain bracing until structural elements are supported by other bracing or until permanent construction is able to withstand lateral earth and hydrostatic pressures.

3.6 MAINTENANCE

A. Monitor and maintain excavation support and protection system.

B. Prevent surface water from entering excavations by grading, dikes, or other means.

C. Continuously monitor vibrations, settlements, and movements to ensure stability of excavations and constructed slopes and to ensure that damage to permanent structures is prevented.

3.7 FIELD QUALITY CONTROL

A. Survey-Work Benchmarks: Resurvey benchmarks regularly, daily or weekly as directed during installation of excavation support and protection systems, excavation progress, and for as long as excavation remains open.

1. Maintain an accurate log of surveyed elevations and positions for comparison with original elevations and positions.
2. Promptly notify Architect if changes in elevations or positions occur or if cracks, sags, or other damage is evident in adjacent construction.

B. Promptly correct detected bulges, breakage, or other evidence of movement to ensure that excavation support and protection system remains stable.

C. Promptly repair damages to adjacent facilities caused by installation or faulty performance of excavation support and protection systems.

3.8 REMOVAL AND REPAIRS

A. Remove excavation support and protection systems when construction has progressed sufficiently to support excavation and earth and hydrostatic pressures.

1. Remove in stages to avoid disturbing underlying soils and rock or damaging structures, pavements, facilities, and utilities.
2. Remove excavation support and protection systems to a minimum depth of 48 (1200) inches (mm) below overlying construction, and abandon remainder.
3. Fill voids immediately with approved backfill compacted to density specified in Section 312000 "Earth Moving."
4. Repair or replace, as approved by Architect, adjacent work damaged or displaced by removing excavation support and protection systems.

B. Leave excavation support and protection systems permanently in place.

END OF SECTION 315000

SECTION 316213 - CONCRETE PILES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes hollow or solid, precast, prestressed concrete piles as directed.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For concrete piles. Prepared by or under the supervision of a qualified professional engineer detailing fabrication and lifting devices necessary for handling and driving piles.

1. Indicate pile dimensions, cross sections, locations, and sizes. Show details of pile splices and shoes.
2. Indicate types of reinforcement, including prestressing strand, and detail fabricating, bending, and placing.
3. Indicate layout and dimensions and identify each pile. Indicate welded connections by AWS standard symbols. Detail cast-in hardware.
4. Indicate transportation, storage, and lifting points.

C. Delegated-Design Submittal: For concrete piles.

1. Indicate compliance with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Concrete design mixes.

C. Material certificates.

D. Material test reports.

E. Pile-Driving Equipment Data: Include type, make, and rated energy range; weight of striking part of hammer; weight of drive cap; and, type, size, and properties of hammer cushion.

F. Pile-driving records.

G. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: Participates in PCI's Plant Certification Program and is designated a PCI-Certified Plant for B2 and C2 product group and category, or better.

B. Design Practices: Comply with ACI 318 (ACI 318M) and the recommendations in PCI Committee Report: "Recommended Practice for Design, Manufacture and Installation of Prestressed Concrete Piling."

C. Quality-Control Standard: PCI MNL-116, "Manual for Quality Control for Plants and Production of Structural Precast Concrete Products."

D. Comply with requirements in ACI 301, "Specifications for Structural Concrete."

E. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. AWS D1.4/D1.4M, "Structural Welding Code - Reinforcing Steel."

1.6 DELIVERY, STORAGE, AND HANDLING

A. Handle and store piles at Project site to prevent cracking, distorting, warping, or other physical damage, and so markings are visible.

B. Lift and support piles only at designated lifting or supporting points as shown on Shop Drawings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: As directed, subject to compliance with requirements, provide products by the following, provide products by one of the following or available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

2.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design piles, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Piles shall withstand transportation, erection, and driving stresses and design loads within limits indicated and under conditions existing at Project site.

1. Design Loads: Loads as directed.

2.3 STEEL REINFORCEMENT

A. Reinforcing Bars: ASTM A615/A615M, Grade 60 (Grade 420); deformed.

B. Low-Alloy-Steel Reinforcing Bars: ASTM A706/A706M.

C. Galvanized Reinforcing Bars: ASTM A767/A767M, Class II zinc coated, hot-dip galvanized after fabrication and bending, as follows:

1. Steel Reinforcement: As directed, ASTM A615/A615M, Grade 60 (Grade 420) or ASTM A706/A706M, deformed.

D. Epoxy-Coated Reinforcing Bars: ASTM A775/A775M or ASTM A934/A934M, as follows:

1. Steel Reinforcement: As directed, ASTM A615/A615M, Grade 60 (Grade 420) or ASTM A706/A706M, deformed.

E. Plain Steel Wire: ASTM A82/A82M, as drawn or galvanized as directed.

F. Deformed-Steel Wire: ASTM A496/A496M.

G. Epoxy-Coated-Steel Wire: ASTM A884/A884M, Class A coated, plain or deformed as directed.

2.4 PRESTRESSING TENDONS

A. Prestressing Strand: ASTM A416/A416M, Grade 250 or 270 (Grade 1725 or 1860); uncoated, seven-wire, low-relaxation strand.

2.5 CONCRETE MATERIALS

A. Portland Cement: ASTM C150/C150M, Type I or Type III or Type II, of same type, brand, and source as directed.

1. Fly Ash: ASTM C618, Class C or F.
2. Silica Fume: ASTM C1240, amorphous silica.

B. Normal-Weight Aggregates: Except as modified by PCI MNL-116, ASTM C33/C33M, with coarse aggregates complying with Class 4S, Class 4M or Class 1N. Provide aggregates from single source.

C. Water: Potable, complying with chemical limits of PCI MNL-116.

D. Air-Entraining Admixture: ASTM C260/C260M.

2.6 PILE ACCESSORIES

A. Pile Shoes: 1-inch- (25-mm-) thick minimum, carbon-steel plate fabricated to match shape of pile tip.

B. Pile Splices: Manufactured from carbon-steel plates or castings and capable of developing strength of continuous pile at splice location.

2.7 CONCRETE MIXES

A. Prepare design mixes for each type of concrete required.

1. Limit use of fly ash and silica fume to not exceed, in total, 25 percent of portland cement by weight.

B. Proportion mixes by either laboratory trial batch or field-test data methods according to ACI 211.1, with materials to be used on Project, to provide normal-weight concrete with the following properties:

1. Compressive Strength (28 Days): 8000 psi (55.2 MPa), 7000 psi (48.3 MPa), 6000 psi (41.4 MPa) or 5000 psi (34.5 MPa) as directed.
2. Maximum Water-Cementitious Material Ratio: 0.40.
3. Air Content: 6.0 percent, plus or minus 1.5 or 2.5 to 4.5 percent as directed.

2.8 FABRICATION

A. Reinforcement: Comply with recommendations in CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement. Clean reinforcement of loose rust and mill scale, earth, and other materials that reduce or destroy bond with concrete.

B. Prestress tendons for piles by either pretensioning or post-tensioning methods. Comply with PCI MNL-116.

C. Pile Shoes: Accurately position and secure pile shoes at pile tips so as to not affect pile alignment during driving. Weld pile shoes to longitudinal reinforcements.

D. Pile Splices: Accurately position and secure pile-splice segments requiring embedding in tips of piles.

E. Place concrete in a continuous operation to prevent seams or planes of weakness from forming in piles. Comply with requirements in PCI MNL-116 for measuring, mixing, transporting, and placing concrete.

F. Fabricate precast, prestressed concrete piles straight and true to size and shape with exposed edges and corners precise and true so each finished unit complies with PCI MNL-116 and PCI MNL-135 product tolerances.

G. Finish: Fabricate concrete piles with normal plant-run finish produced in forms that impart a smooth finish to concrete. Small surface holes caused by air bubbles, normal color variations,

form joint marks, and minor chips and spalls are tolerated. Major or unsightly imperfections, honeycombs, or structural defects are not permitted.

1. Finish unformed surfaces by trowel unless otherwise indicated. Consolidate concrete, bring to proper level with straightedge, float, and trowel to a smooth, uniform finish.

H. Pile-Length Markings: Mark each pile with horizontal lines at 12-inch (305-mm) intervals; label the distance from pile tip at 60-inch (1524-mm) intervals. Maintain markings on piles until driven.

2.9 SOURCE QUALITY CONTROL

A. Testing: Test and inspect piles according to PCI MNL-116.

B. Piles will be considered defective if they do not pass tests and inspections.

PART 3 - EXECUTION

3.1 DRIVING PILES

A. General: Continuously drive piles to elevations or penetration resistance indicated. Establish and maintain axial alignment of leads and piles before and during driving.

B. Heaved Piles: Redrive heaved piles to tip elevation at least as deep as original tip elevation with a driving resistance at least as great as original driving resistance.

C. Driving Tolerances: Drive piles without exceeding the following tolerances, measured at pile heads:

1. Location: 4 inches (102 mm) from location indicated after initial driving, and 6 inches (152 mm) after pile driving is completed.
2. Plumb: Maintain 1 inch (25 mm) in 48 inches (1219 mm) from vertical, or a maximum of 4 inches (102 mm), measured when pile is aboveground in leads.
3. Batter Angle: Maximum 1 inch (25 mm) in 48 inches (1219 mm) from required angle, measured when pile is aboveground in leads.

D. Withdraw damaged or defective piles and piles that exceed driving tolerances and install new piles within driving tolerances.

E. Cut off tops of driven piles square with pile axis and at elevations indicated.

F. Pile-Driving Records: Maintain accurate driving records for each pile, compiled and attested to by a qualified professional engineer.

3.2 FIELD QUALITY CONTROL

A. Special Inspections: As directed, Owner will engage or Engage a qualified special inspector to perform inspections.

B. Testing Agency: As directed, Owner will engage or Engage a qualified testing agency to perform tests and inspections.

C. Tests and Inspections:

1. Dynamic Pile Testing: High-strain dynamic monitoring shall be performed and reported according to ASTM D4945 during initial driving and during re-striking on five single or 3 percent of piles.
2. Low-strain integrity measurement shall be performed and reported for each pile.

D. Piles will be considered defective if they do not pass tests and inspections.

END OF SECTION 316213

SECTION 316216 - STEEL PILES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes steel H piles.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For steel H piles. Show fabrication and installation details for piles, including details of driving points, splices, and pile caps.

1. Indicate welds by standard AWS symbols, distinguishing between shop and field welds, and show size, length, and type of each weld.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Mill test reports.

C. Pile-Driving Equipment Data: Include type, make, and rated energy range; weight of striking part of hammer; weight of drive cap; and, type, size, and properties of hammer cushion.

D. Pile-driving records.

E. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

PART 2 - PRODUCTS

2.1 STEEL H PILES

A. High-Strength, Low-Alloy, Columbium-Vanadium Structural Steel: ASTM A572/A572M, Grade 50 (Grade 345) or Grade 60 (Grade 415) as directed.

1. Manufacturers: Subject to compliance with requirements, provide products by the following, provide products by one of the following or available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following as directed:

B. High-Strength, Low-Alloy, Nickel, Copper, Phosphorous Steel H Piles: ASTM A690/A690M.

1. Manufacturers: Subject to compliance with requirements, provide products by the following, provide products by one of the following, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following as directed:

C. High-Strength, Low-Alloy, Structural Steel: ASTM A588/A588M.

1. Manufacturers: Subject to compliance with requirements, provide products by the following, provide products by one of the following, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following as directed:

2.2 PILE ACCESSORIES

A. Driving Points: Manufacturer's standard one-piece driving point, fabricated from steel castings as follows to provide full bearing of web and flange of pile tip:

B. Splice Unit: Manufacturer's standard splice unit, fabricated from two connected steel plates, of same material as steel H pile or material of equal strength, shaped to encase web and part of each flange.

2.3 FABRICATION

A. Pile-Length Markings: Mark each pile with horizontal lines at 12-inch (305-mm) intervals; label the distance from pile tip at 60-inch (1524-mm) intervals. Maintain markings on piles until driven.

B. Fabricate full-length piles to eliminate splicing during driving, with ends square.

C. Fabricate full-length piles by splicing lengths of steel H pile together. Accurately mill meeting ends of piles and bevel for welding. Maintain axial alignment of pile lengths. Maintain structural properties of pile across splice.

D. Fit and weld driving points to tip of pile according to manufacturer's written instructions and AWS D1.1/D1.1M for procedures, appearance and quality of welds, and methods used in correcting welding work.

PART 3 - EXECUTION

3.1 DRIVING PILES

A. General: Continuously drive piles to elevations or penetration resistance indicated. Establish and maintain axial alignment of leads and piles before and during driving.

B. Heaved Piles: Redrive heaved piles to tip elevation at least as deep as original tip elevation with a driving resistance at least as great as original driving resistance.

C. Driving Tolerances: Drive piles without exceeding the following tolerances, measured at pile heads:

1. Location: 4 inches (102 mm) from location indicated after initial driving, and 6 inches (152 mm) after pile driving is completed.
2. Plumb: Maintain 1 inch (25 mm) in 48 inches (1219 mm) from vertical, or a maximum of 4 inches (102 mm), measured when pile is aboveground in leads.
3. Batter Angle: Maximum 1 inch (25 mm) in 48 inches (1219 mm) from required angle, measured when pile is aboveground in leads.

D. Withdraw damaged or defective piles and piles that exceed driving tolerances and install new piles within driving tolerances.

E. Cut off tops of driven piles square with pile axis and at elevations indicated.

F. Pile-Driving Records: Maintain accurate driving records for each pile, compiled and attested to by a qualified professional engineer.

3.2 FIELD QUALITY CONTROL

A. Special Inspections: Owner will engage or Engage a qualified special inspector to perform inspections as directed.

B. Testing Agency: Owner will engage or Engage a qualified testing agency to perform tests and inspections as directed.

C. Tests and Inspections:

1. Dynamic Pile Testing: High-strain dynamic monitoring shall be performed and reported according to ASTM D4945 during initial driving and during re-striking on five single or 3 percent of piles as directed.
2. Weld Testing: In addition to visual inspection, welds shall be tested and inspected according to AWS D1.1/D1.1M.

D. Steel H piles will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION 316216

SECTION 316219 - TIMBER PILES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes round timber piles.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For timber piles. Show fabrication and installation details for piles, including details of driving shoes, tips or boots, and pile butt protection.

1.4 INFORMATIONAL SUBMITTALS

A. Round timber pile treatment data.

B. Pile-Driving Equipment Data: Include type, make, and rated energy range; weight of striking part of hammer; weight of drive cap; and, type, size, and properties of hammer cushion.

C. Pile-driving records.

D. Field quality-control reports.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Handle and store piles at Project site to prevent breaks, cuts, abrasions, or other physical damage and as required by AWPA M4. Do not drill holes or drive spikes or nails into pile below cutoff elevation.

PART 2 - PRODUCTS

2.1 TIMBER PILES

A. Round Timber Piles: ASTM D25, unused, clean peeled, one piece from butt to tip; of the following species and size basis:

1. Manufacturers: Subject to compliance with requirements, provide products by the following, provide products by one of the following, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following as directed:

2. Species: Coastal Douglas fir or Southern yellow pine as directed.
3. Size Basis: Butt circumference, Class A, Class B, Tip circumference or 8-inch (203-mm) tip and natural taper as directed.

B. Pressure-treat round timber piles according to AWPA U1 as follows:

1. Service Condition: UC4C Ground Contact, Extreme Duty, UC5A Marine Use Northern Waters, UC5B Marine Use Central Waters or UC5C Marine Use Southern Waters as directed.
2. Treatment: Waterborne preservative, Creosote or creosote solution, Oil-borne preservative, Waterborne preservative, creosote or creosote solution, or oil-borne preservative, Waterborne preservative, severe marine borer hazard or Dual treatment consisting of waterborne preservative, followed by creosote or creosote solution as directed.

2.2 PILE ACCESSORIES

A. Driving Shoes: Fabricate from ASTM A1011/A1011M, hot-rolled carbon-steel strip to suit pile-tip diameter.

2.3 FABRICATION

A. Pile Tips: Cut and shape pile tips to accept driving shoes. Fit and fasten driving shoes to pile tips according to manufacturer's written instructions.

B. Pile Butt: Trim pile butt and cut perpendicular to longitudinal axis of pile. Chamfer and shape butt to fit tightly to driving cap of hammer.

C. Field-Applied Wood Preservative: Treat field cuts, holes, and other penetrations according to AWPA M4.

D. Pile-Length Markings: Mark each pile with horizontal lines at 12-inch (305-mm) intervals; label the distance from pile tip at 60-inch (1524-mm) intervals. Maintain markings on piles until driven.

PART 3 - EXECUTION

3.1 DRIVING PILES

A. General: Continuously drive piles to elevations or penetration resistance indicated. Establish and maintain axial alignment of leads and piles before and during driving.

B. Heaved Piles: Redrive heaved piles to tip elevation at least as deep as original tip elevation with a driving resistance at least as great as original driving resistance.

C. Driving Tolerances: Drive piles without exceeding the following tolerances, measured at pile heads:

1. Location: 4 inches (102 mm) from location indicated after initial driving, and 6 inches (152 mm) after pile driving is completed.
2. Plumb: Maintain 1 inch (25 mm) in 48 inches (1219 mm) from vertical, or a maximum of 4 inches (102 mm), measured when pile is aboveground in leads.
3. Batter Angle: Maximum 1 inch (25 mm) in 48 inches (1219 mm) from required angle, measured when pile is aboveground in leads.

D. Withdraw damaged or defective piles and piles that exceed driving tolerances and install new piles within driving tolerances. Fill holes left by withdrawn piles as directed by Architect.

E. Cut off butts of driven piles square with pile axis and at elevations indicated.

1. Cover cut-off piling surfaces with caps overlapping pile end by minimum 2 inches (51 mm) or minimum three coats of preservative treatment according to AWPA M4 as directed.

F. Pile-Driving Records: Maintain accurate driving records for each pile, compiled and attested to by a qualified professional engineer.

3.2 FIELD QUALITY CONTROL

A. Special Inspections: As directed Owner will engage or Engage a qualified special inspector to perform the following special inspections:

1. Pile foundations.
2. Special inspections as directed.

B. Testing Agency: As directed Owner will engage or Engage a qualified testing agency to perform tests and inspections.

C. Tests and Inspections:

1. Dynamic Pile Testing: High-strain dynamic monitoring shall be performed and reported according to ASTM D4945 during initial driving and during re-striking on five single or 3 percent of piles as directed.

END OF SECTION 316219

SECTION 316223 - COMPOSITE PILES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes concrete-filled steel-shell or steel pipe piles.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For composite piles. Show fabrication and installation details for piles, including splices and tip details.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Concrete design mixes.

C. Material certificates.

D. Material test reports.

E. Pile-Driving Equipment Data: Include type, make, and rated energy range; weight of striking part of hammer; weight of drive cap; and, type, size, and properties of hammer cushion.

F. Pile-driving records.

G. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Comply with requirements in ACI 301, "Specifications for Structural Concrete."

B. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel"
2. AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."
3. AWS D1.4/D1.4M, "Structural Welding Code - Reinforcing Steel."

PART 2 - PRODUCTS

2.1 STEEL-SHELL PILES

A. Fluted Pile Shells: Manufacturer's standard, vertically fluted, pile shells; cold formed from steel sheet; 50,000-psi (345-MPa) minimum yield strength after forming. Fabricate watertight, uniformly tapered sections with forged-steel conical nose welded to tip.
   1. Constant Diameter Extensions: Fabricate with splice overlap capable of telescoping into tapered section.
   2. Taper: 0.14 inch in 12 inches (1:86), 0.25 inch in 12 inches (1:48) or 0.40 inch in 12 inches (1:30) as directed.
   3. Thickness: 0.150 inch (3.80 mm), 0.179 inch (4.55 mm), 0.209 inch (5.31 mm) or 0.239 inch (6.07 mm) as directed.

B. Helically Corrugated Pile Shells: Manufacturer's standard, helically corrugated, uniform-diameter, steel sheet shell piles; of enough strength and thickness to remain watertight and resist distortion and buckling due to soil pressure, internal mandrel operation, or redriving. Fabricate in one-piece lengths with minimum 3/16-inch- (4.76-mm-) thick steel-plate boot continuously welded to tip and as follows:
   1. Nominal Diameter: 8-5/8 inches (219 mm), 10-5/8 inches (270 mm), 11-1/8 inches (283 mm), 12-1/4 inches (311 mm), 14 inches (350 mm) or 16-1/8 inches (410 mm) as directed.
   2. Thickness: 0.048 inch (1.21 mm), minimum, 0.060 inch (1.52 mm), minimum, 0.075 inch (1.90 mm), minimum or 0.105 inch (2.66 mm) as directed.

2.2 STEEL PIPE PILES

A. Steel Pipe: ASTM A252, Grade 2 or Grade 3; seamless or welded as directed.

2.3 STEEL REINFORCEMENT

A. Reinforcing Bars: ASTM A615/A615M, Grade 60 (Grade 420); deformed.

B. Low-Alloy-Steel Reinforcing Bars: ASTM A706/A706M.

C. Galvanized Reinforcing Bars: ASTM A767/A767M, Class II zinc coated, hot-dip galvanized after fabrication and bending, as follows:

   1. Steel Reinforcement: As directed ASTM A615/A615M, Grade 60 (Grade 420) or ASTM A706/A706M; deformed.

D. Epoxy-Coated Reinforcing Bars: ASTM A775/A775M or ASTM A934/A934M, as follows:

   1. Steel Reinforcement: As directed ASTM A615/A615M, Grade 60 (Grade 420) or ASTM A706/A706M; deformed.

E. Plain Steel Wire: ASTM A82/A82M, as drawn or galvanized as directed.

F. Deformed-Steel Wire: ASTM A496/A496M.

G. Epoxy-Coated-Steel Wire: ASTM A884/A884M, Class A coated, plain or deformed as directed.

2.4 CONCRETE MATERIALS

A. Portland Cement: ASTM C150/C150M, Type I or II.

1. Fly Ash: ASTM C618, Class C or F.
2. Ground Granulated Blast-Furnace Slag: ASTM C989, Grade 100 or 120.

B. Blended Hydraulic Cement: ASTM C595/C595M, Type IS, portland blast-furnace slag, Type IP, portland-pozzolan, Type I (PM), pozzolan-modified Portland or Type I (SM), slag-modified portland cement as directed.

C. Normal-Weight Aggregates: ASTM C33/C33M, Class 4S, Class 4M or Class 1N, uniformly graded, 3/4-inch (19-mm) maximum aggregate size as directed. Provide aggregates from a single source.

D. Water: Potable, complying with ASTM C94/C94M requirements.

E. Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and to contain no more than 0.1 percent chloride ions by mass of cementitious material.

1. Air-Entraining Admixture: ASTM C260/C260M.
2. Water-Reducing Admixture: ASTM C494/C494M, Type A.
3. Retarding Admixture: ASTM C494/C494M, Type B.
4. Water-Reducing and Retarding Admixture: ASTM C494/C494M, Type D.
5. High-Range, Water-Reducing Admixture: ASTM C494/C494M, Type F.
6. High-Range, Water-Reducing and Retarding Admixture: ASTM C494/C494M, Type G.
7. Plasticizing and Retarding Admixture: ASTM C1017/C1017M, Type II.

2.5 PILE ACCESSORIES

A. Driving Points: Manufacturer's standard 60-degree conical driving point, with integral reinforcing ribs, to provide full bearing of pipe pile tip. Fabricate from steel castings as follows:

B. Inside Cutting Shoes: Manufacturer's standard, inside-flanged, open-ended cutting shoe, to provide full bearing of pipe pile tip. Fabricate from steel castings as follows:

C. Outside Cutting Shoes: Manufacturer's standard, outside-flanged, open-ended cutting shoe, to provide full bearing of pipe pile tip. Fabricate from steel castings as follows:

D. Splice Coupling: Manufacturer's standard splice coupling, rolled from ASTM A36/A36M, carbon-steel bar or cast from heat-treated carbon steel, ASTM A27/A27M, Grade 65-35 (Grade 450-240), with interior stop and internally tapered for friction fit driving.

2.6 CONCRETE MIXES

A. Prepare concrete design mixes according to ACI 301, determined by either laboratory trial batch or field test data basis.

1. Use a qualified testing agency for preparing and reporting proposed mix designs determined by laboratory trial batch.

B. Proportion mixes according to ACI 301 to provide normal-weight concrete suitable for piles with the following properties:

1. Compressive Strength (28 Days): 5000 psi (34.5 MPa), 4000 psi (27.6 MPa) or 3000 psi (20.7 MPa) As directed.
2. Maximum Water-Cementitious Material Ratio at Point of Placement: 0.45 to 0.50 as directed.
3. Slump Limit: 5 inches (127 mm) or 8 inches (203 mm), plus or minus 1 inch (25 mm) as directed.
4. Air Content: 6.0 percent, plus or minus 1.5 or 2.5 to 4.5 percent as directed.

2.7 FABRICATION

A. Fabricate full-length piles to eliminate splicing during driving.

B. Fabricate full-length piles by splicing pile lengths together. Maintain axial alignment of pile lengths. Maintain structural properties of pile across splice.

C. Fit and weld driving points or cutting shoes to tip of pile as directed according to manufacturer's written instructions and AWS D1.1/D1.1M for procedures, appearance and quality of welds, and methods used in correcting welding work.

D. Pile-Length Markings: Mark each pile with horizontal lines at 12-inch (305-mm) intervals; label the distance from pile tip at 60-inch (1524-mm) intervals. Maintain markings on piles until driven.

2.8 CONCRETE MIXING

A. Ready-Mixed Concrete: Comply with ASTM C94/C94M.

1. Do not add water to concrete mix after mixing.
2. Maintain concrete temperature to not exceed 90 deg F (32 deg C).

PART 3 - EXECUTION

3.1 STEEL REINFORCEMENT

A. Comply with recommendations in CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

B. Fabricate and install reinforcement cages symmetrically about axis of pile shell or pipe in a single unit as directed.

3.2 CONCRETE PLACEMENT

A. Place concrete in a continuous operation and without segregation immediately after cleaning out pile shell or pipe as directed.

B. Place concrete by means of bottom discharge bucket, flexible drop chute, or steep-sided funnel hopper or tremie or pump concrete into place.

C. Place concrete in a dry pile shell or pipe unless placement underwater is approved by Architect as directed.

D. Consolidate final 10 feet (3 m) of concrete during placement to ensure that concrete is thoroughly worked around steel reinforcement and into corners.

3.3 DRIVING PILES

A. General: Continuously drive piles to elevations or penetration resistance indicated. Establish and maintain axial alignment of leads and piles before and during driving.

B. Heaved Piles: Redrive heaved piles to tip elevation at least as deep as original tip elevation with a driving resistance at least as great as original driving resistance.

C. Pile Splices: Splice piles during installation and align pile segments concentrically.

D. Driving Tolerances: Drive piles without exceeding the following tolerances, measured at pile heads:

1. Location: 4 inches (102 mm) from location indicated after initial driving, and 6 inches (152 mm) after pile driving is completed.
2. Plumb: Maintain 1 inch (25 mm) in 48 inches (1219 mm) from vertical, or a maximum of 4 inches (102 mm), measured when pile is aboveground in leads.
3. Batter Angle: Maximum 1 inch (25 mm) in 48 inches (1219 mm) from required angle, measured when pile is aboveground in leads.

E. Excavation: Clean out steel pipe pile by removing soil and debris from inside pile before placing steel reinforcement or concrete.

F. Cut off tops of driven piles square with pile axis and at elevations indicated.

G. Pile-Driving Records: Maintain accurate driving records for each pile, compiled and attested to by a qualified professional engineer.

3.4 FIELD QUALITY CONTROL

A. Special Inspections: Owner will engage or Engage a qualified special inspector to perform the following special inspections as directed:

1. Pile foundations.
2. Special inspections as directed.

B. Testing Agency: As directed Owner will engage or Engage a qualified testing agency to perform tests and inspections.

C. Tests and Inspections:

1. Dynamic Pile Testing: High-strain dynamic monitoring shall be performed and reported according to ASTM D4945 during initial driving and during re-striking on five single or 3 percent of piles as directed.
2. Low-strain integrity measurement shall be performed and reported for each pile.
3. Weld Testing: In addition to visual inspection, welds shall be tested and inspected according to AWS D1.1/D1.1M.
4. Concrete: Sampling and testing of concrete for quality control shall include the following:

    a. Sampling Fresh Concrete: ASTM C172/C172M, except modified for slump to comply with ASTM C94/C94M.

        1) Slump: ASTM C143/C143M; one test at point of placement for each compressive-strength test, but no fewer than one test for each concrete load.
        2) Compressive-Strength Tests: ASTM C39/C39M; one set for each truck load. One specimen shall be tested at seven days, two specimens shall be tested at 28 days, and one specimen shall be retained in reserve for later testing if required.

END OF SECTION 316223

SECTION 316316 - AUGER CAST GROUT PILES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes auger cast grout piles.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Design Mixtures: For each grout mixture.

C. Shop Drawings: For auger cast grout piles, prepared by or under the supervision of a qualified professional engineer.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Material certificates.

C. Equipment Data: Description of drilling and grout-pumping equipment.

D. Pile inspection reports.

E. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. AWS D1.4/D1.4M, "Structural Welding Code - Reinforcing Steel."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design piles, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

1. Design Loads: As indicated on Drawings.

2.2 STEEL REINFORCEMENT

A. Reinforcing Bars: ASTM A615/A615M, Grade 60 (Grade 420), deformed.

B. Single Bar Reinforcing: ASTM A722/A722M, high strength, threaded.

1. Mechanical Couplings: Screw-on type, capable of supporting the minimum ultimate tensile strength of the coupled bars.

C. Centralizers: Devices to center steel reinforcement in excavation; spaced not less than 20 feet (6 m) o.c. for vertical piles and 10 feet (3 m) o.c. for battered piles.

2.3 CONCRETE MATERIALS

A. Portland Cement: ASTM C150/C150M, Type I, Type II, Type I/II, Type III or Type V as directed. Supplement with the following:

1. Fly Ash: ASTM C618, Class C or Class F as directed.

B. Fine Aggregate: ASTM C33/C33M with 100 percent passing a No. 8 (2.36-mm) sieve, free of materials with deleterious reactivity to alkali in cement. Provide aggregate from single source.

C. Water: ASTM C94/C94M and potable.

D. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures. Do not use calcium chloride or admixtures containing calcium chloride.

1. Water-Reducing Admixture: ASTM C494/C494M, Type A.
2. Water-Reducing and Retarding Admixture: ASTM C494/C494M, Type D.
3. High-Range, Water-Reducing and Retarding Admixture: ASTM C494/C494M, Type G.
4. Plasticizing and Retarding Admixture: ASTM C1017/C1017M, Type II.

E. Fluidifier: ASTM C937, with expansion of less than 4 percent.

2.4 RELATED MATERIALS

A. Pile-Top Forms: Metal, glass-fiber-reinforced plastic, paper, or fiber tubes.

2.5 GROUT MIXTURES

A. Proportion grout mixture as follows:

1. Minimum Compressive Strength: 5000 psi (34.5 MPa), 4500 psi (31 MPa) or 4000 psi (27.6 MPa) at 28 days as directed; ASTM C109/C109M with cube specimens restrained from expansion according to ASTM C942.
2. Maximum Water-Cementitious Materials Ratio: 0.43 to 0.38 as directed.
3. Grout Flow: 10 to 25 seconds; ASTM C939 and ASTM C109/C109M using a flow cone with 0.75-inch (19-mm) opening.

2.6 FABRICATING REINFORCEMENT

A. Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice."

2.7 GROUT MIXING

A. Ready-Mixed Grout: Measure, batch, mix, and deliver according to ASTM C94/C94M, and furnish batch ticket information.

PART 3 - EXECUTION

3.1 DRILLING AND PUMPING EQUIPMENT

A. Drilling Rig: Capable of advancing hollow-stem, continuous-flight augers of design diameters to depths 20 percent greater than design depths; with stabilizing arm at bottom of leads to prevent rotation, and middle guide for augers greater than 40 feet (12 m) in length.

B. Hollow-Stem Auger: Continuous auger flighting without gaps or breaks, of diameter no more than 3 percent less than pile diameter; with grout pumping hole at bottom of auger head below cutting teeth. Seal grout-pumping hole with temporary tip plug to be fully opened by grout pressure or reinforcing bar during grout installation.

1. Hollow Shaft Diameter: Minimum 1-1/4-inch (32-mm) clear ID.

C. Grout Pump: Positive-displacement pump with a known volume per stroke. Minimum displacement pressure at pump of 350 lbf/sq. in. (2.4 MPa).

D. Automated Monitoring Equipment: Capable of measuring auger depth, penetration rate, and grout volume pumped per unit depth increment and of printing results.

3.2 EXCAVATION

A. Excavate piles to elevations indicated, auger refusal or elevations indicated or auger refusal as directed. Establish and maintain axial alignment of leads and shaft before and during driving.

1. Auger Refusal: Rate of less than 1 fpm (0.3 m/s).

B. Drilling Tolerances:

1. Location: Pile centers maximum 3 inches (75 mm) from locations indicated.
2. Plumb: Within 2 percent from vertical.
3. Batter Angle: Within 4 percent from required angle.

3.3 INSTALLATION

A. Grout Placement: Place grout in continuous operation.

1. Lift auger 6 to 12 inches (152 to 305 mm) at start of grout pumping to facilitate tip plug removal, then return to previously established tip elevation.
2. Develop an initial grout head of 60 inches (1500 mm) before start of auger withdrawal and maintain during extraction.
3. Monitor pumped grout volumes using automated monitoring equipment.
4. Volume of placed grout is at least 115 percent of theoretical volume. If less than required volume is placed for any given 60-inch (1500-mm) segment, lower auger a minimum of 60 inches (1500 mm), or to bottom of pile if less than 60 inches (1500 mm) available, and restart withdrawal.
5. If grout pumping is interrupted during placement, lower auger a minimum of 60 inches (1500 mm), or to bottom of pile if less than 60 inches (1500 mm) available, and restart withdrawal.

B. Steel Reinforcement Installation, General: Comply with recommendations in CRSI's "Manual of Standard Practice."

C. Reinforcing Cages: Install immediately after grout placement and support at ground surface until initial set. Allow cages to fall into shaft freely under their own weight; do not force by vibrating or pushing with mechanical equipment.

D. Adjacent Piles: Do not install piles within 6 pile diameters of piles grouted within the previous 12 hours.

E. If location or out-of-plumb tolerances are exceeded, provide corrective construction. Submit corrective construction proposals to Architect for review before proceeding.

3.4 FIELD QUALITY CONTROL

A. Special Inspections: As directed Owner will engage or engage a qualified special inspector to perform the following special inspections:

1. Pile excavation, placement, and testing.
2. Steel reinforcement welding.

B. Testing Agency: As directed Owner will engage or Engage a qualified testing agency to perform tests and inspections.

C. Grout Tests: Testing of samples of fresh grout obtained according to ASTM C172/C172M shall be performed according to the following requirements:

1. Flow Rate: ASTM C939 and ASTM C109/C109M using a flow cone with 0.75-inch (19-mm) opening.
2. Compressive Strength: ASTM C109/C109M with cube specimens restrained from expansion according to ASTM C942.

    a. Testing Frequency: Obtain six 2-inch (101-mm) cubes for each 50 cu. yd. (38 cu. m) or fraction thereof of grout placed, but not less than one set for each day's pour. Obtain an additional set of cubes from each truck during test pile placement.
    b. Strength of each grout mixture is satisfactory if every average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi (3.4 MPa).

D. Pile Inspection Reports: Prepare inspection reports for each auger cast grout pile.

END OF SECTION 316316

SECTION 316329 - DRILLED CONCRETE PIERS AND SHAFTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Dry-installed drilled piers.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Design Mixtures: For each concrete mixture.

C. Shop Drawings: For concrete reinforcement.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Material certificates.

C. Material test reports.

D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Record drawings.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. AWS D1.4/D1.4M, "Structural Welding Code - Reinforcing Steel."

1.7 FIELD CONDITIONS

A. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by geotechnical engineer. Owner is not responsible for interpretations or conclusions drawn from this data.

1. Make additional test borings and conduct other exploratory operations necessary for drilled piers.
2. The geotechnical report is included or referenced elsewhere in the Project Manual as directed.

B. Survey Work: Engage a qualified land surveyor or professional engineer to perform surveys, layouts, and measurements for drilled piers. Before excavating, lay out each drilled pier to lines and levels required. Record actual measurements of each drilled pier's location, shaft diameter, bottom and top elevations, deviations from specified tolerances, and other specified data.

1. Record and maintain information pertinent to each drilled pier and indicate on record Drawings.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Drilled-Pier Standard: ACI 336.1 except as modified in this Section.

2.2 STEEL REINFORCEMENT

A. Reinforcing Bars: ASTM A615/A615M, Grade 60 (Grade 420), deformed.

B. Low-Alloy-Steel Reinforcing Bars: ASTM A706/A706M, deformed.

C. Plain-Steel Wire: ASTM A82/A82M, as drawn or galvanized as directed.

2.3 CONCRETE MATERIALS

A. Cementitious Material: Use the following cementitious materials, of same type, brand, and source, throughout Project:

1. Portland Cement: ASTM C150/C150M, Type I, Type II, Type I/II, Type III or Type V as directed. Supplement with the following:

a. Fly Ash: ASTM C618, Class C or Class F as directed.
b. Ground Granulated Blast-Furnace Slag: ASTM C989, Grade 100 or 120.

2. Blended Hydraulic Cement: ASTM C595/C595M, Type IS, portland blast-furnace slag, Type IP, portland-pozzolan, Type I (PM), pozzolan-modified Portland or Type I (SM), slag-modified portland cement as directed.

B. Normal-Weight Aggregate: ASTM C33/C33M, graded, 3/4-inch- (19-mm-) nominal maximum coarse-aggregate size.

1. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.

C. Water: ASTM C94/C94M and potable.

D. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and that do not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.

1. Water-Reducing Admixture: ASTM C494/C494M, Type A.
2. Water-Reducing and Retarding Admixture: ASTM C494/C494M, Type D.
3. High-Range, Water-Reducing and Retarding Admixture: ASTM C494/C494M, Type G.
4. Plasticizing and Retarding Admixture: ASTM C1017/C1017M, Type II.

2.4 STEEL CASINGS

A. Steel Pipe Casings: ASTM A283/A283M, Grade C, or ASTM A36/A36M, carbon-steel plate, with joints full-penetration welded according to AWS D1.1/D1.1M.

2.5 CONCRETE MIXTURES AND MIXING

A. Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data, or both, according to ACI 301 (ACI 301M).

B. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement according to ACI 301 (ACI 301M) limits as if concrete were exposed to deicing chemicals.

C. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 or 0.30 percent by weight of cement as directed.

D. Proportion normal-weight concrete mixture as follows:

1. Compressive Strength (28 Days): 6000 psi (41.4 MPa), 5000 psi (34.5 MPa), 4500 psi (31 MPa), 4000 psi (27.6 MPa), 3500 psi (24.1 MPa) or 3000 psi (20.7 MPa) as directed.

E. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C94/C94M, and furnish batch ticket information.

PART 3 - EXECUTION

3.1 EXCAVATION

A. Unclassified Excavation: Excavate to bearing elevations regardless of character of surface and subsurface conditions encountered.

B. Classified Excavation: Excavation is classified as standard excavation, special excavation, and obstruction removal and includes excavation to bearing elevations as follows:

1. Standard excavation includes excavation accomplished with conventional augers fitted with soil or rock teeth, drilling buckets, or underreaming tools attached to drilling equipment of size, power, torque, and downthrust necessary for the Work.
2. Special excavation includes excavation that requires special equipment or procedures where drilled-pier excavation equipment used in standard excavation, operating at maximum power, torque, and downthrust, cannot advance the shaft.
3. Obstructions: Payment for removing unanticipated boulders, concrete, masonry, or other subsurface obstructions that cannot be removed by conventional augers fitted with soil or rock teeth, drilling buckets, or underreaming tools attached to drilling equipment of size, power, torque, and downthrust necessary for the Work is according to Contract provisions for changes in the Work.

C. Excavate shafts for drilled piers to indicated elevations. Remove loose material from bottom of excavation.

D. Notify and allow testing and inspecting agency to test and inspect bottom of excavation. If unsuitable bearing stratum is encountered, make adjustments to drilled piers as determined by Architect.

1. Do not excavate shafts deeper than elevations indicated unless approved by Architect.
2. Payment for additional authorized excavation is according to Contract provisions for changes in the Work.

E. End-Bearing Drilled Piers: Probe with auger to a depth below bearing elevation, equal to diameter of the bearing area of drilled pier. Determine whether voids, clay seams, or solution channels exist.

F. Temporary Casings: Install watertight steel casings of sufficient length and thickness to prevent water seepage into shaft; to withstand compressive, displacement, and withdrawal stresses; and to maintain stability of shaft walls.

1. Remove temporary casings, maintained in plumb position, during concrete placement and before initial set of concrete, or leave temporary casings in place.

G. Bells: Excavate bells for drilled piers to shape, base thickness, and slope angle indicated. Excavate bottom of bells to level plane and remove loose material before placing concrete.

H. Tolerances: Construct drilled piers to remain within ACI 336.1 tolerances.

3.2 INSTALLATION

A. Install steel casings of minimum wall thickness indicated and of diameter not less than diameter of drilled pier.

B. Comply with recommendations in CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

C. Place concrete in continuous operation and without segregation immediately after inspection and approval of shaft by a qualified Special Inspector or testing agency as directed.

D. Place concrete to fall vertically down the center of drilled pier without striking sides of shaft or steel reinforcement.

E. Coordinate withdrawal of temporary casings with concrete placement to maintain at least a 60-inch (1500-mm) head of concrete above bottom of casing. Vibrate top 60 inches (1500 mm) of concrete after withdrawal of temporary casing.

3.3 FIELD QUALITY CONTROL

A. Special Inspections: As directed, Owner will engage or Engage a qualified special inspector to perform the following special inspections:

1. Drilled piers.
2. Excavation.
3. Concrete.
4. Steel reinforcement welding.

B. Testing Agency: As directed, Owner will engage or Engage a qualified testing agency to perform tests and inspections.

C. Drilled-Pier Tests and Inspections: For each drilled pier, before concrete placement.

1. Soil Testing: Bottom elevations, bearing capacities, and lengths of drilled piers indicated have been estimated from available soil data. Actual elevations and drilled-pier lengths and bearing capacities are determined by testing and inspecting agency. Final evaluations and approval of data are determined by Architect.

D. Concrete Tests and Inspections: ACI 301 (ACI 301M).

3.4 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Disposal: Remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off Owner's property.

END OF SECTION 316329

SECTION 321216 - ASPHALT PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cold milling of existing asphalt pavement.
2. Hot-mix asphalt patching.
3. Hot-mix asphalt paving.
4. Hot-mix asphalt overlay.
5. Asphalt curbs.

B. Related Requirements:

1. Section 312000 "Earth Moving" for subgrade preparation, fill material, separation geotextiles, unbound-aggregate subbase and base courses, and aggregate pavement shoulders.
2. Section 321373 "Concrete Paving Joint Sealants" for joint sealants and fillers at pavement terminations.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

1.4 INFORMATIONAL SUBMITTALS

A. Material Certificates: For each paving material. Include statement that mixes containing recycled materials will perform equal to mixes produced from all new materials.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: A paving-mix manufacturer registered with and approved by authorities having jurisdiction or the DOT of state in which Project is located.

B. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements for asphalt paving work as directed.

1. Measurement and payment provisions and safety program submittals included in standard specifications do not apply to this Section.

PART 2 - PRODUCTS

2.1 AGGREGATES

A. Coarse Aggregate: ASTM D692/D692M, sound; angular crushed stone, crushed gravel, or cured, crushed blast-furnace slag.

B. Fine Aggregate: ASTM D1073 or AASHTO M 29, sharp-edged natural sand or sand prepared from stone, gravel, cured blast-furnace slag, or combinations thereof.

C. Mineral Filler: ASTM D242/D242M or AASHTO M 17, rock or slag dust, hydraulic cement, or other inert material.

2.2 ASPHALT MATERIALS

A. Asphalt Binder: ASTM D6373 or AASHTO M 320 binder designation as directed.

B. Tack Coat: As directed ASTM D977 or AASHTO M 140 emulsified asphalt, or ASTM D2397/D2397M or AASHTO M 208 cationic emulsified asphalt, slow setting, diluted in water, of suitable grade and consistency for application.

2.3 AUXILIARY MATERIALS

A. Recycled Materials for Hot-Mix Asphalt Mixes: Reclaimed asphalt pavement; reclaimed, unbound-aggregate base material; and recycled tires, asphalt shingles, or glass from sources and gradations that have performed satisfactorily in previous installations, equal to performance of required hot-mix asphalt paving produced from all new materials.

B. Herbicide: Commercial chemical for weed control, registered by the EPA, and not classified as "restricted use" for locations and conditions of application. Provide in granular, liquid, or wettable powder form.

2.4 MIXES

1. Surface Course Limit: Recycled content no more than 10 percent by weight.

B. Hot-Mix Asphalt: Dense-graded, hot-laid, hot-mix asphalt plant mixes approved by authorities having jurisdiction; designed according to procedures in AI MS-2, "Asphalt Mix Design Methods"; and complying with the following requirements:

1. Provide mixes with a history of satisfactory performance in geographical area where Project is located.
2. Base Course: As directed.
3. Surface Course: As directed.

PART 3 - EXECUTION

3.1 PREPARATION

A. Proof-roll subgrade below pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

3.2 COLD MILLING

A. Clean existing pavement surface of loose and deleterious material immediately before cold milling. Remove existing asphalt pavement by cold milling to grades and cross sections indicated.

1. Mill to a depth as directed.
2. Patch surface depressions deeper than 1 inch (25 mm) after milling, before wearing course is laid.

3.3 PATCHING

A. Asphalt Pavement: Saw cut perimeter of patch and excavate existing pavement section to sound base. Excavate rectangular or trapezoidal patches, extending 12 inches (300 mm) into perimeter of adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Remove excavated material. Recompact existing unbound-aggregate base course to form new subgrade.

B. Portland Cement Concrete Pavement: Break cracked slabs and roll as required to reseat concrete pieces firmly.

1. Remove disintegrated or badly cracked pavement. Excavate rectangular or trapezoidal patches, extending into perimeter of adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Recompact existing unbound-aggregate base course to form new subgrade.

C. Tack Coat: Before placing patch material, apply tack coat uniformly to vertical asphalt surfaces abutting the patch. Apply at a rate of 0.05 to 0.15 gal./sq. yd. (0.2 to 0.7 L/sq. m).

1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

D. Placing Patch Material: Fill excavated pavement areas with hot-mix asphalt base mix for full thickness of patch and, while still hot, compact flush with adjacent surface.

3.4 SURFACE PREPARATION

A. Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.

B. Herbicide Treatment: Apply herbicide according to manufacturer's recommended rates and written application instructions. Apply to dry, prepared subgrade or surface of compacted-aggregate base before applying paving materials.

C. Tack Coat: Apply uniformly to surfaces of existing pavement at a rate of 0.05 to 0.15 gal./sq. yd. (0.2 to 0.7 L/sq. m).

1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

3.5 PLACING HOT-MIX ASPHALT

A. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand in areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.

1. Spread mix at a minimum temperature of 250 deg F (121 deg C).
2. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.

B. Place paving in consecutive strips not less than 10 feet (3 m) wide unless infill edge strips of a lesser width are required.

C. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

3.6 JOINTS

A. Construct joints to ensure a continuous bond between adjoining paving sections. Construct joints free of depressions, with same texture and smoothness as other sections of hot-mix asphalt course.

1. Clean contact surfaces and apply tack coat to joints.
2. Offset longitudinal joints, in successive courses, a minimum of 6 inches (150 mm).
3. Offset transverse joints, in successive courses, a minimum of 24 inches (600 mm).
4. Construct transverse joints at each point where paver ends a day's work and resumes work at a subsequent time. Construct these joints using either "bulkhead" or "papered" method according to AI MS-22, for both "Ending a Lane" and "Resumption of Paving Operations."

3.7 COMPACTION

A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot, hand tampers or with vibratory-plate compactors in areas inaccessible to rollers.

1. Complete compaction before mix temperature cools to 185 deg F (85 deg C).

B. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.

C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to the following density:

1. Average Density: 92 percent of reference maximum theoretical density according to ASTM D2041/D2041M, but not less than 90 percent or greater than 96 percent.

D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.

E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.

F. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.

G. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

3.8 ASPHALT CURBS

A. Construct hot-mix asphalt curbs over compacted pavement surfaces. Apply a light tack coat unless pavement surface is still tacky and free from dust. Spread mix at a minimum temperature of 250 deg F (121 deg C).

1. Asphalt Mix: Same as pavement surface-course mix.

B. Place hot-mix asphalt to curb cross section indicated or, if not indicated, to local standard shapes, by machine or by hand in wood or metal forms. Tamp hand-placed materials and screed to smooth finish. Remove forms after hot-mix asphalt has cooled.

3.9 INSTALLATION TOLERANCES

A. Pavement Thickness: Compact each course to produce the thickness indicated within the following tolerances:

1. Base Course: Plus or minus 1/2 inch (13 mm).
2. Surface Course: Plus 1/4 inch (6 mm), no minus.

B. Pavement Surface Smoothness: Compact each course to produce a surface smoothness within the following tolerances as determined by using a 10-foot (3-m) straightedge applied transversely or longitudinally to paved areas:

1. Base Course: 1/4 inch (6 mm).
2. Surface Course: 1/8 inch (3 mm).

3. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 1/4 inch (6 mm).

3.10 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Replace and compact hot-mix asphalt where core tests were taken.

C. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

3.11 WASTE HANDLING

A. General: Handle asphalt-paving waste according to approved waste management plan required in Section 017419 "Construction Waste Management and Disposal."

END OF SECTION 321216

SECTION 321223 - IMPRINTED ASPHALT

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes embossing patterns in new and existing asphalt pavement.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For each exposed product and for each color and texture specified.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Imprinted-asphalt manufacturer's authorized Installer who is trained and approved for installation of imprinted asphalt required for this Project.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 MATERIALS

A. Templates: Imprinted-asphalt manufacturer's standard flexible templates for imprinting pattern into hot asphalt paving.

1. Pattern: As directed.

B. Coating System: Imprinted-asphalt manufacturer's standard system formulated for exterior application on asphalt paving surfaces.

1. Colorant: UV-stable pigment blend, added to each coating layer.
2. Color: White or Yellow as directed.

C. Precut Marking Material: Imprinted-asphalt manufacturer's standard, reflectorized, thermoplastic, 90-mil (2.3-mm) minimum thickness, formulated for exterior application in imprinted, asphalt paving surfaces, and matching the imprinted pattern of templates.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that utilities, traffic loop detectors, and other items requiring a cut and installation beneath the asphalt surface or repairs to the asphalt surface have been completed and that asphalt surface is flush with adjacent asphalt prior to beginning installation of imprinted asphalt.

3.2 IMPRINTING ASPHALT

A. General: Imprint asphalt according to manufacturer's written instructions, using manufacturer's recommended equipment.

B. Freshly Laid Asphalt: Immediately after asphalt has been laid and compacted but still plastic, begin the surface-imprinting process.

1. Monitor asphalt surface temperature to comply with imprinted-asphalt manufacturer's written recommendations to ensure required temperature to perform surface imprinting.
2. Reheat asphalt if surface temperature drops below that required.

C. Reheating Asphalt: Soften asphalt pavement surface by heating to a depth of at least 1/2 inch (13 mm) without burning asphalt.

1. Heat to a temperature of 300 to 325 deg F (149 to 163 deg C) immediately before applying templates.
2. Regularly monitor the pavement temperature to prevent overheating.
3. Direct flame heaters are not permitted.
4. If pavement is overheated and begins to emit black smoke, remove damaged pavement by milling down 1 inch (25 mm) and replace removed pavement with new, compacted surface course prior to resuming imprinting work.

D. Imprinting the Surface: Apply and imprint templates to a minimum depth of 1/4 inch (6 mm) as required to embed precut marking material flush or barely beneath pavement surface.

E. Applying Coating: After imprinted surface has cooled, apply two layers of base coating followed by two layers or four layers of top coating. Do not allow traffic until coating has completely dried and cured.

F. Applying Precut Marking Material: Position precut marking material aligned with imprinted pattern and slowly heat to a temperature no higher than 325 deg F (163 deg C) until marking material begins to liquefy and flow. Do not allow traffic until installed marking material has cooled to ambient temperature.

END OF SECTION 321223

SECTION 321313 - CONCRETE PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes Concrete Paving. Including the Following:

1. Driveways.
2. Roadways.
3. Parking lots.
4. Curbs and gutters.
5. Walks.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

C. Samples: For each type of product, ingredient, or admixture requiring color selection.

D. Design Mixtures: For each concrete paving mixture. Include alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

1.3 QUALITY ASSURANCE

A. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C94/C94M requirements for production facilities and equipment.

1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities" (Quality Control Manual - Section 3, "Plant Certification Checklist").

1.4 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified independent testing agency to perform preconstruction testing on concrete paving mixtures.

PART 2 - PRODUCTS

2.1 CONCRETE, GENERAL

A. ACI Publications: Comply with ACI 301 (ACI 301M) unless otherwise indicated.

2.2 STEEL REINFORCEMENT

A. Plain-Steel Welded-Wire Reinforcement: ASTM A1064/A1064M, fabricated from as-drawn steel wire into flat sheets.

B. Deformed-Steel Welded-Wire Reinforcement: ASTM A1064/A1064M, flat sheet.

C. Reinforcing Bars: ASTM A615/A615M, Grade 60 (Grade 420); deformed.

D. Joint Dowel Bars: ASTM A615/A615M, Grade 60 (Grade 420) plain-steel bars; zinc coated (galvanized) after fabrication according to ASTM A767/A767M, Class I coating. Cut bars true to length with ends square and free of burrs.

E. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded-wire reinforcement, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete of greater compressive strength than concrete specified.

2.3 CONCRETE MATERIALS

A. Cementitious Materials: Use the following cementitious materials, of same type, brand, and source throughout Project:

1. Portland Cement: ASTM C150/C150M, gray or white portland cement type as directed.
2. Fly Ash: ASTM C618, Class C or Class F.
3. Slag Cement: ASTM C989/C989M, Grade 100 or 120.
4. Blended Hydraulic Cement: ASTM C595/C595M, cement type as directed.

B. Normal-Weight Aggregates: ASTM C33/C33M, class as directed, uniformly graded. Provide aggregates from a single source.

C. Air-Entraining Admixture: ASTM C260/C260M.

D. Chemical Admixtures: Admixtures certified by manufacturer to be compatible with other admixtures and to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material.

E. Color Pigment: ASTM C979/C979M, synthetic mineral-oxide pigments or colored water-reducing admixtures; color stable, free of carbon black, nonfading, and resistant to lime and other alkalis.
1. Color: As directed.

F. Water: Potable and complying with ASTM C94/C94M.

2.4 FIBER REINFORCEMENT

A. Synthetic Fiber: Monofilament polypropylene fibers engineered and designed for use in decorative concrete paving, complying with ASTM C1116/C1116M, Type III, 1/2 to 1-1/2 inches (13 to 38 mm) long.

B. Synthetic Fiber: Fibrillated polypropylene fibers engineered and designed for use in decorative concrete paving, complying with ASTM C1116/C1116M, Type III, 1/2 to 1-1/2 inches (13 to 38 mm) long.

2.5 CURING MATERIALS

A. Absorptive Cover: AASHTO M 182, Class 3, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. (305 g/sq. m) dry or cotton mats.

B. Moisture-Retaining Cover: ASTM C171, polyethylene film or white burlap-polyethylene sheet.

C. Water: Potable.

D. Evaporation Retarder: Waterborne, monomolecular, film forming, manufactured for application to fresh concrete.

E. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C309, Type 1, Class B, dissipating.

F. White, Waterborne, Membrane-Forming Curing Compound: ASTM C309, Type 2, Class B, dissipating.

2.6 RELATED MATERIALS

A. Joint Fillers: ASTM D1751, asphalt-saturated cellulosic fiber or ASTM D1752, cork or self-expanding cork in preformed strips.

B. Slip-Resistive Aggregate Finish: Factory-graded, packaged, rustproof, non-glazing, abrasive aggregate of fused aluminum-oxide granules or crushed emery aggregate containing not less than 50 percent aluminum oxide and not less than 20 percent ferric oxide; unaffected by freezing, moisture, and cleaning materials.

2.7 CONCRETE MIXTURES

A. Prepare design mixtures, proportioned according to ACI 301 (ACI 301M), for each type and strength of normal-weight concrete, and as determined by either laboratory trial mixtures or field experience.

B. Cementitious Materials: Use fly ash, pozzolan, slag cement, and silica fume as needed to reduce the total amount of portland cement, which would otherwise be used, by not less than 40 percent. Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows:

1. Fly Ash or Pozzolan: 25 percent.
2. Slag Cement: 50 percent.
3. Combined Fly Ash or Pozzolan, and Slag Cement: 50 percent, with fly ash or pozzolan not exceeding 25 percent.

C. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete at point of placement having an air content as follows:

1. Air Content: Percent amount as directed plus or minus 1-1/2 percent.

D. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.

E. Synthetic Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than 1.0 lb/cu. yd. (0.60 kg/cu. m) or 1.5 lb/cu. yd. (0.90 kg/cu. m) as directed.

F. Color Pigment: Add color pigment to concrete mixture according to manufacturer's written instructions and to result in hardened concrete color consistent with approved mockup.

G. Concrete Mixtures: Normal-weight concrete.

1. Compressive Strength (28 Days): As directed.
2. Maximum W/C Ratio at Point of Placement: 0.45 or 0.50 as directed.
3. Slump Limit: Dimension as directed, plus or minus 1 inch (25 mm).

2.8 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C94/C94M and ASTM C1116/C1116M. Furnish batch certificates for each batch discharged and used in the Work.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Proof-roll prepared subbase surface below concrete paving to identify soft pockets and areas of excess yielding.

3.2 PREPARATION

A. Remove loose material from compacted subbase surface immediately before placing concrete.

3.3 EDGE FORMS AND SCREED CONSTRUCTION

A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.

B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

3.4 STEEL REINFORCEMENT INSTALLATION

A. Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

3.5 JOINTS

A. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.

B. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.

C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, other fixed objects, and where indicated.

D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, to match jointing of existing adjacent concrete paving:

E. Edging: After initial floating, tool edges of paving, gutters, curbs, and joints in concrete with an edging tool to a 1/4-inch (6-mm) or 3/8-inch (10-mm) radius as directed. Repeat tooling of edges after applying surface finishes. Eliminate edging-tool marks on concrete surfaces.

3.6 CONCRETE PLACEMENT

A. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.

B. Comply with ACI 301 (ACI 301M) requirements for measuring, mixing, transporting, and placing concrete.

C. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.

D. Screed paving surface with a straightedge and strike off.

E. Commence initial floating using bull floats or darbies to impart an open-textured and uniform surface plane before excess moisture or bleedwater appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.

3.7 FLOAT FINISHING

A. General: Do not add water to concrete surfaces during finishing operations.

B. Float Finish: Begin the second floating operation when bleedwater sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.

1. Burlap Finish: Drag a seamless strip of damp burlap across float-finished concrete, perpendicular to line of traffic, to provide a uniform, gritty texture.
2. Medium-to-Fine-Textured Broom Finish: Draw a soft-bristle broom across float-finished concrete surface, perpendicular to line of traffic, to provide a uniform, fine-line texture.
3. Medium-to-Coarse-Textured Broom Finish: Provide a coarse finish by striating float-finished concrete surface 1/16 to 1/8 inch (1.6 to 3 mm) deep with a stiff-bristled broom, perpendicular to line of traffic.

C. Slip-Resistive Aggregate Finish: Before final floating, spread slip-resistive aggregate finish on paving surface according to manufacturer's written instructions.

1. Cure concrete with curing compound recommended by slip-resistive aggregate manufacturer. Apply curing compound immediately after final finishing.
2. After curing, lightly work surface with a steel-wire brush or abrasive stone and water to expose nonslip aggregate.

3.8 CONCRETE PROTECTION AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

B. Comply with ACI 306.1 for cold-weather protection.

C. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h (1 kg/sq. m x h) before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete but before float finishing.

D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.

E. Curing Methods: Cure concrete by moisture curing, moisture-retaining-cover curing, curing compound or a combination of these.

3.9 PAVING TOLERANCES

A. Comply with tolerances in ACI 117 (ACI 117M) and as follows:

1. Elevation: 3/4 inch (19 mm).
2. Thickness: Plus 3/8 inch (10 mm), minus 1/4 inch (6 mm).

3. Surface: Gap below 10-feet- (3-m-) long; unleveled straightedge not to exceed 1/2 inch (13 mm).
4. Joint Spacing: 3 inches (75 mm).
5. Contraction Joint Depth: Plus 1/4 inch (6 mm), no minus.
6. Joint Width: Plus 1/8 inch (3 mm), no minus.

3.10 REPAIR AND PROTECTION

A. Remove and replace concrete paving that is broken, damaged, or defective or that does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Architect.

B. Protect concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.

C. Maintain concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION 321313

SECTION 321316 - DECORATIVE CONCRETE PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes colored, stamped and stenciled concrete paving as directed.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

C. Samples: For each type of exposed color, pattern, or texture indicated.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers trained and approved by manufacturer of decorative concrete paving systems.

B. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C94/C94M requirements for production facilities and equipment.

C. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.

1. Build mockups of decorative concrete paving in the location and of the size indicated or, if not indicated, build mockups where directed by Architect and not less than 96 inches (2400 mm) by 96 inches (2400 mm).

PART 2 - PRODUCTS

2.1 CONCRETE, GENERAL

A. ACI Publications: Comply with ACI 301 (ACI 301M) unless otherwise indicated.

2.2 FORMS

A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, and smooth exposed surfaces.

2.3 STEEL REINFORCEMENT

A. Plain-Steel Welded-Wire Reinforcement: ASTM A1064/A1064M, fabricated from as-drawn steel wire into flat sheets.

B. Reinforcing Bars: ASTM A615/A615M, Grade 60 (Grade 420); deformed.

C. Steel Bar Mats: ASTM A184/A184M; with ASTM A615/A615M, Grade 60 (Grade 420) deformed bars; assembled with clips.

D. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded-wire reinforcement, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete of greater compressive strength than concrete specified, and as follows:

2.4 CONCRETE MATERIALS

A. Cementitious Materials:

1. Portland Cement: ASTM C150/C150M, gray or white portland cement type as directed.
2. Fly Ash: ASTM C618, Class C or F.
3. Slag Cement: ASTM C989/C989M, Grade 100 or 120.
4. Blended Hydraulic Cement: ASTM C595/C595M, cement type as directed.

B. Normal-Weight Aggregates: ASTM C33/C33M, class as directed, uniformly graded. Provide aggregates from a single source with documented service-record data of at least 10 years' satisfactory service in similar paving applications and service conditions using similar aggregates and cementitious materials.

1. Maximum Coarse-Aggregate Size: As directed.
2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.

C. Air-Entraining Admixture: ASTM C260/C260M.

D. Chemical Admixtures: Admixtures certified by manufacturer to be compatible with other admixtures and to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material.

E. Color Pigment: ASTM C979/C979M, synthetic mineral-oxide pigments or colored water-reducing admixtures; color stable, free of carbon black, nonfading, and resistant to lime and other alkalis.

F. Water: Potable and complying with ASTM C94/C94M.

2.5 FIBER REINFORCEMENT

A. Synthetic Fiber: Monofilament polypropylene fibers engineered and designed for use in decorative concrete paving, complying with ASTM C1116/C1116M, Type III, 1/2 to 1-1/2 inches (13 to 38 mm) long as directed.

B. Synthetic Fiber: Fibrillated polypropylene fibers engineered and designed for use in decorative concrete paving, complying with ASTM C1116/C1116M, Type III, 1/2 to 1-1/2 inches (13 to 38 mm) long.

2.6 SURFACE COLORING MATERIALS

A. Pigmented Mineral Dry-Shake Hardener: Factory-packaged, dry combination of portland cement, graded quartz aggregate, color pigments, and plasticizing admixture. Use color pigments that are finely ground, nonfading mineral oxides interground with cement.

B. Pigmented Powder Release Agent: Factory-packaged, dry combination of surface-conditioning and dispersing agents interground with color pigments that facilitates release of stamp mats. Use color pigments that are finely ground, nonfading mineral oxides interground with cement.

C. Liquid Release Agent: Manufacturer's standard, clear, evaporating formulation that facilitates release of stamp mats and texture rollers.

2.7 STAMPING DEVICES

A. Stamp Mats: Semirigid polyurethane mats with projecting textured and ridged underside capable of imprinting texture and joint patterns on plastic concrete.

B. Stamp Tools: Open-grid, aluminum or rigid-plastic stamp tool capable of imprinting joint patterns on plastic concrete.

C. Rollers: Manually controlled, water-filled aluminum rollers with projecting ridges on drum capable of imprinting texture and joint patterns on plastic concrete.

D. Texture Rollers: Manually controlled, abrasion-resistant polyurethane rollers capable of imprinting texture on plastic concrete.

2.8 STENCIL MATERIALS

A. Stencils: Manufacturer's standard, moisture-resistant paper or reusable plastic stencils, designed for use on plastic concrete.

2.9 CURING MATERIALS

A. Evaporation Retarder: Waterborne, monomolecular, film forming, manufactured for application to fresh concrete.

B. Waterborne, Membrane-Forming Curing Compound: ASTM C309, Type I, Class B, manufactured for colored concrete.

1. For integrally colored concrete, curing compound shall be pigmented type approved by coloring admixture manufacturer.
2. For concrete indicated to be sealed, curing compound shall be compatible with sealer.

C. Clear Acrylic Sealer: Manufacturer's standard, waterborne, nonyellowing and UV-resistant, membrane-forming, medium-gloss, acrylic copolymer emulsion solution, manufactured for colored concrete, containing not less than 15 percent solids by volume.

D. Slip-Resistance-Enhancing Additive: Manufacturer's standard finely graded aggregate or polymer additive, designed to be added to clear acrylic sealer to enhance slip resistance of sealed paving surface.

2.10 RELATED MATERIALS

A. Joint Fillers: ASTM D1751, asphalt-saturated cellulosic fiber or ASTM D1752, cork or self-expanding cork in preformed strips.

B. Polyethylene Film: ASTM D4397, 1 mil (0.025 mm) thick, clear.

2.11 CONCRETE MIXTURES

A. Prepare design mixtures, proportioned according to ACI 301 (ACI 301M).

B. Cementitious Materials: Use fly ash, pozzolan, slag cement, and silica fume as needed to reduce the total amount of portland cement, which would otherwise be used, by not less than 40 percent. Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows:

1. Fly Ash or Pozzolan: 25 percent.
2. Slag Cement: 50 percent.
3. Combined Fly Ash or Pozzolan, and Slag Cement: 50 percent, with fly ash or pozzolan not exceeding 25 percent.

C. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete at point of placement having an air content as follows:

1. Air Content: As directed 5-1/2, 4-1/2 or 2-1/2 percent plus or minus 1.5 percent.

D. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.

E. Synthetic Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than 1.0 lb/cu. yd. (0.60 kg/cu. m).

F. Color Pigment: Add color pigment to concrete mixture according to manufacturer's written instructions and to result in hardened concrete color consistent with approved mockup.

G. Concrete Mixtures: Normal-weight concrete.

1. Compressive Strength (28 Days): As directed.
2. Maximum W/C Ratio at Point of Placement: 0.45 or 0.50.
3. Slump Limit: 4 inches (100 mm) or 5 inches (125 mm), plus or minus 1 inch (25 mm) as directed.

2.12 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C94/C94M and ASTM C1116/C1116M. Furnish batch certificates for each batch discharged and used in the Work.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Proof-roll prepared subbase surface below decorative concrete paving to identify soft pockets and areas of excess yielding.

3.2 PREPARATION

A. Remove loose material from compacted subbase surface immediately before placing concrete.

3.3 EDGE FORMS AND SCREED CONSTRUCTION

A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.

3.4 STEEL REINFORCEMENT INSTALLATION

A. Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

3.5 JOINTS

A. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.

B. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.

C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, walks, other fixed objects, and where indicated.

D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness.

E. Edging: After initial floating, tool edges of paving, gutters, curbs, and joints in concrete with an edging tool to a 1/4-inch (6-mm) or 3/8-inch (10-mm) radius. Repeat tooling of edges after applying surface finishes. Eliminate edging-tool marks on concrete surfaces.

3.6 CONCRETE PLACEMENT

A. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.

B. Comply with ACI 301 (ACI 301M) requirements for measuring, mixing, transporting, and placing concrete.

C. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.

D. Screed paving surface with a straightedge and strike off.

E. Commence initial floating using bull floats or darbies to impart an open-textured and uniform surface plane before excess moisture or bleedwater appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.

3.7 FLOAT FINISHING

A. General: Do not add water to concrete surfaces during finishing operations.

B. Float Finish: Begin the second floating operation when bleedwater sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.

3.8 INTEGRALLY COLORED CONCRETE FINISH

A. Integrally Colored Concrete Finish: After final floating, apply the following finish:

1. Burlap Finish: Drag a seamless strip of damp burlap across float-finished concrete, perpendicular to line of traffic, to provide a uniform, gritty texture.
2. Medium-to-Fine-Textured Broom Finish: Draw a soft-bristle broom across float-finished concrete surface, perpendicular to line of traffic, to provide a uniform, fine-line texture.
3. Medium-to-Coarse-Textured Broom Finish: Provide a coarse finish by striating float-finished concrete surface 1/16 to 1/8 inch (1.6 to 3 mm) deep with a stiff-bristled broom, perpendicular to line of traffic.

3.9 STENCILING

A. Cut stencils to slab width and lay on wet concrete. Overlap "mortar joint" on trailing edge of each section of stencil onto leading "mortar joint" of previous section.

B. Slightly embed stencil into concrete by rolling with stencil roller.

C. Apply pigmented mineral dry-shake hardener materials to concrete surfaces according to manufacturer's written instructions.

D. Stencil Rolling: Apply pigmented powder release agent or liquid release agent according to manufacturer's written instructions prior to applying texture roller to surface of concrete.

E. Remove stencils when concrete has sufficiently cured to bear weight. Do not leave stencils in concrete overnight.

F. Remove debris with mechanical blower prior to application of curing compound. If release agent is applied, delay removal of debris for 24 hours, then flood area with low-pressure water hose, wetting release agent, and follow by cleaning surface with pressure washer.

3.10 PIGMENTED MINERAL DRY-SHAKE HARDENER APPLICATION

A. Pigmented Mineral Dry-Shake Hardener Finish: After initial floating, apply dry-shake materials to paving surfaces according to manufacturer's written instructions and as follows:

1. After final power floating, apply the following finish:

    a. Burlap Finish: Drag a seamless strip of damp burlap across float-finished concrete, perpendicular to line of traffic, to provide a uniform, gritty texture.
    b. Medium-to-Fine-Textured Broom Finish: Draw a soft-bristle broom across float-finished concrete surface, perpendicular to line of traffic, to provide a uniform, fine-line texture.
    c. Medium-to-Coarse-Textured Broom Finish: Provide a coarse finish by striating float-finished concrete surface 1/16 to 1/8 inch (1.6 to 3 mm) deep with a stiff-bristled broom, perpendicular to line of traffic.

B. Pigmented Powder Release Agent: Uniformly distribute onto dry-shake-hardened and still-plastic concrete at a rate of 3 to 4 lb/100 sq. ft. (1.5 to 2 kg/10 sq. m).

C. Liquid Release Agent: Uniformly mist surface of dry-shake-hardened and still-plastic concrete at a rate of 5 gal/1000 sq. ft. (0.2 L/sq. m).

3.11 STAMPING

A. Mat Stamping: After floating and while concrete is plastic, apply mat-stamped finish.

1. Pigmented Powder Release Agent: Uniformly distribute onto concrete at a rate of 3 to 4 lb/100 sq. ft. (1.5 to 2 kg/10 sq. m).
2. Liquid Release Agent: Apply liquid release agent to the concrete surface and the stamp mat. Uniformly mist surface of concrete at a rate of 5 gal/1000 sq. ft. (0.2 L/sq. m).

3. After application of release agent, accurately align and place stamp mats in sequence.
4. Uniformly load mats and press into concrete to produce required imprint pattern and depth of imprint on concrete surface. Gently remove stamp mats. Hand stamp edges and surfaces unable to be imprinted by stamp mats.
5. Remove residual release agent according to manufacturer's written instructions, but no fewer than three days after stamping concrete. High-pressure-wash surface and joint patterns, taking care not to damage stamped concrete. Control, collect, and legally dispose of runoff.

B. Tool Stamping: After floating and while concrete is plastic, apply tool-stamped finish.

1. Cover surface with polyethylene film, stretch taut to remove wrinkles, lap sides and ends 3 inches (75 mm), and secure to edge forms. Lightly broom surface to remove air bubbles.
2. Accurately align and place stamp tools in sequence and tamp into concrete to produce required imprint pattern and depth of imprint on concrete surface. Gently remove stamp tools. Hand stamp edges and surfaces unable to be imprinted by stamp tools.
3. Carefully remove polyethylene film immediately after tool stamping.

C. Roller Stamping: After floating and while concrete is plastic, apply roller-stamped finish.

1. Cover surface with polyethylene film, stretch taut to remove wrinkles, lap sides and ends 3 inches (75 mm), and secure to edge forms. Lightly broom surface to remove air bubbles.
2. Accurately align roller and perform rolling operation to produce required imprint pattern and depth of imprint on concrete surface. Hand stamp surfaces inaccessible to roller.
3. Carefully remove polyethylene film immediately after roller stamping.

3.12 CONCRETE PROTECTION AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

B. Comply with ACI 306.1 for cold-weather protection.

C. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h (1 kg/sq. m x h) before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete but before float finishing.

D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.

E. Curing Compound: Apply immediately after final finishing. Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating, and repair damage during curing period.

1. Cure integrally colored concrete with a pigmented curing compound.

2. Cure concrete finished with pigmented mineral dry-shake hardener with a pigmented curing compound.

3.13 SEALER APPLICATION

A. Clear Acrylic Sealer: Apply uniformly in two coats in continuous operations according to manufacturer's written instructions. Allow first coat to dry before applying second coat, at 90 degrees to the direction of the first coat, using same application methods and rates.

1. Begin sealing dry surface no sooner than 14 days after concrete placement.
2. Thoroughly mix slip-resistance-enhancing additive into sealer before applying sealer according to manufacturer's written instructions. Stir sealer occasionally during application to maintain even distribution of additive.

3.14 PAVING TOLERANCES

A. Comply with tolerances in ACI 117 (ACI 117M).

3.15 REPAIR AND PROTECTION

A. Remove and replace decorative concrete paving that is broken or damaged or does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Architect.

B. Detailing: Grind concrete "squeeze" left from tool placement. Color ground areas with slurry of color hardener mixed with water and bonding agent. Remove excess release agent with high-velocity blower.

C. Protect decorative concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.

D. Maintain decorative concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION 321316

SECTION 321373 - CONCRETE PAVING JOINT SEALANTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cold-applied joint sealants.
2. Hot-applied joint sealants.
3. Joint-sealant backer materials.
4. Primers.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For each kind and color of joint sealant required.

C. Paving-Joint-Sealant Schedule: Include the following information:

1. Joint-sealant application, joint location, and designation.
2. Joint-sealant manufacturer and product name.
3. Joint-sealant formulation.
4. Joint-sealant color.

1.4 INFORMATIONAL SUBMITTALS

A. Product certificates.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL

A. Compatibility: Provide joint sealants, backing materials, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer, based on testing and field experience.

2.2 COLD-APPLIED JOINT SEALANTS

A. Single-Component, Nonsag, Silicone Joint Sealant: ASTM D5893/D5893M, Type NS.

B. Single-Component, Self-Leveling, Silicone Joint Sealant: ASTM D5893/D5893M, Type SL.

C. Multicomponent, Nonsag, Urethane, Elastomeric Joint Sealant: ASTM C920, Type M, Grade NS, Class 25, for Use T.

D. Single Component, Pourable, Urethane, Elastomeric Joint Sealant: ASTM C920, Type S, Grade P, Class 25, for Use T.

E. Multicomponent, Pourable, Urethane, Elastomeric Joint Sealant: ASTM C920, Type M, Grade P, Class 25, for Use T.

2.3 HOT-APPLIED JOINT SEALANTS

A. Hot-Applied, Single-Component Joint Sealant: ASTM D6690, Type I.

B. Hot-Applied, Single-Component Joint Sealant: ASTM D6690, Type I or Type II.

C. Hot-Applied, Single-Component Joint Sealant: ASTM D6690, Type I, II, or III.

D. Hot-Applied, Single-Component Joint Sealant: ASTM D6690, Type IV.

2.4 JOINT-SEALANT BACKER MATERIALS

A. Round Backer Rods for Cold- and Hot-Applied Joint Sealants: ASTM D5249, Type 1, of diameter and density required to control sealant depth and prevent bottom-side adhesion of sealant.

B. Round Backer Rods for Cold-Applied Joint Sealants: ASTM D5249, Type 3, of diameter and density required to control joint-sealant depth and prevent bottom-side adhesion of sealant.

C. Backer Strips for Cold- and Hot-Applied Joint Sealants: ASTM D5249; Type 2; of thickness and width required to control joint-sealant depth, prevent bottom-side adhesion of sealant, and fill remainder of joint opening under sealant.

2.5 PRIMERS

A. Primers: Product recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated.

PART 3 - EXECUTION

3.1 INSTALLATION OF JOINT SEALANTS

A. Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated unless more stringent requirements apply.

B. Cleaning of Joints: Clean out joints immediately to comply with joint-sealant manufacturer's written instructions.

C. Joint Priming: Prime joint substrates where indicated or where recommended in writing by joint-sealant manufacturer.

D. Joint-Sealant Installation Standard: Comply with recommendations in ASTM C1193 for use of joint sealants as applicable to materials, applications, and conditions.

E. Install joint-sealant backings to support joint sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.

1. Do not leave gaps between ends of joint-sealant backings.
2. Do not stretch, twist, puncture, or tear joint-sealant backings.
3. Remove absorbent joint-sealant backings that have become wet before sealant application and replace them with dry materials.

F. Install joint sealants immediately following backing installation, using proven techniques that comply with the following:

1. Place joint sealants so they fully contact joint substrates.
2. Completely fill recesses in each joint configuration.
3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.

G. Tooling of Nonsag Joint Sealants: Immediately after joint-sealant application and before skinning or curing begins, tool sealants according to the following requirements to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint:

1. Remove excess joint sealant from surfaces adjacent to joints.
2. Use tooling agents that are approved in writing by joint-sealant manufacturer and that do not discolor sealants or adjacent surfaces.

H. Provide joint configuration to comply with joint-sealant manufacturer's written instructions unless otherwise indicated.

I. Clean off excess joint sealant as the Work progresses, by methods and with cleaning materials approved in writing by joint-sealant manufacturers.

END OF SECTION 321373

SECTION 321400 - UNIT PAVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Brick pavers set in aggregate, bituminous and mortar setting beds.
2. Concrete pavers set in aggregate bituminous and mortar setting beds.
3. Asphalt-block pavers set in bituminous setting beds.
4. Stone pavers set in aggregate and mortar setting beds.
5. Plastic, Steel or Aluminum edge restraints as directed.

1.3 ACTION SUBMITTALS

A. Product Data: For materials other than water and aggregates.

B. Sustainable Design Submittals:

C. Samples: For each type of unit paver indicated and the following:

1. Joint materials involving color selection.
2. Exposed edge restraints involving color selection.

1.4 INFORMATIONAL SUBMITTALS

A. Material Certificates: For unit pavers. Include statements of material properties indicating compliance with requirements, including compliance with standards. Provide for each type and size of unit.

1.5 FIELD CONDITIONS

A. Cold-Weather Protection: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen subgrade or setting beds. Remove and replace unit paver work damaged by frost or freezing.

B. Weather Limitations for Bituminous Setting Bed: Install bituminous setting bed only when ambient temperature is above 40 deg F (4 deg C) and when base is dry.

C. Weather Limitations for Mortar and Grout:

1. Cold-Weather Requirements: Comply with cold-weather construction requirements contained in TMS 602/ACI 530.1/ASCE 6.
2. Hot-Weather Requirements: Comply with hot-weather construction requirements contained in TMS 602/ACI 530.1/ASCE 6. Provide artificial shade and windbreaks and use cooled materials as required. Do not apply mortar to substrates with temperatures of 100 deg F (38 deg C) and higher.

PART 2 - PRODUCTS

2.1 BRICK PAVERS

A. Brick Pavers: Light-traffic paving brick; ASTM C902, Class SX or as directed, Application as directed. Provide brick without frogs or cores in surfaces exposed to view in the completed Work.

1. Thickness: As indicated.
2. Face Size: As indicated.
3. Color: As directed.

B. Temporary Protective Coating: Precoat exposed surfaces of brick pavers with a continuous film of a temporary protective coating that is compatible with brick, mortar, and grout products and can be removed without damaging grout or brick. Do not coat unexposed brick surfaces; handle brick to prevent coated surfaces from contacting backs or edges of other units. If, despite these precautions, coating does contact bonding surfaces of brick, remove coating from bonding surfaces before setting brick.

2.2 CONCRETE PAVERS

A. Concrete Pavers: Solid interlocking paving units complying with ASTM C936/C936M and resistant to freezing and thawing when tested according to ASTM C67, made from normal-weight aggregates.

1. Thickness: 2-3/8 inches (60 mm) or 3-1/8 inches (80 mm) as directed.
2. Face Size and Shape: Square as directed.
3. Face Size and Shape: Rectangle as directed.
4. Face Size and Shape: As directed.
5. Color: As directed.

B. Concrete Pavers: Solid paving units complying with ASTM C1491, made from lightweight concrete.

1. Thickness: As directed.
2. Face Size and Shape: As indicated.
3. Color: As directed.

2.3 ASPHALT-BLOCK PAVERS

A. Asphalt-Block Pavers: Solid units made from asphalt cement complying with ASTM D312, Type III; inorganic stone dust or cement filler; and coarse aggregate, consisting of clean, hard, unweathered stone crushed into angular particles varying in size up to 3/8 inch (9.5 mm).
   1. Thickness: As directed.
   2. Face Size: Wide hexagon as directed.
   3. Finish: As directed.
   4. Color: As directed.

2.4 STONE PAVERS

A. Granite Pavers: Rectangular paving slabs made from granite complying with ASTM C615/C615M.

   1. Color and Grain: Color as directed with medium or fine grain.
   2. Finish: Honed or Thermal as indicated.
   3. Thickness: As directed.
   4. Face Size: As indicated.

B. Quartz-Based Stone Pavers: Rectangular paving slabs or Random polygonal flagstones made from quartz-based stone complying with ASTM C616/C616M, Classification as directed.

   1. Stone Abrasion Resistance: Minimum value of 10, based on testing according to ASTM C241/C241M or ASTM C1353.
   2. Finish: As indicated.
   3. Match Architect's samples for color, finish, and other stone characteristics relating to aesthetic effects.
   4. Thickness: As directed.
   5. Face Size: As indicated.

C. Slate Pavers: As directed rectangular paving slabs or Random polygonal flagstones made from slate complying with ASTM C629/C629M, Classification I Exterior, with a fine, even grain and unfading color, from clear, sound stock.

   1. Color: As directed.
   2. Stone Abrasion Resistance: Minimum value of 8, based on testing according to ASTM C241/C241M or ASTM C1353.
   3. Finish: As directed.
   4. Match Architect's samples for color, finish, and other stone characteristics relating to aesthetic effects.
   5. Thickness: As directed.
   6. Face Size: As directed.

D. Rough Granite Pavers: Rectangular tumbled paving stones, with split or thermal-finished faces and edges, made from granite complying with ASTM C615/C615M.
   1. Color and Grain: As directed.
   2. Thickness: As directed.

3. Face Size: 4 by 4 inches (100 by 100 mm), plus or minus 1/2 inch (13 mm) or 3 to 5 inches (75 to 125 mm) by 8 to 12 inches (200 to 300 mm). As indicated.

2.5 EDGE RESTRAINTS

A. Plastic Edge Restraints: As directed manufacturer's standard triangular PVC extrusions 1-3/4 inches (45 mm) high by 3-1/2 inches (89 mm) wide or 3-1/8 inches (79 mm) high by 9-1/2 inches (241 mm) wide designed to serve as edge restraints for unit pavers; rigid type for straight edges and flexible type for curved edges; with pipe connectors and 3/8-inch (9.5-mm) diameter by 12-inch- (300-mm-) long steel spikes.

B. Steel Edge Restraints: As directed manufacturer's standard painted steel edging 3/16 inch (4.8 mm) thick by 4 inches (100 mm) high or 1/4 inch (6.4 mm) thick by 5 inches (125 mm) high with loops pressed from or welded to face to receive stakes at 36 inches (900 mm) o.c. and steel stakes 15 inches (380 mm) long for each loop.
1. Color: As directed.

C. Aluminum Edge Restraints: As directed.

2.6 ACCESSORIES

A. Cork Joint Filler: Preformed strips complying with ASTM D1752, Type II.

B. Compressible Foam Filler: Preformed strips complying with ASTM D1056, Grade 2A1.

2.7 AGGREGATE SETTING-BED MATERIALS

A. Graded Aggregate for Base: Sound, crushed stone or gravel as directed.

B. Sand for Leveling Course: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C33/C33M for fine aggregate.

C. Sand for Joints: Fine, sharp, washed, natural sand or crushed stone with 100 percent passing No. 16 (1.18-mm) sieve and no more than 10 percent passing No. 200 (0.075-mm) sieve.

D. Drainage Geotextile: Nonwoven needle-punched geotextile fabric, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation greater than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:

1. Survivability: Class 2, AASHTO M 288.
2. Apparent Opening Size: No. 40 (0.425-mm) sieve, maximum; ASTM D4751.
3. Permittivity: 0.5 per second, minimum; ASTM D4491.
4. UV Stability: 50 percent after 500 hours' exposure, ASTM D4355.

E. Herbicide: Commercial chemical for weed control, registered with the EPA. Provide in granular, liquid, or wettable powder form.

2.8 BITUMINOUS SETTING-BED MATERIALS

A. Primer for Base: ASTM D2028/D2028M, cutback asphalt, grade as recommended by unit paver manufacturer.

B. Fine Aggregate for Setting Bed: ASTM D1073, No. 2 or No. 3.

C. Asphalt Cement: ASTM D3381/D3381M, Viscosity Grade AC-10 or Grade AC-20.

D. Neoprene-Modified Asphalt Adhesive: Paving manufacturer's standard adhesive consisting of oxidized asphalt combined with 2 percent neoprene and 10 percent long-fibered mineral fibers containing no asbestos.

E. Sand for Joints: Fine, sharp, washed, natural sand or crushed stone with 100 percent passing No. 16 (1.18-mm) sieve and no more than 10 percent passing No. 200 (0.075-mm) sieve.

2.9 MORTAR SETTING-BED MATERIALS

A. Portland Cement: ASTM C150/C150M, Type I or Type II.

B. Hydrated Lime: ASTM C207, Type S.

C. Sand: ASTM C144.

D. Latex Additive: Manufacturer's standard, acrylic resin or styrene-butadiene-rubber water emulsion, serving as replacement for part or all of gaging water, of type specifically recommended by latex-additive manufacturer for use with field-mixed portland cement and aggregate mortar bed, and not containing a retarder.

E. Water: Potable.

2.10 GROUT MATERIALS

A. High-Performance Cement Grout: ANSI A118.7, sanded.
   1. Polymer Type: Ethylene vinyl acetate or acrylic additive, in dry, redispersible form, prepackaged with other dry ingredients.
   2. Polymer Type: Acrylic resin or styrene-butadiene rubber in liquid-latex form for addition to prepackaged dry-grout mix.

B. Grout Colors: As directed.

C. Water: Potable.

2.11 BITUMINOUS SETTING-BED MIX

A. Mix bituminous setting-bed materials at an asphalt plant in approximate proportion, by weight, of 7 percent asphalt cement to 93 percent fine aggregate unless otherwise indicated. Heat mixture to 300 deg F (149 deg C).

2.12 MORTAR AND GROUT MIXES

A. General: Comply with referenced standards and with manufacturers' written instructions for mix proportions, mixing equipment, mixer speeds, mixing containers, mixing times, and other procedures needed to produce setting-bed and joint materials of uniform quality and with optimal performance characteristics. Discard mortars and grout if they have reached their initial set before being used.

B. Mortar-Bed Bond Coat: As directed mix neat cement and latex additive or water to a creamy consistency.

C. Portland Cement-Lime Setting-Bed Mortar: Type M complying with ASTM C270, Proportion Specification.

D. Latex-Modified, Portland Cement Setting-Bed Mortar: Proportion and mix portland cement, sand, and latex additive for setting bed to comply with written instructions of latex-additive manufacturer and as necessary to produce stiff mixture with a moist surface when bed is ready to receive pavers.

E. Latex-Modified, Portland Cement Bond Coat: Proportion and mix portland cement, aggregate, and liquid latex for bond coat to comply with written instructions of liquid-latex manufacturer.

F. Packaged Grout: Proportion and mix according to grout manufacturer's written instructions.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Mix pavers from several pallets or cubes, as they are placed, to produce uniform blend of colors and textures.

B. Cut unit pavers with motor-driven masonry saw equipment to provide clean, sharp, unchipped edges. Cut units to provide pattern indicated and to fit adjoining work neatly. Use full units without cutting where possible. Hammer cutting is not acceptable.

1. For concrete pavers, a block splitter may be used.

C. Joint Pattern: As directed.

D. Pavers over Waterproofing: Exercise care in placing pavers and setting materials over waterproofing so protection materials are not displaced and waterproofing is not punctured or otherwise damaged. Carefully replace protection materials that become displaced and arrange for repair of damaged waterproofing before covering with paving.

1. Provide joint filler at waterproofing that is turned up on vertical surfaces unless otherwise indicated; where unfilled joints are indicated, provide temporary filler or protection until paver installation is complete.

E. Tolerances: Do not exceed 1/16-inch (1.6-mm) unit-to-unit offset from flush (lippage) or 1/8 inch in 24 inches (3 mm in 600 mm) and 1/4 inch in 10 feet (6 mm in 3 m) from level, or indicated slope, for finished surface of paving.

F. Expansion and Control Joints: Provide for sealant-filled joints at locations and of widths indicated. Provide compressible foam filler as backing for sealant-filled joints unless otherwise indicated; where unfilled joints are indicated, provide temporary filler until paver installation is complete. Install joint filler before setting pavers. Sealant materials and installation are specified in Section 079200 "Joint Sealants."

G. Expansion and Control Joints: Provide cork joint filler at locations and of widths indicated. Install joint filler before setting pavers. Make top of joint filler flush with top of pavers.

H. Provide edge restraints as indicated. Install edge restraints before placing unit pavers.

3.2 AGGREGATE SETTING-BED APPLICATIONS

A. Compact soil subgrade uniformly to at least 95 percent of ASTM D698 or ASTM D1557 laboratory density as directed.

B. Place aggregate base, compact by tamping with plate vibrator, and screed to depth indicated.

C. Place drainage geotextile over compacted base course, overlapping ends and edges at least 12 inches (300 mm).

D. Place leveling course and screed to a thickness of 1 to 1-1/2 inches (25 to 38 mm), taking care that moisture content remains constant and density is loose and uniform until pavers are set and compacted.

E. Treat leveling course with herbicide to inhibit growth of grass and weeds.

F. Set pavers with a minimum joint width of 1/16 inch (1.5 mm) and a maximum of 1/8 inch (3 mm), being careful not to disturb leveling base. If pavers have spacer bars, place pavers hand tight against spacer bars. Use string lines to keep straight lines. Fill gaps between units that exceed 3/8 inch (10 mm) with pieces cut to fit from full-size unit pavers.

G. Vibrate pavers into leveling course with a low-amplitude plate vibrator capable of a 3500- to 5000-lbf (16- to 22-kN) compaction force at 80 to 90 Hz. Use vibrator with neoprene mat on face of plate or other means as needed to prevent cracking and chipping of pavers. Perform at least three passes across paving with vibrator.

H. Spread dry sand and fill joints immediately after vibrating pavers into leveling course. Vibrate pavers and add sand until joints are completely filled, then remove excess sand. Leave a slight surplus of sand on the surface for joint filling.

3.3 BITUMINOUS SETTING-BED APPLICATIONS

A. Apply primer to concrete slab or binder course immediately before placing setting bed.

B. Prepare for setting-bed placement by locating 3/4-inch- (19-mm-) deep control bars approximately 11 feet (3.3 m) apart and parallel to one another, to serve as guides for striking board. Adjust bars to subgrades required for accurate setting of paving units to finished grades indicated.

C. Place bituminous setting bed where indicated, in panels, by spreading bituminous material between control bars. Spread mix at a minimum temperature of 250 deg F (121 deg C). Strike setting bed smooth, firm, even, and not less than 3/4 inch (19 mm) thick. Add fresh bituminous material to low, porous spots after each pass of striking board. After each panel is completed, advance first control bar to next position in readiness for striking adjacent panels. Carefully fill depressions that remain after removing depth-control bars.

1. Roll setting bed with power roller to a nominal depth of 3/4 inch (19 mm). Adjust thickness as necessary to allow accurate setting of unit pavers to finished grades indicated. Complete rolling before mix temperature cools to 185 deg F (85 deg C).

D. Apply neoprene-modified asphalt adhesive to cold setting bed by squeegeeing or troweling to a uniform thickness of 1/16 inch (1.6 mm). Proceed with setting of paving units only after adhesive is tacky and surface is dry to touch.

E. Place pavers carefully by hand in straight courses, maintaining accurate alignment and uniform top surface. Protect newly laid pavers with plywood panels on which workers can stand. Advance protective panels as work progresses but maintain protection in areas subject to continued movement of materials and equipment to avoid creating depressions or disrupting alignment of pavers. If additional leveling of paving is required, and before treating joints, roll paving with power roller after sufficient heat has built up in the surface from several days of hot weather.

F. Joint Treatment: Place unit pavers with hand-tight joints. Fill joints by sweeping sand over paved surface until joints are filled. Remove excess sand after joints are filled.

3.4 MORTAR SETTING-BED APPLICATIONS

A. Saturate concrete subbase with clean water several hours before placing setting bed. Remove surface water about one hour before placing setting bed.

B. Apply mortar-bed bond coat over surface of concrete subbase about 15 minutes before placing mortar bed. Do not exceed 1/16-inch (1.6-mm) thickness for bond coat. Limit area of bond coat to avoid its drying out before placing setting bed.

C. Apply mortar bed over bond coat; spread and screed mortar bed to uniform thickness at subgrade elevations required for accurate setting of pavers to finished grades indicated.

D. Mix and place only that amount of mortar bed that can be covered with pavers before initial set. Before placing pavers, cut back, bevel edge, and remove and discard setting-bed material that has reached initial set.

E. Wet brick pavers before laying if the initial rate of absorption exceeds 30 g/30 sq. in. (30 g/194 sq. cm) per minute when tested according to ASTM C67. Allow units to absorb water so they are damp but not wet at time of laying.

F. Place pavers before initial set of cement occurs. Immediately before placing pavers on mortar bed, apply uniform 1/16-inch- (1.5-mm-) thick bond coat to mortar bed or to back of each paver with a flat trowel.

G. Tamp or beat pavers with a wooden block or rubber mallet to obtain full contact with setting bed and to bring finished surfaces within indicated tolerances. Set each paver in a single operation before initial set of mortar; do not return to areas already set or disturb pavers for purposes of realigning finished surfaces or adjusting joints.

H. Spaced Joint Widths: As directed.

I. Grouted Joints: Grout paver joints complying with ANSI A108.10.

J. Grout joints as soon as possible after initial set of setting bed.

1. Force grout into joints, taking care not to smear grout on adjoining surfaces.
2. Tool exposed joints slightly concave when thumbprint hard, using a jointer larger than joint thickness unless otherwise indicated.

K. Cure grout by maintaining in a damp condition for seven days unless otherwise recommended by grout or liquid-latex manufacturer.

L. Cleaning: Remove excess grout from exposed paver surfaces; wash and scrub clean.

1. Remove temporary protective coating as recommended by coating manufacturer and as acceptable to paver and grout manufacturers.

END OF SECTION 321400

SECTION 321443 - POROUS UNIT PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Concrete grid pavers with aggregate fill with soil fill planted with grass seed for planting with ground cover plants.
2. Solid concrete pavers with openings between pavers filled with aggregate.
3. Aggregate setting bed for pavers.
4. Edge restraints.

1.2 ACTION SUBMITTALS

A. Product Data: For materials other than aggregates.

B. Sustainable Design Submittals:

C. Sieve Analyses: For aggregate materials, according to ASTM C136.

D. Samples:

1. Full-size units of each type of unit paver indicated.
2. Exposed edge restraints.
3. Aggregate fill.
4. Aggregate setting bed materials.

1.3 QUALITY ASSURANCE

A. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for materials and execution.

1. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

PART 2 - PRODUCTS

2.1 CONCRETE UNIT PAVERS

A. Concrete Grid Pavers: Grid paving units complying with ASTM C1319, made from normal-weight aggregates.

1. Thickness: As directed.

2. Face Size and Shape: As indicated.
3. Opening Percentage: As directed.
4. Color: As directed.

B. Solid Concrete Pavers for Porous Paving: Solid interlocking paving units of shapes that provide openings between units, complying with ASTM C936/C936M, resistant to freezing and thawing when tested according to ASTM C67, and made from normal-weight aggregates.

1. Thickness: As directed.
2. Face Size and Shape: As directed.
3. Opening Percentage: As directed.
4. Color: As directed.

2.2 ACCESSORIES

A. Plastic Edge Restraints: Triangular PVC extrusions, 1-3/4 inches (45 mm) high by 3-1/2 inches (90 mm) wide or 3-1/8 inches (80 mm) high by 9-1/2 inches (240 mm) wide as directed, designed to serve as edge restraints for unit pavers; rigid type for straight edges and flexible type for curved edges, with pipe connectors and 3/8-inch- (9.5-mm-) diameter by 12-inch- (300-mm-) long steel spikes.

B. Steel Edge Restraints: Painted steel edging, 3/16-inch (4.8 mm) thick by 4 inches (100 mm) high or 1/4 inch (6.4 mm) thick by 5 inches (125 mm) high as directed, with loops pressed from or welded to face to receive stakes at 36 inches (900 mm) o.c., and with steel stakes 15 inches (380 mm) long for each loop.
1. Color: As directed

C. Aluminum Edge Restraints: As directed.

2.3 AGGREGATE SETTING-BED MATERIALS

A. Graded Aggregate for Subbase: Sound crushed stone or gravel complying as directed.

B. Graded Aggregate for Base Course: Sound crushed stone or gravel complying as directed.

C. Sand for Leveling Course: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C33/C33M for fine aggregate.

D. Soil Mix for Leveling Course: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C33/C33M for fine aggregate blended with planting soil as directed according to Section 329113 "Soil Preparation." Or Section 329115 "Soil Preparation (Performance Specification)." Use blend consisting of 1/2 sand and 1/2 planting soil mix or 2/3 sand and 1/3 planting soil mix as directed.

E. Graded Aggregate for Leveling Course: Sound crushed stone or gravel complying with ASTM D448 for Size No. 8 or 9 as directed.

F. Drainage Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation greater than 50

percent; complying with AASHTO M 288 and the following, measured according to test methods referenced:

1. Survivability: Class 2; AASHTO M 288.
2. Apparent Opening Size: No. 40 (0.425-mm) sieve, maximum; ASTM D4751.
3. Permittivity: 0.5 per second, minimum; ASTM D4491.
4. UV Stability: 50 percent after 500 hours' exposure; ASTM D4355.

2.4 FILL MATERIALS

A. Soil Fill for Porous Paving: Planting soil as directed according to Section 329113 "Soil Preparation or Section 329115 "Soil Preparation (Performance Specification)" as directed.

B. Aggregate Fill for Porous Paving: Graded, sound, crushed stone or gravel complying with ASTM D448 for Size No. 8 or 9 as directed.

1. Color: As directed.

C. Grass Seed: Comply with requirements in Section 329200 "Turf and Grasses."

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Do not use unit pavers with chips, cracks, voids, discolorations, and other defects that might be structurally unsound or visible in finished work.

B. Cut unit pavers with motor-driven masonry saw equipment or a block splitter to provide clean, sharp, unchipped edges. Cut units to provide pattern indicated and to fit adjoining work neatly. Use full units without cutting where possible. Hammer cutting is not acceptable.

C. Tolerances:

1. Variation in Plane between Adjacent Units (Lipping): Do not exceed 1/16-inch (1.5-mm) unit-to-unit offset from flush.
2. Variation from Level or Indicated Slope: Do not exceed 1/8 inch in 24 inches (3 mm in 600 mm) and 1/4 inch in 10 feet (6 mm in 3 m) or a maximum of 1/2 inch (13 mm).

D. Provide edge restraints as indicated. Install edge restraints before placing unit pavers.

3.2 SETTING-BED INSTALLATION

A. Compact subgrade uniformly to at least 95 percent of ASTM D698 or ASTM D1557 laboratory density as directed.

B. Place drainage geotextile over prepared subgrade, overlapping ends and edges at least 12 inches (300 mm).

C. Place aggregate subbase and base, compact by tamping with plate vibrator, and screed to depth indicated.

D. Place aggregate subbase and base, compact to 100 percent of ASTM D1557 maximum laboratory density, and screed to depth indicated.

E. Place drainage geotextile over compacted subbase, overlapping ends and edges at least 12 inches (300 mm).

F. Place drainage geotextile over compacted base course, overlapping ends and edges at least 12 inches (300 mm).

G. Place leveling course, and screed to a thickness as directed, taking care that moisture content remains constant and density is loose and constant until pavers are set and compacted.

3.3 PAVER INSTALLATION

A. Set unit pavers on leveling course, being careful not to disturb leveling base. If pavers have lugs or spacer bars to control spacing, place pavers hand tight against lugs or spacer bars. If pavers do not have lugs or spacer bars, place pavers with a 1/16-inch (1.6-mm) minimum and 1/8-inch (3.2-mm) maximum joint width

B. Compact pavers into leveling course with a low-amplitude plate vibrator capable of a 3500- to 5000-lbf (16- to 22-kN) compaction force at 80 to 90 Hz.

C. Place soil fill immediately after vibrating pavers into leveling course. Spread and screed soil fill level with tops of pavers. Vibrate pavers and add soil fill until porous paving is filled to about 3/4 inch (19 mm) from top surface; remove excess soil fill if any.

D. After filling pavers with soil, sow seed according to Section 329200 "Turf and Grasses," except sow seed at half the rate specified for seeding lawns. Sweep seed from surfaces of pavers into voids and water with fine spray.

E. Place graded aggregate fill immediately after vibrating pavers into leveling course. Spread and screed aggregate fill level with tops of pavers.

F. As work progresses, remove and replace pavers that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Provide new units to match adjoining units and install in same manner as original units, with same joint treatment and with no evidence of replacement.MAINTENANCE AND PROTECTION

G. Water newly planted grass and keep moist until grass is established. Maintain grass that is planted in paving to comply with requirements in Section 329200 "Turf and Grasses."

H. Erect barricades and warning signs as required to protect newly planted areas from traffic. Maintain barricades for 60 days after planting.

END OF SECTION 321443

SECTION 321713 - PARKING BUMPERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes concrete and resilient wheel stops.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Samples: For each exposed product and for each color and texture specified.

PART 2 - PRODUCTS

2.1 PARKING BUMPERS

A. Concrete Wheel Stops: Precast, steel-reinforced, air-entrained concrete, 4000-psi (27.6-MPa) minimum compressive strength, 4-1/2 inches (115 mm) high by 9 inches (225 mm) wide by 72 inches (1800 mm) long. Provide chamfered corners, transverse drainage slots on underside, and a minimum of two factory-formed or -drilled vertical holes through wheel stop for anchoring to substrate.
   1. Mounting Hardware: Galvanized-steel as directed.

B. Resilient Wheel Stops: Solid, integrally colored rubber or plastic; UV stabilized; manufacturer's standard height and width by 72 inches (1800 mm) long. Provide chamfered corners and a minimum of two factory-formed or -drilled vertical holes through wheel stop for anchoring to substrate.
   1. Color: As directed.
   2. Embedded Markings: Molded-in, blue, white or yellow reflective markings as directed, permanently inset in exposed surface.
   3. Mounting Hardware: Galvanized-steel as directed.
   4. Adhesive: As recommended by wheel-stop manufacturer for adhesion to pavement.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install wheel stops according to manufacturer's written instructions unless otherwise indicated.

B. Install wheel stops in bed of adhesive before anchoring.

C. Securely anchor wheel stops to pavement with hardware in each preformed vertical hole in wheel stop as recommended in writing by manufacturer. Recess head of hardware beneath top of wheel stop.

END OF SECTION 321713

SECTION 321716 - MANUFACTURED TRAFFIC-CALMING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes manufactured traffic-calming devices.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Samples: For each exposed product and for each color and texture specified.

PART 2 - PRODUCTS

2.1 MANUFACTURED TRAFFIC-CALMING DEVICES

A. Speed Bumps, Humps or Cushions: Solid, integrally colored, rubber or plastic; UV stabilized. Provide factory-formed or -drilled vertical holes for anchoring to substrate.
   1. Size: 2 inches (51 mm) high by 10 inches (254 mm) wide by 72 inches (1800 mm) long; with tapered, square, or rounded ends.
   2. Size: Modular assembly 3 inches (76 mm) high by 12 feet (3.7 m) in overall width or 4 inches (102 mm) high by 14 feet (4.3 m) in overall width as directed, with overall length as dimensioned on Drawings; and with tapered, square, or rounded ends.
   3. Color: Black or Yellow as directed.
   4. Embedded Markings: Molded-in, blue, white or yellow reflective markings, permanently inset in exposed surface as directed.
   5. Mounting Hardware: Galvanized-steel spike or dowel, 1/2-inch (13-mm) diameter, 10-inch (254-mm) minimum length or lag screw, shield, and washers; 1/2-inch (13-mm) diameter, 8-inch (203-mm) minimum length hardware as standard with device manufacturer as directed.
   6. Adhesive: As directed to permanently adhere traffic-calming devices to pavement.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that pavement is in suitable condition to begin installation according to manufacturer's written instructions.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install manufactured traffic-calming devices according to manufacturer's written instructions unless otherwise indicated.

B. Install devices in bed of adhesive before anchoring.

C. Securely anchor devices to pavement with hardware spaced as recommended in writing by manufacturer for heavy traffic. Recess head of hardware beneath top surface of device.

END OF SECTION 321716

SECTION 321723 - PAVEMENT MARKINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes painted markings applied to asphalt and concrete pavement.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For each exposed product and for each color and texture specified.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Accessibility Standard: Comply with applicable provisions in the USDOJ's "2010 ADA Standards for Accessible Design". the ABA standards of the Federal agency having jurisdiction and ICC A117.1.

2.3 PAVEMENT-MARKING PAINT

A. Pavement-Marking Paint: MPI #32, solvent-borne traffic-marking paint.

1. Color: As directed.

B. Pavement-Marking Paint: MPI #97, latex traffic-marking paint.

1. Color: As directed.

C. Glass Beads: AASHTO M 247, Type 1.

PART 3 - EXECUTION

3.1 PAVEMENT MARKING

A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Architect.

B. As directed allow paving to age for a minimum of 30 or 90 days before starting pavement marking.

C. Sweep and clean surface to eliminate loose material and dust.

D. Apply paint with mechanical equipment to produce pavement markings, of dimensions indicated, with uniform, straight edges. Apply at manufacturer's recommended rates to provide a minimum wet film thickness of 15 mils (0.4 mm).

1. Apply graphic symbols and lettering with paint-resistant, die-cut stencils. Apply paint so that it cannot run beneath stencil.
2. Broadcast glass beads uniformly into wet markings at a rate of 6 lb/gal. (0.72 kg/L).

END OF SECTION 321723

SECTION 321726 - TACTILE WARNING SURFACING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cast-in-place detectable warning tiles.
2. Cast-in-place detectable warning tiles.
3. Detectable warning mats applied to existing concrete paving.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Samples for each type of exposed finish requiring color selection.

PART 2 - PRODUCTS

2.1 TACTILE WARNING SURFACING, GENERAL

A. Accessibility Requirements: Comply with applicable provisions in the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines for Buildings and Facilities and ICC A117.1 for tactile warning surfaces.

1. For tactile warning surfaces composed of multiple units, provide units that when installed provide consistent side-to-side and end-to-end dome spacing that complies with requirements.

2.2 DETECTABLE WARNING TILES

A. Cast-in-Place Detectable Warning Tiles: Accessible truncated-dome detectable warning tiles with replaceable surface configured for setting flush in new concrete walkway surfaces, with slip-resistant surface treatment on domes and field of tile.
1. Material: Cast-fiber-reinforced polymer concrete tile or Molded glass- and carbon-fiber-reinforced polyester as directed.
2. Color: As directed.
3. Shapes and Sizes:

a. Rectangular panel, 12 by 12 inches (305 by 305 mm).
b. Radius panel, nominal 24 inches (610 mm) deep by 6-foot (1829-mm) outside radius.

4. Dome Spacing and Configuration: As directed.
5. Mounting:

    a. Permanently embedded detectable warning tile wet-set into freshly poured concrete.
    b. Detectable warning tile set into formed recess in concrete and adhered with mortar or adhesive as directed.
    c. Replaceable detectable warning tile wet-set into freshly poured concrete and surface-fastened to permanently embedded anchors.

B. Surface-Applied Detectable Warning Tiles: Accessible truncated-dome detectable warning concrete tiles configured for surface application on existing concrete walkway surfaces, with slip-resistant surface treatment on domes, field of tile, and beveled outside edges.
1. Material: Cast-fiber-reinforced polymer concrete tile or Molded glass- and carbon-fiber-reinforced polyester as directed.
2. Color: As directed.
3. Shapes and Sizes:

    a. Rectangular panel, 12 by 12 inches (305 by 305 mm).
    b. Radius panel, nominal 24 inches (610 mm) deep by 6-foot (1829-mm) outside radius.

4. Dome Spacing and Configuration: As directed.
5. Mounting: Adhered and fastened to existing concrete walkway.

2.3 DETECTABLE WARNING MATS

A. Surface-Applied Detectable Warning Mats: Accessible truncated-dome detectable warning resilient mats, UV resistant, manufactured for adhering to existing concrete walkway surfaces, with slip-resistant surface treatment on domes, field of mat, and beveled outside edges.
1. Material: Modified rubber compound, UV resistant.
2. Color: As directed.
3. Shapes and Sizes:

    a. Rectangular panel, As directed.

4. Dome Spacing and Configuration: As directed.
5. Mounting: Adhered to pavement surface with adhesive and fastened with fasteners.

2.4 ACCESSORIES

A. Fasteners and Anchors: Manufacturer's standard as required for secure anchorage of tactile warning surfaces, noncorrosive and compatible with each material joined, and complying with the following:

1. Furnish Type 304 or Type 316 stainless-steel fasteners for exterior use as directed.
2. Fastener Heads: For nonstructural connections, use flathead or oval countersunk screws and bolts with tamper-resistant heads, colored to match tile.

B. Adhesive: As recommended by manufacturer for adhering tactile warning surfacing unit to pavement.

C. Sealant: As recommended by manufacturer for sealing perimeter of tactile warning surfacing unit.

PART 3 - EXECUTION

3.1 INSTALLATION OF TACTILE WARNING SURFACING

A. General: Prepare substrate and install tactile warning surfacing according to manufacturer's written instructions unless otherwise indicated.

B. Place tactile warning surfacing units in dimensions and orientation indicated. Comply with location requirements of AASHTO MP 12.

C. Cast-in-Place Detectable Warning Tiles: Set each detectable warning tile accurately and firmly in place and completely seat tile back and embedments in wet concrete by tamping or vibrating. Set surface of tile flush with surrounding concrete and adjacent tiles. Remove concrete from tile surfaces and clean using methods recommended in writing by manufacturer.

D. Removable Cast-in-Place Detectable Warning Tiles: Set each detectable warning tile accurately and firmly in place with embedding anchors and fasteners attached, and firmly seat tile back in wet concrete by tamping or vibrating. Set surface of tile flush with surrounding concrete and adjacent tiles. Remove concrete from tile surfaces and clean tiles using methods recommended in writing by manufacturer.

E. Surface-Applied Detectable Warning Tiles: Prepare existing paving surface by grinding and cleaning as recommended by manufacturer. Apply adhesive to back of tiles in amounts and pattern recommended by manufacturer, set tiles in place. Install anchor devices through face of tiles and into pavement using anchors located as recommended by manufacturer. Apply sealant in continuous bead around perimeter of installation.

F. Surface-Applied Detectable Warning Mats: Prepare existing paving surface by grinding and cleaning as recommended by manufacturer. Apply adhesive to back of mat and set mat in place. Firmly seat mat in adhesive bed. Install anchor devices through face of mat and into pavement using anchors located as recommended by manufacturer. Set heads of anchors flush with mat surface. Apply sealant in continuous bead around perimeter of mat.

G. Remove and replace tactile warning surfacing that is broken or damaged or does not comply with requirements in this Section. Remove in complete sections from joint to joint unless otherwise approved by Architect. Replace using tactile warning surfacing installation methods acceptable to Architect.

H. Protect tactile warning surfacing from damage and maintain free of stains, discoloration, dirt, and other foreign material.

END OF SECTION 321726

SECTION 321813 - SYNTHETIC GRASS SURFACING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes synthetic grass surfacing.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For synthetic grass surfacing.

1. Include sections and details.
2. Show locations of seams and method of seaming.
3. Show layout of game lines, numbers, and letters. Indicate application method of each line and marking.

C. Samples: For each type of synthetic grass surfacing.

1.4 INFORMATIONAL SUBMITTALS

A. Product test reports.

B. Sample warranties.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace synthetic grass surfacing that fails in materials or workmanship within specified warranty period.

1. Warranty Period: 8 or 12 years from date of Substantial Completion as directed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Turf Fabric: Turf fabric tested according to the following methods, with additional test method conditions for each method according to ASTM F1551.

1. Tuft Bind: Not less than 8 lbf (36 N) or 10 lbf (45 N) according to ASTM D1335 as directed.
2. Breaking Strength: As directed minimum 200 lbf (890 N) or 250 lbf (1112 N) in warp direction and minimum 200 lbf (890 N) or 250 lbf (1112 N) perpendicular to warp direction, according to ASTM D5034.

B. Synthetic Grass Surfacing: Assembly tested according to the following methods, with additional test method conditions for each method according to ASTM F1551.

1. Shock Attenuation: No greater than as directed G(max) at time of installation according to ASTM F355.
2. Abrasiveness Index: Value as directed according to ASTM F1015.
3. Athletic Shoe Traction Index: As directed determined according to ASTM F2333 for football or soccer shoe, as follows:

a. Rotational: Mean or Range of value as directed.
b. Translational: Mean or Range of value as directed.

C. Permeability: As directed.

D. Durability: As directed

E. Synthetic Grass Surfacing: Complete surfacing system, consisting of synthetic yarns bound to water-permeable backing and infill indicated, suitable as directed for playing fields.

F. Turf Fabric: Woven turf fabric with multicolored fiber and UV resistance, complying with the following:

1. Yarn Fiber: As directed.
2. Lead Content of Yarn Fiber: Maximum of 100 ppm according to ASTM F2765.
3. Pile Weight: As directed according to ASTM D5848.
4. Pile Height: As directed according to ASTM D5823.

G. Backing: Manufacturer's standard woven or nonwoven polypropylene primary backing with urethane-coated secondary backing; provide perforations or drainage channels sufficient to meet permeability indicated.

H. Infill: Manufacturer's standard infill as directed.

1. Infill Proportions: As directed.

I. Game Lines and Markings: Provide game lines and markers in widths and colors according to requirements indicated on Drawings.

1. Application Method: Tufted into the maximum extent practicable, with remaining lines inlaid.

2.2 MATERIALS

A. Rubber Infill: Ground latex-coated SBR crumb rubber mesh free of metal, nonmetal fibers, and contaminants; mesh size as recommended by synthetic grass surfacing manufacturer.

B. Sand Infill: Uniformly sized latex-coated silica sand free of silts, clays, and contaminants, and of subangular or rounder shape according to ASTM F1632; mesh size as recommended by synthetic grass surfacing manufacturer.

C. Seam Adhesive: One- or two-part urethane, recommended or approved by synthetic grass surfacing manufacturer, and suitable for ambient conditions at time of installation.

D. Seam Tape: Synthetic grass manufacturer's recommended seam tape, minimum 12 inches (305 mm) or 15 inches (381 mm) wide as directed, 18 inches (457 mm) wide for inlaid game lines.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine base and other conditions, with Installer present, for compliance with requirements for installation tolerances, permeability, and other conditions affecting performance of the Work.

3.2 INSTALLATION

A. Avoid disturbance of base during installation of shock-attenuation pad and turf fabric.

B. Roll out turf fabric and allow to relax at least four hours prior to seaming.

C. Provide seams flat and snug, with no gaps or fraying. Remove yarns that are trapped within seams. Attach turf fabric to perimeter restraint system as recommended by the manufacturer.

D. Install inlaid game lines and markings by cutting through turf fabric and installing snugly fitting game line turf fabric. Provide seaming tape that extends minimum 6 inches (152 mm) beyond seam.

E. Repair loose seams and bubbles formed due to expansion of turf fabric prior to installation of infill.

F. Evenly broadcast and groom infill by machine in proportions and depth after settling as recommended by the manufacturer, and to meet indicated performance requirements. Rake fibers trapped by infill to surface.

3.3 DEMONSTRATION

A. Train Owner's maintenance personnel in proper maintenance procedures for synthetic grass surfacing.

END OF SECTION 321813

SECTION 321816.13 - PLAYGROUND PROTECTIVE SURFACING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Unitary, seamless surfacing.
2. Unitary, tile surfacing.
3. Organic loose-fill surfacing.
4. Inorganic loose-fill surfacing.

1.2 DEFINITIONS

A. Critical Height: Standard measure of shock attenuation according to ASTM F2223; same as "critical fall height" in ASTM F1292.

B. Unitary Surfacing: A protective surfacing of one or more material components bound together to form a continuous surface; same as "unitary system" in ASTM F2223.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Shop Drawings: For each type of protective surfacing.

1. Include plans, sections, placement and penetration details, and attachment to substrates.
2. Include accessories and edge terminations.
3. Include patterns made by varying colors of surfacing and details of graphics.
4. Include fall heights and use zones for equipment and structures specified in Section 116800 "Play Field Equipment and Structures," coordinated with the critical heights for protective surfacing.

D. Samples: For each exposed product and for each color and texture specified.

1.4 INFORMATIONAL SUBMITTALS

A. Material certificates.

B. Product certificates.

C. Field quality-control reports.

D. Sample warranty.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.7 WARRANTY

A. Special Warranty: Manufacturer and Installer agree to repair or replace components of protective surfacing that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Years as directed from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Impact Attenuation: Critical fall height tested according to ASTM F1292.

B. Accessibility Standard: Minimum surfacing performance according to ASTM F1951.

2.2 UNITARY, SINGLE-DENSITY, SEAMLESS SURFACING

A. Description: Manufacturer's standard, site-mixed and applied, single-layer material in thickness as required, tested for impact attenuation according to ASTM F1292 and for accessibility according to ASTM F1951.
1. Critical Height: As directed.
2. Overall Thickness: As directed.
3. Primer/Adhesive: Manufacturer's standard primer and weather-resistant, moisture-cured polyurethane adhesive suitable for unit, substrate, and location.
4. Color(s): As directed.

B. Leveling and Patching Material: Portland cement-based grout or epoxy- or polyurethane-based formulation suitable for exterior use and approved by protective surfacing manufacturer.

2.3 UNITARY, DUAL-DENSITY, SEAMLESS SURFACING

A. Description: Manufacturer's standard, site-mixed and applied, two-layer material with wearing layer over cushioning layer, with combined, overall thickness as required, tested for impact attenuation according to ASTM F1292 and for accessibility according to ASTM F1951.

1. Critical Height: As directed.
2. Overall Thickness: As directed.
3. Primer/Adhesive: Manufacturer's standard primer and weather-resistant, moisture-cured polyurethane adhesive suitable for unit, substrate, and location.
4. Wearing Layer Color(s): As directed.

B. Leveling and Patching Material: Portland cement-based grout or epoxy- or polyurethane-based formulation suitable for exterior use and approved by protective surfacing manufacturer.

2.4 UNITARY, TILE SURFACING

A. Description: Manufacturer's standard blend of rubber or PVC particles forming an integral wearing and cushioning material, with overall thickness as required, tested for impact attenuation according to ASTM F1292 and for accessibility according to ASTM F1951.
1. Unit Size: 24 by 24 inches (600 by 600 mm) as directed.
2. Base Profile: Integral ribbed or grid-patterned underside forming channels for water drainage between protective surfacing and substrate.
3. Edging and Corner Units: Tapered, bevel-edged units that transition from top surface of protective surfacing to the adjacent, lower surface; size compatible with field units maintaining layout pattern continuity. Provide edging and corner units where protective surfacing does not abut vertical surfaces.
4. Critical Height: 7 feet (2.1 m) or 12 feet (3.7 m) as directed.
5. Overall Thickness: As directed.
6. Primer/Adhesive: Manufacturer's standard primer and weather-resistant, moisture-cured polyurethane adhesive suitable for unit, substrate, and location.
7. Anchors: Manufacturer's standard for unit, substrate, and location.
8. Tile Color(s): As directed.
9. Filler/Sealant: Manufacturer's standard clear silicone or polyurethane filler/sealant suitable for exterior use.

B. Leveling and Patching Material: Portland cement-based grout or epoxy- or polyurethane-based formulation suitable for exterior use and approved by protective surfacing manufacturer.

2.5 UNITARY, DUAL-DENSITY, TILE SURFACING

A. Description: Manufacturer's standard colored wearing layer bonded to rubber cushioning layer, tested for impact attenuation according to ASTM F1292 and for accessibility according to ASTM F1951.
1. Unit Size: 24 by 24 inches (600 by 600 mm) as directed.
2. Base Profile: Integral ribbed or grid-patterned underside forming channels for water drainage between protective surfacing and substrate.
3. Edging and Corner Units: Tapered, bevel-edged units that transition from top surface of protective surfacing to the adjacent, lower surface; size compatible with field units maintaining layout pattern continuity. Provide edging and corner units where protective surfacing does not abut vertical surfaces.
4. Critical Height: As directed.
5. Overall Thickness: Not less than as directed.
6. Primer/Adhesive: Manufacturer's standard primer and weather-resistant, moisture-cured polyurethane adhesive suitable for unit, substrate, and location.

7. Anchors: Manufacturer's standard for unit, substrate, and location.
8. Wearing Layer Color(s): As directed.
9. Filler/Sealant: Manufacturer's standard clear silicone or polyurethane filler/sealant suitable for exterior use.

B. Leveling and Patching Material: Portland cement-based grout or epoxy- or polyurethane-based formulation suitable for exterior use and approved by protective surfacing manufacturer.

2.6 ORGANIC LOOSE-FILL SURFACING

A. Engineered Wood Fiber: ASTM F2075; containing no bark, leaves, twigs, or foreign or toxic materials; tested for accessibility according to ASTM F1951.
1. Critical Height: As directed.
2. Uncompressed Material Depth: As directed.

B. Wood Chips: Random-sized wood chips suitable for mulching trees and shrubs, free of metal scrap and other impurities that can cause injuries; complying with the testing and performance requirements for hazardous metals and tramp metal according to ASTM F2075.

C. Double-Shredded Bark Mulch: Random-sized bark, shredded twice, suitable for mulching trees and shrubs, free of metal scrap and other impurities that can cause injuries; complying with the testing and performance requirements for hazardous metals and tramp metal according to ASTM F2075.

2.7 INORGANIC LOOSE-FILL SURFACING

A. Shredded Rubber: Rubber particles, free from steel wires, rubber dust, and other foreign substances, tested for impact attenuation according to ASTM F1292 and for accessibility according to ASTM F1951.
1. Critical Height: As directed.
2. Uncompressed Material Depth: As directed.
3. Color(s): As directed.
4. Critical Height: As directed.
5. Uncompressed Material Depth: Not less than as required for critical height indicated or 9 inches (229 mm) as directed.

2.8 LOOSE-FILL ACCESSORIES

A. Edging: Anchored-in-place, weather-resistant containment barrier designed to minimize sharp edges, protrusions, and tripping hazards; formed by interconnected, modular, polyethylene, PVC-coated metal or rubber units.

1. Color: As directed.
2. Anchor Stakes: Manufacturer's standard, of corrosion-resistant-coated metal or noncorrodible material, designed to be nonprotruding when installed, for connecting units and securing in-place.

B. Stabilizing Mats: Water-permeable PVC or rubber mats tested for impact attenuation according to ASTM F1292, with anchoring system designed to anchor mat securely to subgrade through loose fill, and rated for use in the following locations:

1. At high-traffic areas and playground equipment where indicated on Drawings.

PART 3 - EXECUTION

3.1 PREPARATION

A. Prepare substrates to receive surfacing products according to protective surfacing manufacturer's written instructions.

1. Repair: Fill holes and depressions in unsatisfactory surfaces with leveling and patching material.
2. Terminal Edges: Saw cut concrete or asphalt for terminal edges of protective surfacing as directed.

3.2 INSTALLATION OF SEAMLESS SURFACING

A. Mix and apply components of seamless surfacing according to manufacturer's written instructions to produce uniform, monolithic, and impact-attenuating protective surfacing of required overall thickness.

1. Substrate Primer: Apply over prepared substrate at manufacturer's standard spreading rate for type of substrate.
2. Poured Cushioning Layer: Spread evenly over primed substrate in one continuous operation, with a minimum of cold joints.
3. Intercoat Primer: Over cured cushioning layer, apply primer at manufacturer's standard spreading rate.
4. Wearing Layer: Spread over primed base course in one continuous operation and, except where color changes, with no minimum of cold joints as directed.
5. Edge Treatment: As directed.

3.3 INSTALLATION OF TILE SURFACING

A. Apply components of tile surfacing according to manufacturer's written instructions to produce a uniform wearing surface with no unaligned units, raised edges (lipping), or other surface imperfections.

B. Lay out units from center marks established between principal perimeter edges, discounting minor offsets, so units at opposite sides of installation are of equal width. Adjust as necessary to avoid using cut widths that equal less than one-half of a unit.

C. Edging: Maintain fully cushioned thickness required to comply with performance requirements.

D. Filler/Sealant: Mask area surrounding cutouts around playground equipment supports and other obstructions. Apply a full bead of filler/sealant, filling cutouts immediately after laying tile around cutout.

3.4 INSTALLATION OF LOOSE-FILL SURFACING

A. Apply components of loose-fill surfacing according to manufacturer's written instructions to produce a uniform surface.

B. Edging: Place and permanently secure edging in place, and attach units to each other.

C. Loose Fill: Place loose-fill materials to required depth after installation of playground equipment support posts and foundations. Include manufacturer's recommended amount of additional material to offset natural compaction over time. Include manufacturer's recommended amount of additional material to offset mechanical compaction.

D. Stabilizing Mats: Coordinate installation of mats and mat anchoring system with placing loose fill.

E. Compaction: After initial grading, mechanically compact loose fill before finish grading.

F. Finish Grading: Hand rake to a uniformly smooth finished surface and to required elevations.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage or engage a qualified testing agency to perform tests as directed.

B. Perform the following tests with the assistance of a factory-authorized service representative:

1. Perform "Installed Surface Performance Test" according to ASTM F1292 for each protective surfacing type and thickness in each playground area.

C. Playground protective surfacing will be considered defective if it does not pass tests.

D. Prepare test reports.

END OF SECTION 321816.13

SECTION 323113 - CHAIN LINK FENCES AND GATES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Chain-link fences.
2. Swing gates.
3. Privacy slats.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For each type of fence and gate assembly.

1. Include plans, elevations, sections, details, and attachments to other work.

C. Samples: For each exposed product and for each color and texture specified.

D. Delegated-Design Submittal: For structural performance of chain-link fence and gate frameworks, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.4 INFORMATIONAL SUBMITTALS

A. Product certificates.

B. Product test reports.

C. Sample warranty.

1.5 WARRANTY

A. Special Warranty: As directed manufacturer agrees or Installer agrees to repair or replace components of chain-link fences and gates that fail in materials or workmanship within specified warranty period.

1. Warranty Period: As directed five or 15 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design chain-link fence and gate frameworks.

B. Structural Performance: Chain-link fence and gate frameworks shall withstand the design wind loads and stresses for fence height(s) and under exposure conditions indicated according to ASCE/SEI 7:

1. Design Wind Load: As directed.

    a. Minimum Post Size: Determine according to ASTM F1043 for post spacing not to exceed 10 feet (3 m) for Material Group IA, ASTM F1043, Schedule 40 steel pipe or Group IC, electric-resistance-welded round steel pipe as directed.
    b. Minimum Post Size and Maximum Spacing: Determine according to CLFMI WLG 2445, based on mesh size and pattern specified.

2.2 CHAIN-LINK FENCE FABRIC

A. General: Provide fabric in one-piece heights measured between top and bottom of outer edge of selvage knuckle or twist according to "CLFMI Product Manual" and requirements indicated below:

1. Fabric Height: As directed
2. Steel Wire for Fabric: Wire diameter as directed.

    a. Mesh Size: As directed.
    b. Aluminum-Coated Fabric: ASTM A491, Type I, as directed.
    c. Zinc-Coated Fabric: ASTM A392, Type II, Class 1, 1.2 oz./sq. ft. (366 g/sq. m) or Class 2, 2.0 oz./sq. ft. (610 g/sq. m) with zinc coating applied before or after weaving as directed.
    d. Zn-5-Al-MM Aluminum-Mischmetal-Coated Fabric: ASTM F1345, Type III, Class 1, 0.60 oz./sq. ft. (183 g/sq. m) or Class 2, 1.0 oz./sq. ft. (305 g/sq. m) as directed.
    e. Polymer-Coated Fabric: ASTM F668, as directed.

        1) Color: As directed according to ASTM F934.

    f. Coat selvage ends of metallic-coated fabric before the weaving process with manufacturer's standard clear protective coating.

3. Aluminum Wire Fabric: ASTM F1183, as directed with mill or caustic-cleaned or etched finish, and wire diameter of 0.148 inch (3.76 mm) or 0.192 inch (4.88 mm) as directed.

    a. Mesh Size: 2 inches (50 mm) or 1 inch (25 mm) as directed.

4. Selvage: Knuckled at both selvages or Twisted top and knuckled bottom as directed.

2.3 FENCE FRAMEWORK

A. Posts and Rails: ASTM F1043 for framework, including rails, braces, and line; terminal; and corner posts. Provide members with minimum dimensions and wall thickness according to ASTM F1043 or ASTM F1083 based on the following:

1. Fence Height: 72 inches (1830 mm) or 96 inches (2440 mm) as directed.
2. Light-Industrial-Strength Material: As directed.
    a. Line Post: As directed.
    b. End, Corner, and Pull Posts: As directed.
3. Heavy-Industrial-Strength Material: As directed.
    a. Line Post: As directed.
    b. End, Corner, and Pull Posts: As directed.
4. Horizontal Framework Members: Intermediate, top and bottom rails according to ASTM F1043.
5. Brace Rails: ASTM F1043.
6. Metallic Coating for Steel Framework:
    a. Type A zinc coating.
    b. Type B zinc with organic overcoat.
    c. External, Type B zinc with organic overcoat and internal, Type D zinc-pigmented coating.
    d. Type C, Zn-5-Al-MM alloy coating.
    e. Coatings: Any coating above.
7. Polymer coating over metallic coating.
    a. Color: According to ASTM F934 as directed.

2.4 TENSION WIRE

A. Metallic-Coated Steel Wire: 0.177-inch- (4.5-mm-) diameter, marcelled tension wire according to ASTM A817 or ASTM A824, with the following metallic coating:

1. Type I: Aluminum coated (aluminized).
2. Type II: Zinc coated (galvanized) with minimum coating weight matching chain-link fabric coating weight.
3. Type III: Zn-5-Al-MM alloy with the following minimum coating weight matching chain-link fabric coating weight.

B. Polymer-Coated Steel Wire: 0.177-inch- (4.5-mm-) or 0.148-inch- (3.8-mm-) diameter as directed, tension wire according to ASTM F1664, as directed.

1. Color: As directed according to ASTM F934.

2.5 SWING GATES

A. General: ASTM F900 for gate posts and single or double swing gate types as directed.

1. Gate Leaf Width: 36 inches (914 mm) as directed.
2. Framework Member Sizes and Strength: Based on gate fabric height of 72 inches (1830 mm) or less or of more than 72 inches (1830 mm) as directed.

B. Pipe and Tubing:

1. Zinc-Coated Steel: ASTM F1043 and ASTM F1083; protective coating and finish to match fence framework or manufacturer's standard protective coating and finish as directed.
2. Aluminum: ASTM B429/B429M; mill or manufacturer's standard finish as directed.
3. Gate Posts: As directed.
4. Gate Frames and Bracing: As directed.

C. Frame Corner Construction: Welded or assembled with corner fittings.

D. Extended Gate Posts and Frame Members: Fabricate gate posts and frame end members to extend 12 inches (300 mm) above top of chain-link fabric at both ends of gate frame to attach barbed wire assemblies.

E. Hardware:

1. Hinges: Swing as directed.
2. Latch: Permitting operation from both sides of gate with provision for padlocking accessible from both sides of gate.
3. Lock: Internal device as directed.
4. Padlock and Chain: As directed.
5. Closer: As directed.

2.6 FITTINGS

A. Provide fittings according to ASTM F626.

B. Barbed Wire Arms: As directed Pressed steel or cast iron or Aluminum, with clips, slots, or other means for attaching strands of barbed wire, and means for attaching to posts, integral with post cap, for each post unless otherwise indicated, and as follows:

1. Provide line posts with arms that accommodate top rail or tension wire.
2. Provide corner arms at fence corner posts unless extended posts are indicated.
3. Single-Arm Type: Type I, slanted arm or Type II, vertical arm as directed.
4. Double-Arm Type: Type III, V-shaped arm or Type IV, A-shaped arm as directed.

C. Finish:

1. Metallic Coating for Pressed Steel or Cast Iron: Not less than 1.2 oz./sq. ft. (366 g/sq. m) of zinc.

a. Polymer coating over metallic coating.

2. Aluminum: Mill finish.

2.7 PRIVACY SLATS

A. Fiber-Glass-Reinforced Plastic Slats: UV-light-stabilized fiber-glass-reinforced plastic, not less than 0.06 inch (1.5 mm) thick, sized to fit mesh specified for direction indicated, with vandal-resistant fasteners and lock strips.

B. Tubular Polyethylene Slats: Minimum 0.023-inch (0.58-mm)-thick tubular polyethylene, manufactured for chain-link fences from virgin polyethylene with UV inhibitor, sized to fit mesh specified for direction indicated, with vandal-resistant fasteners and lock strips or fins for increased privacy factor as directed.

C. Hedge-Type Slats: UV-light-stabilized, flame-resistant, PVC "needles" woven into braided, galvanized wire core, sized to fit mesh specified for direction indicated.

D. Color: As directed.

2.8 BARBED WIRE

A. Steel Barbed Wire: ASTM A121, two-strand barbed wire, 0.099-inch- (2.51-mm-) diameter line wire with 0.080-inch- (2.03-mm-) diameter, four-point round barbs spaced not more than 5 inches (127 mm) o.c.

1. Aluminum Coating: Type A.
2. Zinc Coating: Type Z, Class 3.

B. Polymer-Coated, Galvanized-Steel Barbed Wire: ASTM F1665, two-strand barbed wire, 0.080-inch- (2.03-mm-) diameter line wire with 0.080-inch- (2.03-mm-) diameter, four-point, round aluminum alloy or galvanized-steel barbs spaced not more than 5 inches (127 mm) o.c. as directed:

1. Polymer Coating: As directed.

a. Color: As directed according to ASTM F934.

2.9 GROUT AND ANCHORING CEMENT

A. Non-shrink, Nonmetallic Grout: Factory-packaged, non-staining, noncorrosive, nongaseous grout complying with ASTM C1107/C1107M. Provide grout, recommended in writing by manufacturer, for exterior applications.

B. Anchoring Cement: Factory-packaged, non-shrink, non-staining, hydraulic-controlled expansion cement formulation for mixing with water at Project site to create pourable anchoring, patching, and grouting compound. Provide formulation that is resistant to erosion from water exposure without needing protection by a sealer or waterproof coating, and that is recommended in writing by manufacturer for exterior applications.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Do not begin installation before final grading is completed unless otherwise permitted by Architect.

3.2 PREPARATION

A. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of 500 feet (152 m) or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

3.3 CHAIN-LINK FENCE INSTALLATION

A. Install chain-link fencing according to ASTM F567 and more stringent requirements specified.

B. Post Excavation: Drill or hand-excavate holes for posts to diameters and spacings indicated, in firm, undisturbed soil.

C. Post Setting: Set posts in concrete with mechanical anchors by mechanically driving into soil at indicated spacing into firm, undisturbed soil.

1. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.
2. Concrete Fill: Place concrete around posts to dimensions indicated and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.

    a. Exposed Concrete: Extend 2 inches (50 mm) above grade; shape and smooth to shed water.
    b. Concealed Concrete: Place top of concrete 2 inches (50 mm) below grade to allow covering with surface material.
    c. Posts Set into Sleeves in Concrete: Use steel pipe sleeves preset and anchored into concrete for installing posts. After posts are inserted into sleeves, fill annular space between post and sleeve with non-shrink, nonmetallic grout or anchoring cement, mixed and placed according to anchoring material manufacturer's written instructions. Finish anchorage joint to slope away from post to drain water.
    d. Posts Set into Holes in Concrete: Form or core drill holes not less than 5 inches (127 mm) deep and 3/4 inch (20 mm) larger than OD of post. Clean holes of loose material, insert posts, and fill annular space between post and concrete with non-shrink, nonmetallic grout or anchoring cement, mixed and placed according to anchoring material manufacturer's written instructions. Finish anchorage joint to slope away from post to drain water.

3. Mechanically Driven Posts: Drive into soil to depth of 30 inches (762 mm) or 36 inches (914 mm) as directed. Protect post top to prevent distortion.

D. Terminal Posts: Install terminal end, corner, and gate posts according to ASTM F567 and terminal pull posts at changes in horizontal or vertical alignment of 15 degrees or more or 30 degrees or more as directed. For runs exceeding 500 feet (152 m), space pull posts an equal distance between corner or end posts.

E. Line Posts: Space line posts uniformly at 96 inches (2440 mm) or 10 feet (3 m) o.c. as directed.

F. Tension Wire: Install according to ASTM F567, maintaining plumb position and alignment of fence posts. Pull wire taut, without sags. Fasten fabric to tension wire with 0.120-inch- (3.05-mm-) diameter hog rings of same material and finish as fabric wire, spaced a maximum of 24 inches (610 mm) o.c. Install tension wire in locations indicated before stretching fabric. Provide horizontal tension wire at the following locations:

1. Extended along top and bottom of fence fabric.

G. Chain-Link Fabric: Apply fabric to outside or inside of enclosing framework as directed. Leave 1-inch (25-mm) or 2-inch (50-mm) bottom clearance between finish grade or surface and bottom selvage unless otherwise indicated. Pull fabric taut and tie to posts, rails, and tension wires. Anchor to framework so fabric remains under tension after pulling force is released.

H. Privacy Slats: Install slats in direction indicated, securely locked in place.

1. Vertically or Horizontally, for privacy factor of 70 to 75 as directed.
2. Diagonally for privacy factor of 80 to 85.
3. Direction and privacy factor as indicated on Drawings.

I. Barbed Wire: Install barbed wire uniformly spaced, angled toward security side of fence as indicated on Drawings. Pull wire taut, install securely to extension arms, and secure to end post or terminal arms.

3.4 ADJUSTING

A. Gates: Adjust gates to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.

B. Lubricate hardware and other moving parts.

END OF SECTION 323113

SECTION 323113.53 - HIGH-SECURITY CHAIN LINK FENCES AND GATES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. High-security chain-link fences.
2. Horizontal-slide, motor-operated gates.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For each type of fence and gate assembly.

1. Include plans, elevations, sections, details, and attachments to other work.

C. Samples: For each exposed product and for each color and texture specified.

D. Delegated-Design Submittal: For structural performance of chain-link fence and gate frameworks, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.4 INFORMATIONAL SUBMITTALS

A. Product certificates.

B. Product test reports.

C. Field quality-control reports.

D. Sample warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 WARRANTY

A. Special Warranty: As directed Manufacturer agrees or Installer agrees to repair or replace components of high-security chain-link fences and gates that fail in materials or workmanship within specified warranty period.

1. Warranty Period: As directed five or 15 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design chain-link fence and gate frameworks.

B. Structural Performance: Chain-link fence and gate frameworks shall withstand the design wind loads and stresses for fence height(s) and under exposure conditions indicated according to ASCE/SEI 7:

1. Design Wind Load: As indicated on Drawings.

a. Minimum Post Size: Determine according to ASTM F1043 for post spacing not to exceed 10 feet (3 m) for Material Group IA, ASTM F1043, Schedule 40 steel pipe or Group IC, electric-resistance-welded round steel pipe as directed.
b. Minimum Post Size and Maximum Spacing: Provide line posts of size and in spacing indicated, but not less than sizes and spacings determined according to CLFMI WLG 2445, based on mesh size and pattern specified.

C. Deflection Limits: Fence deflections shall be within the following limits:

1. Fabric Tension: Maximum 2.5 inches (64 mm) when tested by applying a 30-lbf (133-N) force at midpoint between rails and horizontally between posts for every eighth lower panel along the fence line. Measure fabric movement from the relaxed position at the point where the force is applied.
2. Fence Post Rigidity: Maximum ¾-inch (19 mm) when a 50-lbf (222-N) force is applied at midheight of every eighth post along the fence line. Measure post movement from the relaxed position at the point where the force is applied.

2.2 CHAIN-LINK FENCE FABRIC

A. General: Provide fabric in height measured between top and bottom of outer edge of selvage according to "CLFMI Product Manual" and requirements indicated below:

1. Fabric Height: One piece, as directed.

a. Steel Wire for Fabric: Wire diameter as directed.

1) Mesh Size: As directed.

2. Fabric Heights and Overlap: Two-piece height with lower fabric height as directed and upper fabric height as directed.

    a. Steel Wire Lower Fabric: Wire diameter as directed.

        1) Mesh Size: As directed.

    b. Steel Wire Upper Fabric: Wire diameter of 0.120 inch (3.05 mm).

        1) Mesh Size: 3/8 inch (9.5 mm).

3. Aluminum-Coated Fabric: ASTM A491, Type I, as directed.
4. Zinc-Coated Fabric: As directed ASTM A392, Type II, Class 1, 1.2 oz./sq. ft. (366 g/sq. m) or Class 2, 2.0 oz./sq. ft. (610 g/sq. m) with zinc coating applied before or after weaving.
5. Zn-5Al-MM Aluminum-Mischmetal-Coated Fabric: ASTM F1345, Type III, Class 2, 1.0 oz./sq. ft. (305 g/sq. m).
6. Polymer-Coated Fabric: ASTM F668, Class 2b as directed.

    a. Color: As directed according to ASTM F934.

7. Selvage: Twisted and barbed top and bottom.

2.3 SECURITY FENCE FRAMEWORK

A. Posts and Rails: ASTM F1043 for framework, including rails, braces, and line; terminal; and corner posts.

1. Fence Height: 96 inches (2440 mm) or 12 feet (3.66 m) as directed.
2. Heavy-Industrial-Strength Material: Group IA, round steel pipe, Schedule 40 or Group IC, round steel pipe, electric-resistance-welded pipe as directed.

    a. Line Post: As directed.
    b. End, Corner, and Pull Posts: As directed.

3. Rail Members: Intermediate, top, bottom and brace rails according to ASTM F1043 for Heavy Industrial.
4. Metallic Coating for Steel Framework:

    a. Type A, zinc coating.
    b. Type B, zinc with organic overcoat.
    c. External, Type B, zinc with organic overcoat and internal, Type D zinc-pigmented coating.
    d. Type C, Zn-5-Al-MM alloy coating.
    e. Coatings: Any coating above.

5. Polymer coating over metallic coating.

    a. Color: As directed according to ASTM F934.

2.4 TENSION WIRE

A. Metallic-Coated Steel Wire: 0.177-inch- (4.5-mm-) diameter, marcelled tension wire according to ASTM A817 or ASTM A824, with the following metallic coating:

1. Type I: Aluminum coated (aluminized).
2. Type II: Zinc coated (galvanized) with Class 5 minimum coating weight of not less than 2.0 oz./sq. ft. (610 g/sq. m) of uncoated wire surface.

B. Polymer-Coated Steel Wire: 0.177-inch- (4.5-mm-diameter, tension wire according to ASTM F1664, Class 2b as directed over -coated steel wire.

1. Color: As directed according to ASTM F934.

2.5 HORIZONTAL-SLIDE GATES

A. General: ASTM F1184 for gate posts and single or double sliding gate types as directed. Provide automated vehicular gates according to ASTM F2200.

1. Classification: Type I Overhead Slide.
2. Classification: Type II Cantilever Slide, Class 1 with external or Class 2 with internal roller assemblies as directed.

B. Pipe and Tubing:

1. Zinc-Coated Steel: Protective coating and finish to match fence framework or Manufacturer's standard protective coating and finish as directed.
2. Aluminum: ASTM B429/B429M; mill or manufacturer's standard finish as directed.
3. Gate Posts: ASTM F1184 Provide posts as directed.
4. Gate Frames and Bracing: As directed.

C. Frame Corner Construction: Welded or assembled with corner fittings and 3/8-inch- (9.5-mm-) diameter, adjustable truss rods for panels 60 inches (1520 mm) or wider.

D. Extended Gate Posts and Frame Members: Extend gate posts and frame end members above top of chain-link fabric at both ends of gate frame 12 inches (300 mm) as required to attach barbed wire or tape assemblies as directed.

2.6 FITTINGS

A. Provide fittings according to ASTM F626.

B. Barbed Wire Arms: Pressed steel or cast iron or Aluminum as directed, with clips, slots, or other means for attaching strands of barbed wire, and means for attaching to posts, integral with post cap, for each post unless otherwise indicated, and as follows:

1. Provide line posts with arms that accommodate top rail or tension wire.
2. Provide corner arms at fence corner posts unless extended posts are indicated.
3. Single-Arm Type: Type I, slanted arm Type II, vertical arm as directed.
4. Double-Arm Type: Type III, V-shaped arm or Type IV, A-shaped arm as directed.

5. Use bolts or rivets for connection to posts.

C. Power-Driven Fabric Fasteners: As recommended in writing by manufacturer.

D. Finish:

1. Metallic Coating for Pressed Steel or Cast Iron: Not less than 1.2 oz. /sq. ft. (366 g/sq. m) of zinc.

a. Polymer coating over metallic coating.

2. Aluminum: Mill finish.

2.7 BARBED WIRE

A. Steel Barbed Wire: ASTM A121, High Security Grade, two-strand barbed wire; 0.099-inch- (2.51-mm-) diameter line wire with 0.080-inch- (2.03-mm-) diameter, four-point round barbs spaced not more than 3 inches (76 mm) o.c.

1. Aluminum Coating: Type A.

B. Polymer-Coated, Galvanized-Steel Barbed Wire: ASTM F1665, Type II, two-strand barbed wire; 0.080-inch- (2.03-mm-) diameter line wire with 0.080-inch- (2.03-mm-) diameter, four-point, round aluminum-alloy or galvanized-steel barbs spaced not more than 3 inches (76 mm) o.c. as directed.

1. Polymer Coating: As directed class 2b over coated steel wire.

a. Color: As directed according to ASTM F934.

2.8 BARBED TAPE

A. Wire-Reinforced Tape: ASTM F1910; continuous coil with four-point, needle-sharp barbs permanently cold clenched around a core wire.

1. Core Wire: High-tensile-strength, zinc-coated steel or stainless steel.
2. Configuration: Single or Double coil as directed.
3. Style: Helical or Concertina pattern as directed.
4. Coil Diameter(s): As directed.
5. Barb Length Classification: As directed.
6. Barb Spacing: 4 inches (102 mm) o.c.

B. Clips and Tie Wires: Stainless steel.

C. Ground-Barrier Stakes: 3/8-inch- (9.5-mm-) diameter galvanized reinforcing bar, 18 inches (457 mm) long with 180-degree end hook 3-1/2 inches (89 mm) long.

2.9 GATE OPERATORS

A. Operators: Factory-assembled, automatic gate-operating system designed for gate size, type, weight, and frequency of use. Control system shall have characteristics suitable for Project conditions, with control stations, safety devices, and weatherproof enclosures.

1. Operator design shall allow for removal of cover or motor without disturbing limit-switch adjustment and without affecting auxiliary emergency operation.
2. Electronic components shall have built-in troubleshooting diagnostic feature.
3. Unit shall be designed and wired for both right-hand/left-hand opening, permitting universal installation.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. UL Standard: Manufacture and label gate operators according to UL 325.

D. Motors: Comply with NEMA MG 1.

1. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet (1000 m) above sea level.
2. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
3. Service Factor: 1.15.
4. Electrical Characteristics:

    a. Horsepower: As directed.
    b. Voltage: As directed, single phase, 60 hertz.
    c. Voltage: As directed, three phase, 60 hertz.

E. Hydraulic Slide Gate Operators:

1. Duty: Medium or Heavy as directed.
2. Gate Speed: Minimum 45 feet (13.7 m) or 60 feet (18.2 m) per minute as directed.
3. Maximum Gate Weight: 800 lb (363 kg).
4. Frequency of Use: As directed.

F. Controls: As directed.

2.10 GROUT AND ANCHORING CEMENT

A. Non-shrink, Nonmetallic Grout: Factory-packaged, non-staining, noncorrosive, nongaseous grout complying with ASTM C1107/C1107M. Provide grout, recommended in writing by manufacturer, for exterior applications.

B. Anchoring Cement: Factory-packaged, non-shrink, non-staining, hydraulic-controlled expansion cement formulation for mixing with water at Project site to create pourable anchoring, patching, and grouting compound. Provide formulation that is resistant to erosion

from water exposure without needing protection by a sealer or waterproof coating, and that is recommended in writing by manufacturer for exterior applications.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Do not begin installation before final grading is completed unless otherwise permitted by Architect.

3.2 PREPARATION

A. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of 500 feet (152 m) or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

3.3 CHAIN-LINK FENCE INSTALLATION

A. Install chain-link fencing according to ASTM F567 and more stringent requirements specified.

B. Post Excavation: Drill or hand-excavate holes for posts to diameters and spacings indicated, in firm, undisturbed soil.

C. Post Setting: Set posts in concrete or with mechanical anchors at indicated spacing into firm, undisturbed soil.

1. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.
2. Concrete Fill: Place concrete around posts to dimensions indicated and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.

    a. Exposed Concrete: Extend 2 inches (50 mm) above grade or to same elevation as concrete grade beam; shape and smooth to shed water.
    b. Concealed Concrete: Place top of concrete 2 inches (50 mm) below grade to allow covering with surface material.
    c. Posts Set into Sleeves in Concrete: Use steel pipe sleeves preset and anchored into concrete for installing posts. After posts are inserted into sleeves, fill annular space between post and sleeve with non-shrink, nonmetallic grout or anchoring cement, mixed and placed according to anchoring material manufacturer's written instructions. Finish anchorage joint to slope away from post to drain water.
    d. Posts Set into Holes in Concrete: Form or core drill holes not less than 5 inches (127 mm) deep and 3/4 inch (19 mm) larger than OD of post. Clean holes of loose material, insert posts, and fill annular space between post and concrete with non-shrink, nonmetallic grout or anchoring cement, mixed and placed according to anchoring material manufacturer's written instructions. Finish anchorage joint to slope away from post to drain water.

D. Terminal Posts: Install terminal end, corner, and gate posts according to ASTM F567 and terminal pull posts at changes in horizontal or vertical alignment of 15 degrees or more, at any abrupt change in grade, and at intervals not greater than 500 feet (152 m). For runs exceeding 500 feet (152 m), space pull posts an equal distance between corner or end posts.

E. Line Posts: Space line posts uniformly at 96 inches (2440 mm) or 10 feet (3 m) o.c. as directed.

F. Barbed Wire Arms: Bolt or rivet to top of post. Angle single arms away from approach side of fence.

G. Tension Wire: Install according to ASTM F567, maintaining plumb position and alignment of fence posts. Provide horizontal tension wire at the following locations:

1. Extended along top and bottom of fence fabric.
2. Extended along top of barbed wire arms or extended posts and top of fence fabric to support barbed tape as directed.

H. Bottom Rails: Secure to posts with fittings; anchor rail at midspan to concrete footing or continuous grade beam as directed.

I. Chain-Link Fabric: Apply fabric on the approach side of fence, inside of enclosing framework. Pull fabric taut and tie to posts, rails, and tension wires. Anchor to framework so fabric remains under tension after pulling force is released.

1. Overlapping Fabric: Overlap ends of fence fabric at or between posts or rails; overlap 6 inches (152 mm) and secure with wire ties or steel strap method.
2. Bottom Clearance: Leave 1-1/2 inches (38 mm) or 2 inches (50 mm) between finish grade or surface and bottom selvage unless otherwise indicated.
3. Buried Fabric: Where indicated, bury the bottom 12 inches (300 mm) of a continuous 18-inch- (457-mm-) wide or 24 inches (610 mm) of a continuous 30-inch- (762-mm-) wide, polymer-coated chain-link fabric in a vertical trench below the fencing; overlap above-grade fence fabric 6 inches (152 mm) and secure to bottom rail with tie wires. Backfill and compact trench.

J. Power-Fastening of Fabric: Fasten 0.192- or 0.148-inch (4.87- or 3.76-mm) wire fabric with 2- or 1-inch (50- or 25-mm) mesh size. Fasten fabric to line posts 12 inches (300 mm) o.c. and to braces 24 inches (610 mm) o.c.

K. Fasteners: Install nuts for tension bands and carriage bolts on the side of fence opposite the fabric side. Peen ends of bolts or score threads to prevent removal of nuts.

L. Barbed Wire: Install barbed wire uniformly spaced, angled toward security side of fence as indicated on Drawings. Pull wire taut, install securely to extension arms, and secure to end post or terminal arms.

M. Barbed Tape: Install according to ASTM F1911. Install barbed tape uniformly in configurations indicated and fasten securely to prevent movement or displacement.

N. Ground-Barrier Stakes: Stake barbed-tape coils at 10 feet (3 m) o.c., driven into ground to full depth.

3.4 GATE-OPERATOR INSTALLATION

A. Ground electric-powered motors, controls, and other devices according to NFPA 70 and manufacturer's written instructions.

3.5 ADJUSTING

A. Gates: Adjust gates to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.

B. Automatic Gate Operator: Energize circuits to electrical equipment and devices, start units, and verify proper motor rotation and unit operation.

1. Hydraulic Operator: Purge operating system, adjust pressure and fluid levels, and check for leaks.
2. Test and adjust operator, controls, alarms, and safety devices. Replace damaged and malfunctioning controls and equipment.
3. Lubricate operator and related components.

C. Lubricate hardware and other moving parts.

END OF SECTION 323113.53

SECTION 323116 - WELDED WIRE FENCES AND GATES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metallic-coated-steel, welded-wire fences.
2. Swing gates.
3. Gate operators, including controls.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For fencing and gates.

1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power, signal, and control wiring.

C. Samples: For each fence material and for each color specified.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Fabricator of products.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Wind Loading: Comply with ASCE/SEI 7 requirements for fence height, wind exposure category, design wind speed, and design wind pressure.

B. Lightning-Protection System: Maximum grounding-resistance value of 25 ohms under normal dry conditions.

2.2 METALLIC-COATED-STEEL, WELDED-WIRE FENCES

A. Metallic-Coated-Steel, Welded-Wire Fences:

B. Fence Fabric: Metallic-coated-steel wire.

1. Spacing of Vertical Wires: As directed.
2. Vertical Wire Size: As directed.
3. Spacing of Horizontal Wires: As directed.
4. Horizontal Wire Size: As directed.

C. Posts:

1. Line Posts: As directed.
2. End and Corner Posts: As directed.

D. Post Caps: As directed.

E. Rails: Rectangular tubes.

1. Size: 1-3/16 by 1-1/2 inches (30 by 38 mm), 1-3/8 by 1-1/2 inches (35 by 38 mm) or 1-1/2 by 1-1/2 inches (38 by 38 mm) as directed.
2. Metal and Thickness: 0.064-inch (1.63-mm) or 0.079-inch (2.01-mm) nominal-thickness, metallic-coated steel sheet or 0.060-inch (1.52-mm) or 0.075-inch (1.90-mm) nominal-thickness, uncoated steel sheet, hot-dip galvanized after fabrication as directed.

F. Finish: Organic coating complying with requirements in ASTM F2408 or Powder coating as directed.

2.3 SWING GATES

A. Galvanized-Steel Frames and Bracing: Fabricate members from square tubes as directed. Formed from 0.108-inch (2.74-mm) nominal-thickness, metallic-coated steel sheet or formed from 0.105-inch (2.66-mm) nominal-thickness steel sheet and hot-dip galvanized after fabrication.

B. Infill: Welded-wire fence fabric matching adjacent fence.

C. Hardware: Latches permitting operation from both sides of gate, hinges, and keepers for each gate leaf more than 5 feet (1.52 m) wide. Provide center gate stops and cane bolts for pairs of gates as directed. Fabricate latches with integral eye openings for padlocking; padlock accessible from both sides of gate.

D. Metallic-Coated-Steel Finish: High-performance coating or Galvanized finish as directed.

2.4 GATE OPERATORS

A. Gate Operators:

B. Provide factory-assembled automatic operating system designed for gate size, type, weight, and operation frequency. Provide operation control system with characteristics suitable for Project conditions, with remote-control stations, safety devices, and weatherproof enclosures; coordinate electrical requirements with building electrical system.

1. Provide operator with UL approval or -approved components as directed.

C. Comply with NFPA 70.

D. UL Standard: Manufacturer and label gate operators to comply with UL 325.

E. Motor Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, within installed environment, with indicated operating sequence, and without exceeding nameplate rating or considering service factor. Comply with NEMA MG 1 and the following:

1. Voltage: As directed.
2. Duty: Continuous duty at ambient temperature of 105 deg F (40 deg C) and at altitude of 3300 feet (1005 m) above sea level.
3. Service Factor: 1.15 for open drip proof motors; 1.0 for totally enclosed motors.
4. Phase: One or Polyphase as directed.

F. Gate Operators: As directed:

1. Hydraulic Gate Operators:

a. Duty: As directed.
b. Maximum Gate Weight: 800 lb (363 kg).
c. Frequency of Use: As directed.

2. Mechanical Gate Operators:

a. Duty: As directed.
b. Maximum Gate Weight: As directed.
c. Frequency of Use: As directed.

G. Remote Controls: Electric controls separated from gate and motor and drive mechanism, with NEMA ICS 6, Type 1 or NEMA ICS 6, Type 4 enclosure for surface, recessed or flush, concrete base or pedestal mounting as directed, and with space for additional optional equipment. Provide the following remote-control device(s):

1. Control Station: As directed keyed, two or three-position switch with open, stop, and close function; located remotely from gate. Provide two keys per station.
2. Control Station: As directed momentary-contact, single or three-button-operated with open, stop, and close function; located remotely from gate. Key switch to lock out open and close buttons.
3. Card Reader: As directed functions only when authorized card is presented. Programmable, multiple or single-code system, permitting four different access periods; face-lighted unit fully visible at night.

    a. Reader Type: As directed.

4. Digital Keypad Entry Unit: Programmable, multiple-code capability.
5. Radio Control: Digital system consisting of code-compatible universal receiver for each gate. Provide one or two programmable transmitter(s) as directed.
6. Telephone Entry System: Hands-free, voice-communication system for connection to building telephone system with digital-entry code activation of gate operator and auxiliary keypad entry.

H. Vehicle Loop Detector: System includes automatic closing timer with adjustable time delay, timer cutoff switch, and loop detector designed to open and close gate, hold gate open until traffic clears or reverse gate as directed.

I. Vehicle Presence Detector: System includes automatic closing timer with adjustable time delay, timer cutoff switch, and presence detector designed to open and close gate, hold gate open until traffic clears or reverse gate as directed.

J. Obstruction Detection Devices: Provide each motorized gate with automatic safety sensor(s). Activation of sensor(s) causes operator to immediately stop gate in opening cycle and reverse gate in closing cycle, and hold until clear of obstruction.

K. Accessories:

1. Warning Module: As directed Audio Visual, constant strobe-light alarm sounding three to five seconds in advance of gate operation and continuing until gate stops moving; compliant with the United States Access Board's ADA-ABA Accessibility Guidelines.
2. Battery Backup System: Battery-powered drive and access-control system, independent of primary drive system.
3. Intercom System: As directed.
4. Instructional, Safety, and Warning Labels and Signs: According to UL 325 or as directed.

2.5 FENCE AND GATE MATERIALS

A. Metallic-Coated-Steel Wire: Welded-wire fence fabric, hot-dip galvanized after fabrication. Weight of zinc coating shall be not less than 1.0 oz./sq. ft. (305 g/sq. m).

B. Uncoated Steel Sheet: Hot-rolled steel sheet, ASTM A1011/A1011M, Structural Steel, Grade 45 (Grade 310) or cold-rolled steel sheet, ASTM A1008/A1008M, Structural Steel, Grade 50 (Grade 340).

C. Metallic-Coated Steel Sheet: Galvanized-steel sheet or aluminum-zinc, alloy-coated steel sheet.

D. Galvanized-Steel Sheet: ASTM A653/A653M, structural quality, Grade 50 (Grade 340), with G90 (Z275) or G60 (Z180) coating as directed.

E. Aluminum-Zinc, Alloy-Coated Steel Sheet: ASTM A792/A792M, structural quality, Grade 50 (Grade 340), with AZ60 (AZM180) coating.

F. Galvanizing: For components indicated to be galvanized and for which galvanized coating is unspecified, hot-dip galvanize to comply with ASTM A123/A123M. For hardware items, hot-dip galvanize to comply with ASTM A153/A153M.

2.6 COATING MATERIALS

A. Epoxy Primer for Galvanized Steel: Epoxy primer recommended in writing by topcoat manufacturer.

1. Products: As directed

B. Polyurethane Intermediate Coat and Topcoat: Complying with MPI #72 and compatible with undercoat.

1. Products: As directed.

2.7 MISCELLANEOUS MATERIALS

A. Concrete: Normal-weight, air-entrained, ready-mix concrete complying with requirements in Section 033000 "Cast-in-Place Concrete" with a minimum 28-day compressive strength of 3000 psi (20 MPa), 3-inch (75-mm) slump, and 1-inch (25-mm) maximum aggregate size or dry, packaged, normal-weight concrete mix complying with ASTM C387/C387M mixed with potable water according to manufacturer's written instructions.

2.8 GROUNDING MATERIALS

A. Comply with requirements of Section 260526 "Grounding and Bonding for Electrical Systems."

B. Grounding Conductors: Size as indicated on Drawings. Bare, solid wire for No. 6 AWG and smaller; stranded wire for No. 4 AWG and larger.

1. Material above Finished Grade: Copper or Aluminum as directed.
2. Material on or below Finished Grade: Copper.
3. Bonding Jumpers: Braided copper tape, 1-5/8 inch (41 mm) wide and 1/16 inch (1.6 mm) thick, woven of No. 30 AWG bare copper wire, terminated with copper ferrules.

C. Grounding Connectors and Grounding Rods: Comply with UL 467.

2.9 METALLIC-COATED-STEEL FINISHES

A. Galvanized Finish: Clean welds, mechanical connections, and abraded areas and repair galvanizing to comply with ASTM A780/A780M.

B. Surface Preparation: Clean surfaces of oil and other contaminants. Use cleaning methods that do not leave residue. After cleaning, apply a zinc-phosphate conversion coating compatible with the organic coating to be applied over it. Clean welds, mechanical connections, and abraded areas and apply galvanizing repair paint, complying with SSPC-Paint 20, to comply with ASTM A780/A780M.

C. Powder Coating: Epoxy prime coat and TGIC polyester topcoat to a minimum dry film thickness of 2 mils (0.05 mm). Comply with coating manufacturer's written instructions to achieve a minimum total dry film thickness of 4 mils (0.10 mm).

1. Color and Gloss: As directed.
2. Comply with surface finish testing requirements in ASTM F2408.

D. High-Performance Coating: Apply epoxy primer, polyurethane intermediate coat, and polyurethane topcoat to prepared surfaces. Apply at spreading rates recommended by coating manufacturer.

1. Match approved Samples for color, texture, and coverage. Remove and refinish, or recoat work that does not comply with specified requirements.

PART 3 - EXECUTION

3.1 FENCE INSTALLATION

A. Install fences according to manufacturer's written instructions.

B. Install fences by setting posts as indicated and fastening rails and infill panels to posts. Peen threads of bolts after assembly to prevent removal.

C. Post Excavation: Drill or hand-excavate holes for posts in firm, undisturbed soil. Excavate holes to a diameter of not less than 4 times post size and a depth of not less than 24 inches (600 mm) plus 3 inches (75 mm) for each foot (300 mm) or fraction of a foot (300 mm) that fence height exceeds 4 feet (1.2 m).

D. Post Setting: Set posts in concrete with mechanical anchors by mechanically driving into soil at indicated spacing into firm, undisturbed soil.

1. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.
2. Concrete Fill: Place concrete around posts and sleeves and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.
3. Posts Set in Concrete: Extend post to within 6 inches (150 mm) of specified excavation depth, but not closer than 3 inches (75 mm) to bottom of concrete.

4. Mechanically Driven Posts: Drive into soil to depth of 30 inches (762 mm) or 36 inches (914 mm) as directed. Protect post top to prevent distortion.
5. Space posts uniformly at 6 feet (1.83 m) or 8 feet (2.44 m) o.c. as directed

3.2 GATE INSTALLATION

A. Install gates according to manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach hardware using tamper-resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate where necessary.

3.3 GATE OPERATOR INSTALLATION

A. General: Install gate operators according to manufacturer's written instructions, aligned and true to fence line and grade.

B. Excavation for Support Posts, Pedestals or Concrete Bases as directed: Hand-excavate holes for bases in firm, undisturbed soil to dimensions and depths and at locations as required by gate operator component manufacturer's written instructions and as indicated.

C. Concrete Bases: Cast-in-place or precast concrete, depth not less than 12 inches (300 mm), dimensioned and reinforced according to gate operator component manufacturer's written instructions and as indicated on Drawings.

D. Vehicle Loop Detector System: Cut grooves in pavement and bury and seal wire loop according to manufacturer's written instructions. Connect to equipment operated by detector.

E. Comply with NFPA 70 and manufacturer's written instructions for grounding of electric-powered motors, controls, and other devices.

3.4 GROUNDING AND BONDING

A. Comply with Section 260526 "Grounding and Bonding for Electrical Systems."

B. Fence Grounding: Install at maximum intervals of 1500 feet (450 m) except as follows:

1. Fences within 100 Feet (30 m) of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of 750 feet (225 m).

    a. Gates and Other Fence Openings: Ground fence on each side of opening. Bond metal gates to gate posts.

C. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is 6 inches (150 mm) below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at grounding location.

D. Bonding Method for Gates: Connect bonding jumper between gate post and gate frame.

E. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.

F. Bonding to Lightning-Protection System: If fence terminates at lightning-protected building or structure, ground the fence and bond the fence grounding conductor to lightning-protection down conductor or lightning-protection grounding conductor, complying with NFPA 780.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage or Engage a qualified testing agency to perform tests and inspections as directed.

1. Grounding-Resistance Tests: Subject completed grounding system to a megger test at each grounding location. Measure grounding resistance not less than two full days after last trace of precipitation, without soil having been moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural grounding resistance. Perform tests by two-point method according to IEEE 81.

END OF SECTION 323116

SECTION 323119 - DECORATIVE METAL FENCES AND GATES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Decorative metallic-coated-steel tubular picket fences.
2. Decorative steel fences.
3. Decorative aluminum fences.
4. Swing gates.
5. Gate operators, including controls.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For fencing and gates.

1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power, signal, and control wiring.

C. Samples: For each fence material and for each color specified.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Product test reports.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Fabricator of products.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Wind Loading: Comply with ASCE/SEI 7 requirements for fence height, wind exposure, design wind speed, and design wind pressure.

B. Lightning-Protection System: Maximum grounding-resistance value of 25 ohms under normal dry conditions.

2.2 DECORATIVE METALLIC-COATED-STEEL TUBULAR PICKET FENCES

A. Decorative Metallic-Coated-Steel Tubular Picket Fences: As directed comply with ASTM F2408 for residential, light-industrial (commercial) or industrial application (class) unless otherwise indicated.

B. Post Caps: As directed.

C. Pickets: Square tubes.
1. Picket Spacing: As directed.

D. Metallic-Coated Steel Sheet: Galvanized-steel sheet or aluminum-zinc, alloy-coated steel sheet.

E. Finish: Organic coating complying with requirements in ASTM F2408 or Powder coating as directed.

2.3 DECORATIVE STEEL FENCES

A. Decorative Steel Fences: Fences made from steel tubing bars and shapes, hot-dip galvanized.

B. Posts: Square steel tubing. As directed.

C. Post Caps: As directed.

D. Rails:

1. Steel Tube Rails: Square steel tubing as directed.
2. Steel Channel Rails: Steel channels as directed.

E. Pickets: As directed.

1. Picket Spacing: As directed.

F. Infill: Forge-welded-steel bar grating.

1. Perimeter Bars: Steel flat bars 1 by 1/8 inch (25 by 3.2 mm).
2. Vertical Main Bars: Steel flat bars 1 by 1/8 inch (25 by 3.2 mm) or 1-3/16 by 5/32 inch (30 by 4 mm) as directed.
3. Vertical Main Bar Spacing: As directed.

4. Horizontal Cross Rods: 3/16-inch- (4.8-mm-) or 1/4-inch- (6.4-mm-) diameter, steel rods as directed.
5. Horizontal Cross Rod Spacing: As directed.

G. Fasteners: Stainless-steel carriage bolts and tamperproof nuts.

H. Fabrication: Assemble fences into sections by welding pickets to rails.

I. Fabrication: Fabricate bar grating infill into sections of size indicated.

J. Galvanizing: For items other than hardware that are indicated to be galvanized, hot-dip galvanize to comply with ASTM A123/A123M. For hardware items, hot-dip galvanize to comply with ASTM A153/A153M.

1. Hot-dip galvanize posts and rails.
2. Hot-dip galvanize rail and picket assemblies after fabrication.
3. Hot-dip galvanize bar grating infill after fabrication.

K. Finish for Bar Grating Infill: Powder coating.

L. Finish for Steel Items Other Than Bar Grating Infill: As directed.

M. Finish for Metallic-Coated-Steel Items Other Than Bar Grating Infill: High-performance coating or Galvanized finish as directed.

2.4 DECORATIVE ALUMINUM FENCES

A. Decorative Aluminum Fences: Fences made from aluminum extrusions.

B. Posts: Square extruded tubes as directed.

C. Post Caps: Aluminum castings with round ball finial.

D. Rails: Extruded-aluminum channels, as directed.

E. Pickets: Extruded-aluminum tubes, as directed.

1. Picket Spacing: As directed.

F. Fasteners: Manufacturer's standard tamperproof, corrosion-resistant, color-coated fasteners matching fence components with resilient polymer washers.

G. Fabrication: Assemble fences into sections by welding or fastening pickets to rails as directed.

H. Finish: Baked enamel or powder coating.

2.5 SWING GATES

A. Galvanized-Steel Frames and Bracing: As directed fabricate members from square tubes 1-1/2 by 1-1/2 inches (38 by 38 mm), 1-3/4 by 1-3/4 inches (45 by 45 mm), 2 by 2 inches (51 by 51

mm) or 2-1/2 by 2-1/2 inches (64 by 64 mm) formed from 0.108-inch (2.74-mm) nominal-thickness, metallic-coated steel sheet or formed from 0.105-inch (2.66-mm) nominal-thickness steel sheet and hot-dip galvanized after fabrication.

B. Steel Frames and Bracing: As directed fabricate members from square steel tubing 1-1/2 by 1-1/2 inches (38 by 38 mm), 2 by 2 inches (51 by 51 mm) or 2-1/2 by 2-1/2 inches (64 by 64 mm) with 1/8-inch (3.2-mm) wall thickness. Hot-dip galvanize frames after fabrication.

C. Aluminum Frames and Bracing: Fabricate members from square extruded-aluminum tubes as directed.

D. Hardware: Latches permitting operation from both sides of gate, hinges, and keepers for each gate leaf more than 5 feet (1.52 m) wide. Provide center gate stops and cane bolts for pairs of gates. Fabricate latches with integral eye openings for padlocking; padlock accessible from both sides of gate.

E. Galvanizing: For items other than hardware that are indicated to be galvanized, hot-dip galvanize to comply with ASTM A123/A123M. For hardware items, hot-dip galvanize to comply with ASTM A153/A153M.

F. Metallic-Coated-Steel Finish: High-performance coating or Galvanized finish.

G. Steel Finish: As directed.

H. Aluminum Finish: Baked enamel or powder coating.

2.6 GATE OPERATORS

A. Gate Operators:

B. Provide factory-assembled automatic operating system designed for gate size, type, weight, and operation frequency. Provide operation control system with characteristics suitable for Project conditions, with remote-control stations, safety devices, and weatherproof enclosures; coordinate electrical requirements with building electrical system.

1. Provide operator with UL approval or -approved components as directed.

C. Comply with NFPA 70.

D. UL Standard: Manufacturer and label gate operators to comply with UL 325.

E. Motor Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, within installed environment, with indicated operating sequence, and without exceeding nameplate rating or considering service factor. Comply with NEMA MG 1 and the following:

1. Voltage: As directed.
2. Duty: Continuous duty at ambient temperature of 105 deg F (40 deg C) and at altitude of 3300 feet (1005 m) above sea level.
3. Service Factor: 1.15 for open drip-proof motors; 1.0 for totally enclosed motors.
4. Phase: One or Polyphase as directed.

F. Gate Operators: As directed:

1. Hydraulic Gate Operators:

   a. Duty: Light, Medium or Heavy duty, residential or commercial/industrial as directed.
   b. Maximum Gate Weight: 800 lb (363 kg).
   c. Frequency of Use: As directed.

2. Mechanical Gate Operators:

   a. Duty: Light, Medium or Heavy duty, residential or commercial/industrial as directed.
   b. Maximum Gate Weight: As directed.
   c. Frequency of Use: As directed.

G. Remote Controls: As directed electric controls separated from gate and motor and drive mechanism, with NEMA ICS 6, Type 1 or NEMA ICS 6, Type 4 enclosure for surface, recessed or flush, concrete base or pedestal mounting, and with space for additional optional equipment. Provide the following remote-control device(s):

1. Control Station: As directed keyed, two or three-position switch with open, stop, and close function; located remotely from gate. Provide two keys per station.
2. Control Station: As directed momentary-contact, single or three-button-operated with open, stop, and close function; located remotely from gate. Key switch to lock out open and close buttons.
3. Card Reader: Functions only when authorized card is presented. As directed programmable, multiple or single-code system, permitting four different access periods; face-lighted unit fully visible at night.

   a. Reader Type: As directed.

4. Digital Keypad Entry Unit: Programmable, multiple-code capability.
5. Radio Control: Digital system consisting of code-compatible universal receiver for each gate, located where indicated, with remote antenna with coaxial cable and mounting brackets designed to operate gates. As directed provide one or two programmable transmitter(s).
6. Telephone Entry System: Hands-free, voice-communication system for connection to building telephone system with digital-entry code activation of gate operator.

H. Vehicle Loop Detector: System includes automatic closing timer with adjustable time delay, timer cutoff switch, and loop detector designed to open and close gate, hold gate open until traffic clears or reverse gate as directed.

I. Vehicle Presence Detector: System includes automatic closing timer with adjustable time delay, timer cutoff switch, and presence detector designed to open and close gate, hold gate open until traffic clears or reverse gate as directed.

J. Obstruction Detection Devices: Provide each motorized gate with automatic safety sensor(s). Activation of sensor(s) causes operator to immediately stop gate in opening cycle and reverse gate in closing cycle, and hold until clear of obstruction.

K. Accessories:

1. Warning Module: As directed Audio Visual, constant or strobe-light alarm sounding three to five seconds in advance of gate operation and continuing until gate stops moving; compliant with the United States Access Board's ADA-ABA Accessibility Guidelines.
2. Battery Backup System: Battery-powered drive and access-control system, independent of primary drive system.
3. Intercom System: As directed.
4. Instructional, Safety, and Warning Labels and Signs: According to UL 325 or as directed.

2.7 ALUMINUM

A. Extrusions: ASTM B221 (ASTM B221M), Alloy 6063-T5.

B. Tubing: ASTM B429/B429M, Alloy 6063-T6.

C. Castings: ASTM B26/B26M, Alloy A356.0-T6.

2.8 STEEL AND IRON

A. Plates, Shapes, and Bars: ASTM A36/A36M.

B. Bars (Pickets): Hot-rolled, carbon steel complying with ASTM A29/A29M, Grade 1010.

C. Tubing: ASTM A500/A500M, cold-formed steel tubing.

D. Bar Grating: NAAMM MBG 531.

E. Uncoated Steel Sheet: Hot-rolled steel sheet, ASTM A1011/A1011M, Structural Steel, Grade 45 (Grade 310) or cold-rolled steel sheet, ASTM A1008/A1008M, Structural Steel, Grade 50 (Grade 340) as directed.

F. Galvanized-Steel Sheet: ASTM A653/A653M, structural quality, Grade 50 (Grade 340), with G90 (Z275) or G60 (Z180) coating as directed.

G. Aluminum-Zinc, Alloy-Coated Steel Sheet: ASTM A792/A792M, structural quality, Grade 50 (Grade 340), with AZ60 (AZM180) coating.

2.9 COATING MATERIALS

A. Epoxy Zinc-Rich Primer for Uncoated Steel: Complying with MPI #20 and compatible with coating specified to be applied over it.

B. Epoxy Primer for Galvanized Steel: Epoxy primer recommended in writing by topcoat manufacturer.

C. Intermediate Coat for Uncoated Steel: Epoxy or polyurethane intermediate recommended in writing by primer and topcoat manufacturer.

D. Polyurethane Intermediate Coat and Topcoat: Complying with MPI #72 and compatible with undercoat.

2.10 MISCELLANEOUS MATERIALS

A. Concrete: Normal-weight, air-entrained, ready-mix concrete complying with requirements in Section 033000 "Cast-in-Place Concrete" with a minimum 28-day compressive strength of 3000 psi (20 MPa), 3-inch (75-mm) slump, and 1-inch (25-mm) maximum aggregate size or dry, packaged, normal-weight concrete mix complying with ASTM C387/C387M mixed with potable water according to manufacturer's written instructions.

2.11 GROUNDING MATERIALS

A. Comply with requirements of Section 260526 "Grounding and Bonding for Electrical Systems."

B. Grounding Conductors: Size as indicated on Drawings. Bare, solid wire for No. 6 AWG and smaller; stranded wire for No. 4 AWG and larger.

1. Material above Finished Grade: Copper or Aluminum as directed.
2. Material on or below Finished Grade: Copper.

C. Grounding Connectors and Grounding Rods: Comply with UL 467.

2.12 ALUMINUM FINISHES

A. Baked-Enamel or Powder-Coat Finish: AAMA 2603 except with a minimum dry film thickness of 2 mils (0.05 mm). Comply with coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.

1. Color and Gloss: As directed.

2.13 STEEL FINISHES

A. Surface Preparation: Clean surfaces according to SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning." Or SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning" as directed. After cleaning, apply a conversion coating compatible with the organic coating to be applied over it.

B. Powder Coating: Immediately after cleaning, apply manufacturer's standard two-coat finish consisting of epoxy primer and TGIC polyester topcoat to a minimum total dry film thickness of not less than 8 mils (0.20 mm). Comply with coating manufacturer's written instructions.

1. Color and Gloss: As directed.

C. Primer Application: Apply zinc-rich epoxy primer immediately after cleaning, to provide a minimum dry film thickness of 2 mils (0.05 mm) per applied coat, to surfaces that are exposed after assembly and installation, and to concealed surfaces.

D. High-Performance Coating: Apply intermediate and polyurethane topcoats to prime-coated surfaces. Comply with coating manufacturer's written instructions and with requirements in SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting. Apply at spreading rates recommended by coating manufacturer.

1. Match approved Samples for color, texture, and coverage. Remove and refinish, or recoat work that does not comply with specified requirements.

2.14 METALLIC-COATED-STEEL FINISHES

A. Galvanized Finish: Clean welds, mechanical connections, and abraded areas and repair galvanizing to comply with ASTM A780/A780M.

B. Surface Preparation: Clean surfaces of oil and other contaminants. Use cleaning methods that do not leave residue. After cleaning, apply a zinc-phosphate conversion coating compatible with the organic coating to be applied over it. Clean welds, mechanical connections, and abraded areas and apply galvanizing repair paint, complying with SSPC-Paint 20, to comply with ASTM A780/A780M.

C. Powder Coating: Immediately after cleaning and pretreating, apply manufacturer's standard TGIC polyester powder-coat finish to a minimum dry film thickness of 2 mils (0.05 mm).

1. Color and Gloss: As directed.

D. Powder Coating: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat finish consisting of zinc-rich epoxy prime coat and TGIC polyester topcoat to a minimum dry film thickness of 2 mils (0.05 mm). Comply with coating manufacturer's written instructions to achieve a minimum total dry film thickness of 4 mils (0.10 mm).

1. Color and Gloss: As directed.

E. High-Performance Coating: Apply epoxy primer, polyurethane intermediate coat, and polyurethane topcoat to prepared surfaces. Comply with coating manufacturer's written instructions and with requirements in SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting. Apply at spreading rates recommended by coating manufacturer.

1. Match approved Samples for color, texture, and coverage. Remove and refinish, or recoat work that does not comply with specified requirements.

PART 3 - EXECUTION

3.1 DECORATIVE FENCE INSTALLATION

A. Install fences according to manufacturer's written instructions.

B. Install fences by setting posts as indicated and fastening rails and infill panels to posts. Peen threads of bolts after assembly to prevent removal.

C. Post Excavation: Drill or hand-excavate holes for posts in firm, undisturbed soil. Excavate holes to a diameter of not less than 4 times post size and a depth of not less than 24 inches (600 mm) plus 3 inches (75 mm) for each foot (300 mm) or fraction of a foot (300 mm) that fence height exceeds 4 feet (1.2 m).

D. Post Setting: Set posts in concrete with mechanical anchors by mechanically driving into soil at indicated spacing into firm, undisturbed soil.

1. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.
2. Concrete Fill: Place concrete around posts and sleeves and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.
3. Posts Set in Concrete: Extend post to within 6 inches (150 mm) of specified excavation depth, but not closer than 3 inches (75 mm) to bottom of concrete.
4. Mechanically Driven Posts: Drive into soil to depth of 30 inches (762 mm) or 36 inches (914 mm) as directed. Protect post top to prevent distortion.
5. Space posts uniformly at 6 feet (1.83 m) or 8 feet (2.44 m) o.c. as directed.

3.2 GATE INSTALLATION

A. Install gates according to manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach hardware using tamper-resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate where necessary.

3.3 GATE OPERATOR INSTALLATION

A. General: Install gate operators according to manufacturer's written instructions, aligned and true to fence line and grade.

B. Excavation for Support Posts, Pedestals or Concrete Bases: Hand-excavate holes for bases in firm, undisturbed soil to dimensions and depths and at locations as required by gate operator component manufacturer's written instructions and as indicated.

C. Concrete Bases: Cast-in-place or precast concrete, depth not less than 12 inches (300 mm), dimensioned and reinforced according to gate operator component manufacturer's written instructions and as indicated on Drawings.

D. Vehicle Loop Detector System: Cut grooves in pavement and bury and seal wire loop according to manufacturer's written instructions. Connect to equipment operated by detector.

E. Comply with NFPA 70 and manufacturer's written instructions for grounding of electric-powered motors, controls, and other devices.

3.4 GROUNDING AND BONDING

A. Comply with Section 260526 "Grounding and Bonding for Electrical Systems."

B. Fence Grounding: Install at maximum intervals of 1500 feet (450 m) except as follows:

1. Fences within 100 Feet (30 m) of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of 750 feet (225 m).

    a. Gates and Other Fence Openings: Ground fence on each side of opening.

C. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is 6 inches (150 mm) below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at grounding location.

D. Bonding Method for Gates: Connect bonding jumper between gate post and gate frame.

E. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.

F. Bonding to Lightning-Protection System: If fence terminates at lightning-protected building or structure, ground the fence and bond the fence grounding conductor to lightning-protection down conductor or lightning-protection grounding conductor, complying with NFPA 780.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: As directed owner will engage or Engage a qualified testing agency to perform tests and inspections.

1. Grounding-Resistance Tests: Subject completed grounding system to a megger test at each grounding location. Measure grounding resistance not less than two full days after last trace of precipitation, without soil having been moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural grounding resistance. Perform tests by two-point method according to IEEE 81.

END OF SECTION 323119

SECTION 323119.53 - DECORATIVE METAL SECURITY FENCES AND GATES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Decorative metallic-coated-steel security fences.
2. Swing gates.
3. Gate operators, including controls.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For fencing and gates.

1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power, signal, and control wiring.

C. Samples: For each fence material and for each color specified.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Wind Loading: Comply with ASCE/SEI 7 requirements for fence height, wind exposure category, design wind speed, and design wind pressure.

B. Lightning-Protection System: Maximum grounding-resistance value of 25 ohms under normal dry conditions.

C. Vehicle Crash Testing: Comply with requirements of ASTM F2656 for impact category, impact velocity, and penetration rating.

2.2 DECORATIVE METALLIC-COATED-STEEL SECURITY FENCES

A. Decorative Metallic-Coated-Steel Security Fences:

B. Posts:

1. Posts: 1-3/4-by-4-inch (45-by-102-mm) double-thickness, I-shaped sections formed from 0.108-inch (2.74-mm) nominal-thickness, metallic-coated steel sheet or 0.105-inch (2.66-mm) nominal-thickness, uncoated steel sheet, hot-dip galvanized after fabrication.
2. Posts: 4-by-4-inch (102-by-102-mm) square tubes formed from 0.079-inch (2.01-mm) nominal-thickness, metallic-coated steel sheet or 0.075-inch (1.90-mm) nominal-thickness, uncoated steel sheet, hot-dip galvanized after fabrication.
3. Posts: As directed 2-1/2-by-2-1/2-inch (64-by-64-mm), 3-by-3-inch (76-by-76-mm) or 4-by-4-inch (102-by-102-mm) square tubes formed from 0.108-inch (2.74-mm) nominal-thickness, metallic-coated steel sheet or 0.105-inch (2.66-mm) nominal-thickness, uncoated steel sheet, hot-dip galvanized after fabrication.
4. Posts at Swing Gate Openings: Square tubes 3 by 3 inches (76 by 76 mm) formed from 0.108-inch (2.74-mm) nominal-thickness, metallic-coated steel sheet or formed from 0.105-inch (2.66-mm) nominal-thickness steel sheet and hot-dip galvanized after fabrication.
5. Posts at Swing Gate Openings: As directed square steel tubing 3 by 3 inches (76 by 76 mm) or 4 by 4 inches (102 by 102 mm) with 3/16-inch (4.76-mm) wall thickness, hot-dip galvanized.

C. Post Caps: Aluminum castings.

D. Rails: 2-by-2-inch (51-by-51-mm) square tubes.

1. Metal and Thickness: 0.079-inch (2.01-mm) nominal-thickness, metallic-coated steel sheet or 0.075-inch (1.90-mm) nominal-thickness, uncoated steel sheet, hot-dip galvanized after fabrication.

E. Rails: 1-3/4-by-1-3/4-inch (44-by-44-mm) square tubes.

1. Metal and Thickness: 0.079-inch (2.01-mm) nominal-thickness, metallic-coated steel sheet or 0.075-inch (1.90-mm) nominal-thickness, uncoated steel sheet, hot-dip galvanized after fabrication.

F. Rails: 2-by-2-1/2-inch (51-by-64-mm) pentagon-shaped box channel designed to shed water and to enclose wire rope reinforcement.

1. Metal and Thickness: 0.108-inch (2.74-mm) nominal-thickness, metallic-coated steel sheet or 0.105-inch (2.66-mm) nominal-thickness, uncoated steel sheet, hot-dip galvanized after fabrication.

2. As directed provide rails with wire rope reinforcement at 34 inches (864 mm), 41 inches (1041 mm) and 48 inches (1219 mm) above ground in addition to rails at top and bottom of fence.
3. Wire Rope Reinforcement: FS RR-W-41-G, 3/4-inch (19-mm) diameter, zinc-coated-steel wire rope.

    a. Class: Class 2, 6 by 19.
    b. Minimum Breaking Force: 58,800 lb (26 671 kg).

G. Pickets: 3/4-by-2-3/4-inch (19-by-70-mm) M-shaped pales.

1. Metal and Thickness: 0.079-inch (2.01-mm) nominal-thickness, metallic-coated steel sheet or 0.075-inch (1.90-mm) nominal-thickness, uncoated steel sheet, hot-dip galvanized after fabrication.
2. Picket Spacing: 6 inches (152.4 mm) o.c., maximum.

H. Fasteners: Stainless-steel carriage bolts with tamperproof nuts.

I. Metallic-Coated Steel Sheet: Galvanized-steel sheet or aluminum-zinc, alloy-coated steel sheet.

J. Galvanizing: For components indicated to be galvanized, hot-dip galvanize to comply with ASTM A123/A123M. For hardware items, hot-dip galvanize to comply with ASTM A153/A153M.

K. Finish: Organic coating complying with requirements in ASTM F2408 or Powder coating as directed.

2.3 SWING GATES

A. Galvanized-Steel Frames and Bracing: As directed fabricate members from square tubes 1-1/2 by 1-1/2 inches (38 by 38 mm), 1-3/4 by 1-3/4 inches (45 by 45 mm), 2 by 2 inches (51 by 51 mm) or 2-1/2 by 2-1/2 inches (64 by 64 mm) formed from 0.108-inch (2.74-mm) nominal-thickness, metallic-coated steel sheet or formed from 0.105-inch (2.66-mm) nominal-thickness steel sheet and hot-dip galvanized after fabrication.

B. Steel Frames and Bracing: As directed fabricate members from square steel tubing 1-1/2 by 1-1/2 inches (38 by 38 mm), 2 by 2 inches (51 by 51 mm) or 2-1/2 by 2-1/2 inches (64 by 64 mm) with 1/8-inch (3.2-mm) wall thickness. Hot-dip galvanize frames after fabrication.

C. Hardware: Latches permitting operation from both sides of gate, hinges, and keepers for each gate leaf more than 5 feet (1.52 m) wide. Provide center gate stops and cane bolts for pairs of gates. Fabricate latches with integral eye openings for padlocking; padlock accessible from both sides of gate.

D. Galvanizing: For items other than hardware that are indicated to be galvanized, hot-dip galvanize to comply with ASTM A123/A123M. For hardware items, hot-dip galvanize to comply with ASTM A153/A153M.

E. Metallic-Coated-Steel Finish: High-performance coating or Galvanized finish as directed.

F. Steel Finish: As directed.

2.4 GATE OPERATORS

A. Gate Operators:

B. Provide factory-assembled automatic operating system designed for gate size, type, weight, and operation frequency. Provide operation control system with characteristics suitable for Project conditions, with remote-control stations, safety devices, and weatherproof enclosures; coordinate electrical requirements with building electrical system.

1. Provide operator with UL approval or -approved components as directed.

C. Comply with NFPA 70.

D. UL Standard: Manufacturer and label gate operators to comply with UL 325.

E. Motor Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, within installed environment, with indicated operating sequence, and without exceeding nameplate rating or considering service factor. Comply with NEMA MG 1 and the following:

1. Voltage: As directed.
2. Duty: Continuous duty at ambient temperature of 105 deg F (40 deg C) and at altitude of 3300 feet (1005 m) above sea level.
3. Service Factor: 1.15 for open drip proof motors; 1.0 for totally enclosed motors.
4. Phase: One or Polyphase as directed.

F. Gate Operators: As directed:

1. Hydraulic Gate Operators:

a. Duty: As directed Light, Medium or Heavy duty, residential or commercial/industrial as directed.
b. Maximum Gate Weight: 800 lb (363 kg).
c. Frequency of Use: As directed.

2. Mechanical Gate Operators:

a. Duty: Light, Medium, Heavy duty, residential or commercial/industrial as directed.
b. Maximum Gate Weight: As directed.
c. Frequency of Use: As directed.

G. Remote Controls: As directed electric controls separated from gate and motor and drive mechanism, with NEMA ICS 6, Type 1 or NEMA ICS 6, Type 4 enclosure for surface, recessed or flush, concrete base or pedestal mounting, and with space for additional optional equipment. Provide the following remote-control device(s):

1. Control Station: As directed keyed, two or three-position switch with open, stop, and close function; located remotely from gate. Provide two keys per station.

2. Control Station: As directed momentary-contact, single or three-button-operated with open, stop, and close function; located remotely from gate. Key switch to lock out open and close buttons.
3. Card Reader: Functions only when authorized card is presented. Programmable, multiple or single-code system, permitting four different access periods ; face-lighted unit fully visible at night.

    a. Reader Type: As directed.

4. Digital Keypad Entry Unit: Programmable, multiple-code capability.
5. Radio Control: Digital system consisting of code-compatible universal receiver for each gate. As directed provide one or two programmable transmitter(s).
6. Telephone Entry System: Hands-free, voice-communication system for connection to building telephone system with digital-entry code activation of gate operator.

H. Vehicle Loop Detector: System includes automatic closing timer with adjustable time delay, timer cutoff switch, and loop detector designed as directed.

I. Vehicle Presence Detector: System includes automatic closing timer with adjustable time delay, timer cutoff switch, and presence detector designed as directed.

J. Obstruction Detection Devices: Provide each motorized gate with automatic safety sensor(s). Activation of sensor(s) causes operator to immediately stop gate in opening cycle and reverse gate in closing cycle, and hold until clear of obstruction.

K. Accessories:

1. Warning Module: As directed Audio, Visual, constant or strobe-light alarm sounding three to five seconds in advance of gate operation and continuing until gate stops moving; compliant with the United States Access Board's ADA-ABA Accessibility Guidelines.
2. Battery Backup System: Battery-powered drive and access-control system, independent of primary drive system.
3. Intercom System: As directed.
4. Instructional, Safety, and Warning Labels and Signs: According to UL 325 or Manufacturer's standard for components and features specified as directed.

2.5 STEEL AND IRON

A. Plates, Shapes, and Bars: ASTM A36/A36M.

B. Tubing: ASTM A500/A500M, cold-formed steel tubing.

C. Uncoated Steel Sheet: Hot-rolled steel sheet, ASTM A1011/A1011M, Structural Steel, Grade 45 (Grade 310) or cold-rolled steel sheet, ASTM A1008/A1008M, Structural Steel, Grade 50 (Grade 340) as directed.

D. Galvanized-Steel Sheet: ASTM A653/A653M, structural quality, Grade 50 (Grade 340), with G90 (Z275) or G60 (Z180) coating as directed.

E. Aluminum-Zinc, Alloy-Coated Steel Sheet: ASTM A792/A792M, structural quality, Grade 50 (Grade 340), with AZ60 (AZM180) coating.

2.6 COATING MATERIALS

A. Epoxy Zinc-Rich Primer for Uncoated Steel: Complying with MPI #20 and compatible with coating specified to be applied over it.

B. Epoxy Primer for Galvanized Steel: Epoxy primer recommended in writing by topcoat manufacturer.

C. Intermediate Coat for Uncoated Steel: Epoxy or polyurethane intermediate recommended in writing by primer and topcoat manufacturer.

D. Polyurethane Intermediate Coat and Topcoat: Complying with MPI #72 and compatible with undercoat.

2.7 MISCELLANEOUS MATERIALS

A. Concrete: Normal-weight, air-entrained, ready-mix concrete complying with requirements in Section 033000 "Cast-in-Place Concrete" with a minimum 28-day compressive strength of 3000 psi (20 MPa), 3-inch (75-mm) slump, and 1-inch (25-mm) maximum aggregate size or dry, packaged, normal-weight concrete mix complying with ASTM C387/C387M mixed with potable water according to manufacturer's written instructions.

2.8 GROUNDING MATERIALS

A. Comply with requirements of Section 260526 "Grounding and Bonding for Electrical Systems."

B. Grounding Conductors: Size as indicated on Drawings. Bare, solid wire for No. 6 AWG and smaller; stranded wire for No. 4 AWG and larger.

1. Material above Finished Grade: As directed Copper or Aluminum.
2. Material on or below Finished Grade: Copper.

C. Grounding Connectors and Grounding Rods: Comply with UL 467.

2.9 STEEL FINISHES

A. Surface Preparation: Clean surfaces according to SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning" or SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning" as directed. After cleaning, apply a conversion coating compatible with the organic coating to be applied over it.

B. Primer Application: Apply zinc-rich epoxy primer immediately after cleaning, to provide a minimum dry film thickness of 2 mils (0.05 mm) per applied coat, to surfaces that are exposed after assembly and installation, and to concealed surfaces.

C. High-Performance Coating: Apply intermediate and polyurethane topcoats to prime-coated surfaces. Comply with coating manufacturer's written instructions and with requirements in SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting. Apply at spreading rates recommended by coating manufacturer.

1. Match approved Samples for color, texture, and coverage. Remove and refinish, or recoat work that does not comply with specified requirements.

2.10 METALLIC-COATED-STEEL FINISHES

A. Galvanized Finish: Clean welds, mechanical connections, and abraded areas and repair galvanizing to comply with ASTM A780/A780M.

B. Surface Preparation: Clean surfaces of oil and other contaminants. Use cleaning methods that do not leave residue. After cleaning, apply a zinc-phosphate conversion coating compatible with the organic coating to be applied over it. Clean welds, mechanical connections, and abraded areas and apply galvanizing repair paint, complying with SSPC-Paint 20, to comply with ASTM A780/A780M.

C. Powder Coating: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat finish consisting of zinc-rich epoxy prime coat and TGIC polyester topcoat to a minimum dry film thickness of 2 mils (0.05 mm). Comply with coating manufacturer's written instructions to achieve a minimum total dry film thickness of 4 mils (0.10 mm).

1. Color and Gloss: As directed.

D. High-Performance Coating: Apply epoxy primer, polyurethane intermediate coat, and polyurethane topcoat to prepared surfaces. Comply with coating manufacturer's written instructions and with requirements in SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting. Apply at spreading rates recommended by coating manufacturer.

1. Match approved Samples for color, texture, and coverage. Remove and refinish, or recoat work that does not comply with specified requirements.

PART 3 - EXECUTION

3.1 DECORATIVE SECURITY FENCE INSTALLATION

A. Install fences according to manufacturer's written instructions.

B. Install fences by setting posts as indicated and fastening rails and infill panels to posts. Peen threads of bolts after assembly to prevent removal.

C. Post Excavation: Drill or hand-excavate holes for posts in firm, undisturbed soil. Excavate holes to a diameter of not less than 4 times post size and a depth of not less than 24 inches (600 mm) plus 3 inches (75 mm) for each foot (300 mm) or fraction of a foot (300 mm) that fence height exceeds 4 feet (1.2 m).

D. Post Setting: Set posts in concrete with mechanical anchors by mechanically driving into soil at indicated spacing into firm, undisturbed soil.

1. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.
2. Concrete Fill: Place concrete around posts and sleeves and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.
3. Posts Set in Concrete: Extend post to within 6 inches (150 mm) of specified excavation depth, but not closer than 3 inches (75 mm) to bottom of concrete.
4. Mechanically Driven Posts: Drive into soil to depth of 30 inches (762 mm) or 36 inches (914 mm) as directed. Protect post top to prevent distortion.
5. Space posts uniformly at 6 feet (1.83 m) or 8 feet (2.44 m) o.c. as directed

3.2 GATE INSTALLATION

A. Install gates according to manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach hardware using tamper-resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate where necessary.

3.3 GATE OPERATOR INSTALLATION

A. General: Install gate operators according to manufacturer's written instructions, aligned and true to fence line and grade.

B. Excavation for Support Posts, Pedestals or Concrete Bases: Hand-excavate holes for bases in firm, undisturbed soil to dimensions and depths and at locations as required by gate operator component manufacturer's written instructions and as indicated.

C. Concrete Bases: Cast-in-place or precast concrete, depth not less than 12 inches (300 mm), dimensioned and reinforced according to gate operator component manufacturer's written instructions and as indicated on Drawings.

D. Vehicle Loop Detector System: Cut grooves in pavement and bury and seal wire loop according to manufacturer's written instructions. Connect to equipment operated by detector.

E. Comply with NFPA 70 and manufacturer's written instructions for grounding of electric-powered motors, controls, and other devices.

3.4 GROUNDING AND BONDING

A. Comply with Section 260526 "Grounding and Bonding for Electrical Systems."

B. Fence Grounding: Install at maximum intervals of 1500 feet (450 m) except as follows:

1. Fences within 100 Feet (30 m) of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of 750 feet (225 m).

a. Gates and Other Fence Openings: Ground fence on each side of opening.

C. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is 6 inches (150 mm) below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at grounding location.

D. Bonding Method for Gates: Connect bonding jumper between gate post and gate frame.

E. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.

F. Bonding to Lightning-Protection System: If fence terminates at lightning-protected building or structure, ground the fence and bond the fence grounding conductor to lightning-protection down conductor or lightning-protection grounding conductor, complying with NFPA 780.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: As directed Owner will engage or Engage a qualified testing agency to perform tests and inspections.

1. Grounding-Resistance Tests: Subject completed grounding system to a megger test at each grounding location. Measure grounding resistance not less than two full days after last trace of precipitation, without soil having been moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural grounding resistance. Perform tests by two-point method according to IEEE 81.

END OF SECTION 323119.53

SECTION 323223 - SEGMENTAL RETAINING WALLS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes single- and multiple-depth segmental retaining walls with and without soil reinforcement.

B. Related Requirements:

1. Section 312000 "Earth Moving" for excavation for segmental retaining walls.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Samples: For each color and texture of concrete unit specified.

D. Delegated-Design Submittal: For segmental retaining walls.

1.3 INFORMATIONAL SUBMITTALS

A. Research/Evaluation Reports: For segmental retaining wall units and soil reinforcement, from ICC-ES.

B. Preconstruction test reports.

C. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM E329 for testing indicated.

1.5 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified testing agency to perform the following preconstruction testing:

1. Test soil reinforcement and backfill materials for pullout resistance according to ASTM D6706.
2. Test soil reinforcement and backfill materials for coefficient of friction according to ASTM D5321.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Basis of Design: Design of segmental retaining walls is based on products indicated. If comparable products of another manufacturer are proposed, engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design segmental retaining walls.

B. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design segmental retaining walls.

C. Compliance Review: Qualified professional engineer responsible for segmental retaining wall design shall review and approve submittals and source and field quality-control reports for compliance of materials and construction with design.

D. Structural Performance: Engineering design shall be based on the following loads and be according to NCMA's "Design Manual for Segmental Retaining Walls."

1. Horizontal Peak Ground Acceleration (A) for Project: As directed

2.2 SEGMENTAL RETAINING WALL UNITS

A. Concrete Units: ASTM C1372, Normal Weight, except that maximum water absorption shall not exceed 7 percent by weight and units shall not differ in height more than plus or minus 1/16 inch (1.6 mm) from specified dimension.

B. Retain first subparagraph below for projects in areas where walls are subject to freezing.

1. Provide units that comply with requirements in ASTM C1372 for freeze-thaw durability.
2. Provide units that interlock with courses above and below by means of integral lugs, lips, or tongues and grooves, pins, clips, splines or and hollow cores filled with drainage fill as directed.

C. Color: As directed.

D. Shape and Texture: Provide units as directed.

E. Shape and Texture: Provide units matching basic shape, dimensions, and face texture of basis-of-design product.

2.3 INSTALLATION MATERIALS

A. Pins and Clips: Product supplied by segmental retaining wall unit manufacturer for use with units provided, made from non-degrading polymer reinforced with glass fibers.

B. Cap Adhesive: Product supplied or recommended by segmental retaining wall unit manufacturer for adhering cap units to units below.

C. Leveling Base: Comply with requirements in Section 312000 "Earth Moving" for base or drainage course as directed.

D. Drainage Fill: Comply with requirements in Section 312000 "Earth Moving" for drainage course.

E. Soil Fill: Comply with requirements in Section 312000 "Earth Moving" for satisfactory soils.

F. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.

G. Drainage Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation greater than 50 percent.

1. Apparent Opening Size: No. 70 to 100 (0.212- to 0.150-mm) sieve, maximum; ASTM D4751.
2. Minimum Grab Tensile Strength: 110 lb (49.9 kg); ASTM D4632.

H. Soil Reinforcement: Product specifically manufactured for use as soil reinforcement and as follows:
1. Product Type: As directed.

PART 3 - EXECUTION

3.1 RETAINING WALL INSTALLATION

A. General: Place units according to NCMA's "Segmental Retaining Wall Installation Guide" and segmental retaining wall unit manufacturer's written instructions.

1. Lay units in running bond or bond pattern indicated.
2. Form corners and ends by using special units, cutting units with motor-driven saw or splitting units with mason's hammer and chisel as directed.

B. Leveling Base: Place and compact base material to thickness indicated and with not less than 95 percent maximum dry unit weight according to ASTM D698.

C. First Course: Place first course of segmental retaining wall units for full length of wall. Place units in firm contact with each other, properly aligned and level.

1. Tamp units into leveling base as necessary to bring tops of units into a level plane.

D. Subsequent Courses: Remove excess fill and debris from tops of units in course below. Place units in firm contact, properly aligned, and directly on course below.

E. Cap Units: Place cap units and secure with cap adhesive.

3.2 FILL PLACEMENT

A. General: Comply with requirements in Section 312000 "Earth Moving," with NCMA's "Segmental Retaining Wall Installation Guide," and with segmental retaining wall unit manufacturer's written instructions.

B. Fill voids between and within units with drainage fill. Place fill as each course of units is laid.

C. Place, spread, and compact drainage fill and soil fill in uniform lifts for full width and length of embankment as wall is laid. Place and compact fills without disturbing alignment of units. Where both sides of wall are indicated to be filled, place fills on both sides at same time. Begin at wall, and place and spread fills toward embankment.

1. Use only hand-operated compaction equipment within 48 inches (1200 mm) of wall, or one-half of height above bottom of wall, whichever is greater.
2. Compact reinforced-soil fill to not less than 95 percent maximum dry unit weight according to ASTM D698.

    a. In areas where only hand-operated compaction equipment is allowed, compact fills to not less than 90 percent maximum dry unit weight according to ASTM D698.

3. Compact nonreinforced-soil fill to comply with Section 312000 "Earth Moving."

D. Place drainage geotextile against back of wall, and place layer of drainage fill at least 12 inches (300 mm) or 6 inches (150 mm) wide as directed behind drainage geotextile to within 12 inches (300 mm) of finished grade. Place another layer of drainage geotextile between drainage fill and soil fill.

E. Place a layer of drainage fill at least 12 inches (300 mm) or 6 inches (150 mm) wide as directed behind wall to within 12 inches (300 mm) of finished grade. Place a layer of drainage geotextile between drainage fill and soil fill.

F. Wrap subdrainage pipe with filter fabric and place in drainage fill as indicated, sloped not less than 0.5 percent to drain.

G. Place impervious fill over top edge of drainage fill layer.

H. Place soil reinforcement in horizontal joints of retaining wall where indicated and according to soil-reinforcement manufacturer's written instructions. Embed reinforcement a minimum of 8 inches (200 mm) into retaining wall and stretch tight over compacted backfill. Anchor soil reinforcement before placing fill.

1. Place additional soil reinforcement at corners and curved walls to provide continuous reinforcement.
2. Place geosynthetics with seams, if any, oriented perpendicular to segmental retaining walls.
3. Do not dump fill material directly from trucks onto geosynthetics.
4. Place at least 6 inches (150 mm) of fill over reinforcement before compacting with tracked vehicles or 4 inches (100 mm) before compacting with rubber-tired vehicles.
5. Do not turn vehicles on fill until first layer of fill is compacted and second layer is placed over each soil-reinforcement layer.

3.3 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage or Engage a qualified testing agency to perform tests and inspections as directed.

B. Comply with requirements in Section 312000 "Earth Moving" for field quality control.

1. In each compacted backfill layer, perform at least one field in-place compaction test for each 150 feet (45 m) or less of segmental retaining wall length.
2. In each compacted backfill layer, perform at least one field in-place compaction test for each 24 inches (600 mm) of fill depth and each 50 feet (15 m) or less of segmental retaining wall length.

END OF SECTION 323223

SECTION 323300 - SITE FURNISHINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Seating.
2. Bicycle racks.
3. Trash receptacles.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Samples: For each exposed product and for each color and texture specified.

1.3 CLOSEOUT SUBMITTALS

A. Maintenance data.

PART 2 - PRODUCTS

2.1 SEATING

A. Frame: As directed.

B. Seat and Back:

1. Material:

a. Aluminum Sheet: Perforated or Expanded metal as directed.
b. Painted Steel: As directed.
c. Stainless Steel: As directed.
d. Wood: As directed.
e. Recycled, Plastic or Fiberglass Planks: Evenly spaced, parallel.
f. Recycled, Plastic or Fiberglass Sheet: Solid or Perforated as directed.

2. Seat Height: As indicated.
3. Seat Surface Shape: Flat or Contoured or dished as directed.
4. Overall Height: As indicated.
5. Overall Width: As indicated.

6. Overall Depth: As indicated.
7. Arms: As directed.

    a. Arm Material: Match frame or seat as directed.

8. Seating Configuration: Multiple units as indicated.

    a. Straight, Angled or Curved shape as directed.
    b. Closed hexagon, circle or shape indicated around a tree trunk, planter or light post as directed.

C. Aluminum Finish: Mill finish or Color coated as directed.

1. Color: As directed.

D. Steel Finish: Galvanized and color or PVC-color coated as directed.

1. Color: As directed

E. Stainless-Steel Finish: No. 6.

F. Wood Finish: As directed.

1. Stain: As directed.

G. Fiberglass or HDPE Color: As directed.

H. Graphics: As directed.

2.2 BICYCLE RACKS

A. Bicycle Rack Construction:

1. Frame: As directed.

    a. Pipe or Tubing OD: As directed.
    b. Locking Bars: Solid round bar, not less than 3/4 inch (19 mm) or 1 inch (25 mm) in diameter as directed.

2. Style: As directed.

    a. Overall Height: As indicated.
    b. Overall Width: As indicated.
    c. Overall Depth: As indicated.
    d. Capacity: Designed to accommodate no fewer than as directed.

3. Security: Designed to lock wheel and frame.
4. Accessories: Base covers for each pipe and tubing anchored end or Wheel stops as directed.
5. Installation Method: As indicated.

B. Aluminum Finish: Mill finish or Color coated as directed.

1. Color: As directed.

C. Steel Finish: Galvanized or Color coated as directed.

1. Color: As directed.

D. Stainless-Steel Finish: No. 4.

E. Wood Finish: Unfinished or Manufacturer's standard finish.

2.3 TRASH RECEPTACLES

A. Aluminum Facing Surrounds: As directed.

B. Steel Facing Surrounds: As directed.

C. Stainless-Steel Facing Surrounds: As directed.

D. Wood Facing Surrounds: As directed.

E. Fiberglass Facing Surrounds: Molded fiberglass shape.

F. Plastic Facing Surrounds: As directed.

G. Support Frames: As directed Steel or Galvanized steel; welded.

H. Trash Receptacles:

1. Receptacle Shape and Form: As directed.
2. Lids and Tops: As directed.

    a. Description: As directed.
    b. Opening for depositing trash covered by self-closing, spring-loaded-hinged, push-in or rotating weather flap as directed.

3. Receptacle Height: As indicated.
4. Overall Width: As indicated.
5. Inner Container: As directed.
6. Disposable Liners: Provide receptacle designed to accommodate disposable liners.
7. Capacity: As directed.
8. Service Access: Removable lid or top or Fixed lid or top, side access; inner container and disposable liner lift or slide-out for emptying; lockable with padlock hasps; keyed lock with two keys per receptacle; self-latching hinge.
9. Post Mount: As directed.

I. Aluminum Finish: Mill finish or Color coated as directed.

1. Color: As directed.

J. Steel Finish: Galvanized and color or PVC-color coated as directed.

1. Color: As directed.

K. Stainless-Steel Finish: No. 6.

L. Wood Finish: As directed

1. Stain: As directed.

M. Fiberglass or HDPE Color: As directed.

N. Graphics: As directed.

1. Copy: As directed.

2.4 MATERIALS

A. Aluminum: Alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated; free of surface blemishes and complying with the following:

1. Rolled or Cold-Finished Bars, Rods, and Wire: ASTM B211 (ASTM B211M).
2. Extruded Bars, Rods, Wire, Profiles, and Tubes: ASTM B221 (ASTM B221M).
3. Structural Pipe and Tube: ASTM B429/B429M.
4. Sheet and Plate: ASTM B209 (ASTM B209M).
5. Castings: ASTM B26/B26M.

B. Steel and Iron: Free of surface blemishes and complying with the following:

1. Plates, Shapes, and Bars: ASTM A36/A36M.
2. Steel Pipe: Standard-weight steel pipe complying with ASTM A53/A53M, or electric-resistance-welded pipe complying with ASTM A135/A135M.
3. Tubing: Cold-formed steel tubing complying with ASTM A500/A500M.
4. Mechanical Tubing: Cold-rolled, electric-resistance-welded carbon or alloy steel tubing complying with ASTM A513/A513M, or steel tubing fabricated from steel complying with ASTM A1011/A1011M and complying with dimensional tolerances in ASTM A500/A500M; zinc coated internally and externally.
5. Sheet: Commercial steel sheet complying with ASTM A1011/A1011M.
6. Perforated Metal: As directed from steel sheet not less than 0.075-inch (1.9-mm), 0.090-inch (2.3-mm) or 0.120-inch (3.0-mm) nominal thickness; manufacturer's standard perforation pattern.
7. Expanded Metal: Carbon-steel sheets, deburred after expansion, and complying with ASTM F1267.
8. Malleable-Iron Castings: ASTM A47/A47M, grade as recommended by fabricator for type of use intended.
9. Gray-Iron Castings: ASTM A48/A48M, Class 200.

C. Stainless Steel: Free of surface blemishes and complying with the following:

1. Sheet, Strip, Plate, and Flat Bars: ASTM A666.

2. Pipe: Schedule 40 steel pipe complying with ASTM A312/A312M.
3. Tubing: ASTM A554.

D. Wood: Surfaced smooth on four sides with eased edges; kiln dried, free of knots, solid stock of species indicated.

1. Wood Species: As directed.

a. Douglas Fir: Clear Grade, vertical grain.
b. Pine: Southern pine; No. 2 or better; preservative treated, kiln dried after treatment.
c. Eastern White, Red or Yellow Cedar: Select Grade or better.
d. Redwood: As directed Clear all heart or Construction heart or better, free-of-heart center.
e. Teak (Tectona Grandis): Clear Grade.

2. Finish: Manufacturer's standard stain and transparent sealer or transparent wood-preservative treatment and sealer as directed.

E. Fiberglass: Multiple laminations of glass-fiber-reinforced polyester resin with UV-light stable, colorfast, nonfading, weather- and stain-resistant, colored polyester gel coat, and with manufacturer's standard finish.

F. Plastic: Color impregnated, color and UV-light stabilized, and mold resistant.

1. Polyethylene: Fabricated from virgin plastic HDPE resin.

G. Anchors, Fasteners, Fittings, and Hardware: As directed.

1. Angle Anchors: For inconspicuously bolting legs of site furnishings to on or below-grade substrate; one per leg or extent as indicated.
2. Antitheft Hold-Down Brackets: For securing site furnishings to substrate; two per unit as directed.

H. Non-shrink, Nonmetallic Grout: Premixed, factory-packaged, non-staining, noncorrosive, nongaseous grout complying with ASTM C1107/C1107M; recommended in writing by manufacturer, for exterior applications.

I. Erosion-Resistant Anchoring Cement: Factory-packaged, non-shrink, non-staining, hydraulic-controlled expansion cement formulation for mixing with potable water at Project site to create pourable anchoring, patching, and grouting compound; resistant to erosion from water exposure without needing protection by a sealer or waterproof coating; recommended in writing by manufacturer, for exterior applications.

J. Galvanizing: Where indicated for steel and iron components, provide the following protective zinc coating applied to components after fabrication:

1. Zinc-Coated Tubing: External, zinc with organic overcoat, consisting of a minimum of 0.9 oz./sq. ft. (0.27 kg/sq. m) of zinc after welding, a chromate conversion coating, and a clear, polymer film. Internal, same as external or consisting of 81 percent zinc pigmented coating, not less than 0.3 mil (0.0076 mm) thick.

2. Hot-Dip Galvanizing: According to ASTM A123/A123M, ASTM A153/A153M, or ASTM A924/A924M.

2.5 WOOD-PRESERVATIVE-TREATED MATERIALS

A. Preservative Treatment: Pressure-treat wood according to AWPA U1, Use Category UC3b, and the following:

1. Use preservative chemicals acceptable to authorities having jurisdiction and containing no arsenic or chromium. Use chemical formulations that do not bleed through or otherwise adversely affect finishes. Do not use colorants to distinguish treated materials from untreated materials.
2. Kiln-dry lumber and plywood after treatment to a maximum moisture content, respectively, of 19 and 15 percent. Do not use materials that are warped or do not comply with requirements for untreated materials.

2.6 FABRICATION

A. Metal Components: Form to required shapes and sizes with true, consistent curves, lines, and angles. Separate metals from dissimilar materials to prevent electrolytic action.

B. Welded Connections: Weld connections continuously. Weld solid members with full-length, full-penetration welds and hollow members with full-circumference welds. At exposed connections, finish surfaces smooth and blended, so no roughness or unevenness shows after finishing and welded surface matches contours of adjoining surfaces.

C. Pipes and Tubes: Form simple and compound curves by bending members in jigs to produce uniform curvature for each repetitive configuration required; maintain cylindrical cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of handrail and railing components.

D. Preservative-Treated Wood Components: Complete fabrication of treated items before treatment if possible. If cut after treatment, apply field treatment complying with AWPA M4 to cut surfaces.

E. Exposed Surfaces: Polished, sanded, or otherwise finished; all surfaces smooth, free of burrs, barbs, splinters, and sharpness; all edges and ends rolled, rounded, or capped.

F. Factory Assembly: Factory assemble components to greatest extent possible to minimize field assembly. Clearly mark units for assembly in the field.

2.7 ALUMINUM FINISHES

A. Powder-Coat Finish: Manufacturer's standard polyester powder-coat finish complying with finish manufacturer's written instructions for surface preparation, including pretreatment, application, baking, and minimum dry film thickness.

2.8 STEEL AND GALVANIZED-STEEL FINISHES

A. Powder-Coat Finish: Manufacturer's standard polyester, powder-coat finish complying with finish manufacturer's written instructions for surface preparation, including pretreatment, application, baking, and minimum dry film thickness.

B. PVC Finish: Manufacturer's standard, UV-light stabilized, mold-resistant, slip-resistant, matte-textured, dipped or sprayed-on, PVC-plastisol finish, with flame retardant added; complying with coating manufacturer's written instructions for pretreatment, application, and minimum dry film thickness.

2.9 IRON FINISHES

A. Powder-Coat Finish: Manufacturer's standard polyester powder-coat finish complying with finish manufacturer's written instructions for surface preparation, including pretreatment, application, baking, and minimum dry film thickness.

2.10 STAINLESS-STEEL FINISHES

A. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.

B. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.

1. Run directional finishes with long dimension of each piece.
2. Directional Satin Finish: No 4.
3. Dull Satin Finish: No. 6.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with manufacturer's written installation instructions unless more stringent requirements are indicated. Complete field assembly of site furnishings where required.

B. Unless otherwise indicated, install site furnishings after landscaping and paving have been completed.

C. Install site furnishings level, plumb, true, and securely anchored or positioned at locations indicated on Drawings.

D. Post Setting: Set cast-in support posts in concrete footing with smooth top, shaped to shed water. Protect portion of posts above footing from concrete splatter. Verify that posts are set plumb or at correct angle and are aligned and at correct height and spacing. Hold posts in position during placement and finishing operations until concrete is sufficiently cured.

E. Posts Set into Voids in Concrete: Form or core-drill holes for installing posts in concrete to depth recommended in writing by manufacturer of site furnishings and 3/4 inch (19 mm) larger than OD of post. Clean holes of loose material, insert posts, and fill annular space between post

and concrete with non-shrink, nonmetallic grout or anchoring cement, mixed and placed to comply with anchoring material manufacturer's written instructions, with top smoothed and shaped to shed water.

F. Pipe Sleeves: Use steel pipe sleeves preset and anchored into concrete for installing posts. After posts have been inserted into sleeves, fill annular space between post and sleeve with non-shrink, nonmetallic grout or anchoring cement, mixed and placed to comply with anchoring material manufacturer's written instructions, with top smoothed and shaped to shed water.

END OF SECTION 323300

SECTION 328400 - PLANTING IRRIGATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Piping.
2. Manual valves.
3. Automatic control valves.
4. Automatic drain valves.
5. Sprinklers.
6. Quick couplers.
7. Controllers.
8. Boxes for automatic control valves.

1.2 PERFORMANCE REQUIREMENTS

A. Irrigation zone control shall be automatic operation with controller and automatic control or manual operation with manual valves as directed.

B. Location of Sprinklers and Specialties: Design location is approximate. Make minor adjustments necessary to avoid plantings and obstructions such as signs and light standards. Maintain 100 percent irrigation coverage of areas indicated.

C. Delegated Design: Design 100 percent coverage irrigation system, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

1. Available land records indicate the following soil conditions:

a. Type: As directed.
b. Texture:

1) Sand: Percent as directed.
2) Silt: Percent as directed.
3) Clay: Percent as directed.

c. Particle Size:

1) Sand: As directed.
2) Silt: As directed.
3) Clay: As directed.

d. Structure: As directed.
e. Density: As directed.
f. Moisture Content: Percent as directed.

g. Infiltration Rate: As directed.

D. Minimum Working Pressures: The following are minimum pressure requirements for piping, valves, and specialties unless otherwise indicated:

1. Irrigation Main Piping: 200 psig (1380 kPa).
2. Circuit Piping: 150 psig (1035 kPa).

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Sustainable Design Submittals:

C. Wiring Diagrams: For power, signal, and control wiring.

D. Delegated-Design Submittal: For irrigation systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.4 INFORMATIONAL SUBMITTALS

A. Zoning Chart: Show each irrigation zone and its control valve.

B. Controller Timing Schedule: Indicate timing settings for each automatic controller zone.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Comply with requirements in the piping schedule for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes.

B. Galvanized-Steel Pipe: ASTM A53/A53M, Standard Weight, Type E, Grade B.

1. Galvanized-Steel Pipe Nipples: ASTM A733, made of ASTM A53/A53M or ASTM A106/A106M, Standard Weight, seamless-steel pipe with threaded ends.
2. Galvanized, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.
3. Malleable-Iron Unions: ASME B16.39, Class 150, hexagonal-stock body with ball-and-socket, metal-to-metal, bronze seating surface, and female threaded ends.
4. Cast-Iron Flanges: ASME B16.1, Class 125.

C. Ductile-Iron Pipe with Push-on Joint: AWWA C151, with push-on-joint bell and spigot ends.

1. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.

    a. Gaskets: AWWA C111, rubber.

D. Soft Copper Tube: ASTM B88, Type L (ASTM B88M, Type B), water tube, annealed temper.

1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper solder-joint fittings. Furnish wrought-copper fittings if indicated.
2. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end.
3. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces and solder-joint or threaded ends.

E. Hard Copper Tube: ASTM B88, Type L (ASTM B88M, Type B), and ASTM B88, Type M (ASTM B88M, Type C), water tube, drawn temper.

1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper solder-joint fittings. Furnish wrought-copper fittings if indicated.
2. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end.
3. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces and solder-joint or threaded ends.

F. PE Pipe with Controlled ID: ASTM F771, PE 3408 compound; SIDR 11.5 and SIDR 15.

1. Insert Fittings for PE Pipe: ASTM D2609, nylon or propylene plastic with barbed ends. Include bands or other fasteners.

G. PVC Pipe: ASTM D1785, PVC 1120 compound, as directed.

1. PVC Socket Fittings: ASTM D2466, as directed.
2. PVC Threaded Fittings: ASTM D2464, Schedule 80.
3. PVC Socket Unions: Construction similar to MSS SP-107, except both headpiece and tailpiece shall be PVC with socket ends.

H. PVC Pipe, Pressure Rated: ASTM D2241, PVC 1120 compound, SDR 21 and SDR 26.

1. PVC Socket Fittings: ASTM D2467, Schedule 80.
2. PVC Socket Unions: Construction similar to MSS SP-107, except both headpiece and tailpiece shall be PVC with socket or threaded ends.

2.2 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick unless otherwise indicated; full-face or ring type unless otherwise indicated.

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

C. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

D. Solder Filler Metals: ASTM B32, lead-free alloys. Include water-flushable flux according to ASTM B813.

E. Solvent Cements for Joining PVC Piping: ASTM D2564. Include primer according to ASTM F656.

F. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

2.3 MANUAL VALVES

A. Curb Valves:

1. Description:

   a. Standard: AWWA C800.
   b. NPS 1 (DN 25) and Smaller Pressure Rating: 100 psig (690 kPa) minimum or 150 psig (1035 kPa) as directed.
   c. NPS 1-1/4 to NPS 2 (DN 32 to DN 50) Pressure Rating: 80 psig (550 kPa) minimum or 150 psig (1035 kPa) as directed.
   d. Body Material: Brass or bronze with ball or ground-key plug.
   e. End Connections: Matching piping.
   f. Stem: With wide-tee head.

B. Curb-Valve Casing:

1. Standard: Similar to AWWA M44 for cast-iron valve casings.
2. Top Section: Telescoping, of length required for depth of burial of curb valve.
3. Barrel: Approximately 3-inch (75-mm) diameter.
4. Plug: With lettering "WATER."
5. Bottom Section: With base of size to fit over valve.
6. Base Support: Concrete collar or wood frame.

C. Shutoff Rods for Curb-Valve Casings: As directed furnish one or two steel, tee-handle shutoff rod(s) with one pointed end, stem of length to operate deepest buried valve, and slotted end matching curb valve for Project.

D. Brass Ball Valves:
1. Description:

   a. Standard: MSS SP-110.

b. SWP Rating: 150 psig (1035 kPa).
c. CWP Rating: 600 psig (4140 kPa).
d. Body Design: Two piece.
e. Body Material: Forged brass.
f. Ends: Threaded or solder joint if indicated.
g. Seats: PTFE or TFE.
h. Stem: Brass.
i. Ball: Chrome-plated brass.
j. Port: Full or regular, but not reduced.

E. Bronze Ball Valves:
1. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig (1035 kPa).
c. CWP Rating: 600 psig (4140 kPa).
d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Threaded or solder joint if indicated.
g. Seats: PTFE or TFE.
h. Stem: Bronze.
i. Ball: Chrome-plated brass.
j. Port: Full or regular, but not reduced.

F. Iron Ball Valves:
1. Description:

a. Standard: MSS SP-72.
b. CWP Rating: 200 psig (1380 kPa).
c. Body Design: Split body.
d. Body Material: ASTM A126, gray iron.
e. Ends: Flanged.
f. Seats: PTFE or TFE.
g. Stem: Stainless steel.
h. Ball: Stainless steel.
i. Port: Full.

G. Plastic Ball Valves:
1. Description:

a. Standard: MSS SP-122.
b. Pressure Rating: 125 psig (860 kPa) minimum or 150 psig (1035 kPa) as directed.
c. Body Material: PVC.
d. Type: Union.
e. End Connections: Socket or threaded.
f. Port: Full.

H. Iron Gate Valves, Resilient Seated:

1. Description:

a. Standard: AWWA C509.
b. Pressure Rating: 200 psig (1380 kPa) or 250 psig (1725 kPa) minimum as directed.
c. Body Material: Ductile or gray iron with bronze trim.
d. End Connections: Mechanical joint or push-on joint.
e. Interior Coating: Comply with AWWA C550.
f. Body Design: Nonrising stem.
g. Operator: Stem nut.
h. Disc: Solid wedge with resilient coating.

I. Iron Gate Valve Casings:

1. Standard: AWWA M44 for cast-iron valve casings.
2. Top Section: Adjustable extension of length required for depth of burial of valve.
3. Barrel: Approximately 5-inch (125-mm) diameter.
4. Plug: With lettering "WATER."
5. Bottom Section: With base of size to fit over valve.
6. Base Support: Concrete collar or wood frame.

J. Operating Wrenches for Iron Gate Valve Casings: As directed furnish one or two steel, tee-handle operating wrench(es) with one pointed end, stem of length to operate deepest buried valve, and socket matching valve operating nut for Project.

2.4 AUTOMATIC CONTROL VALVES

A. Bronze, Automatic Control Valves:
1. Description: Cast-bronze body, normally closed, diaphragm type with manual-flow adjustment, and operated by 24-V ac solenoid.

B. Plastic, Automatic Control Valves:
1. Description: Molded-plastic body, normally closed, diaphragm type with manual-flow adjustment, and operated by 24-V ac solenoid.

2.5 AUTOMATIC DRAIN VALVES

A. Description: Spring-loaded-ball type of corrosion-resistant construction and designed to open for drainage if line pressure drops below 2-1/2 to 3 psig (17 to 20 kPa).

2.6 SPRINKLERS

A. General Requirements: Designed for uniform coverage over entire spray area indicated at available water pressure.

B. Plastic, Exposed, Impact-Drive Rotary Sprinklers:
1. Description:

a. Construction: ABS and corrosion-resistant metals.
b. Mounting: Aboveground, exposed on riser.

2. Capacities and Characteristics:

   a. Flow: As directed.
   b. Arc: As directed.
   c. Radius: As directed.
   d. Inlet: As directed.

C. Plastic, Pop-up, Gear-Drive Rotary Sprinklers:
   1. Description:

      a. Body Material: ABS.
      b. Nozzle: ABS or Brass as directed.
      c. Retraction Spring: Stainless steel.
      d. Internal Parts: Corrosion resistant.

   2. Capacities and Characteristics:

      a. Flow: As directed.
      b. Pop-up Height: 4 inches (100 mm) aboveground to nozzle.
      c. Arc: As directed.
      d. Radius: As directed.
      e. Inlet: As directed.

D. Plastic, Pop-up, Impact-Drive Rotary Sprinklers:
   1. Description:

      a. Case: ABS.
      b. Pop-up Height: As directed 4 inches (100 mm) or Approximately 3 inches (75 mm) aboveground to nozzle.
      c. Sprinkler Construction: ABS and other corrosion-resistant metals.

   2. Capacities and Characteristics:

      a. Nozzle: ABS or Brass as directed.
      b. Flow: As directed.
      c. Arc: As directed.
      d. Radius: As directed.
      e. Inlet: NPS 3/4 (DN 20) or NPS 1-1/4 (DN 32) as directed.

E. Plastic, Surface Spray Sprinklers:
   1. Description:

      a. Body Material and Flange: ABS.
      b. Pattern: Fixed, with flow adjustment.

   2. Capacities and Characteristics:

      a. Nozzle: ABS or Brass as directed.
      b. Flow: As directed.
      c. Arc: As directed.
      d. Radius: As directed.

e. Inlet: As directed.

F. Plastic, Surface, Pop-up Spray Sprinklers:
1. Description:

a. Body Material and Flange: ABS.
b. Pattern: Fixed, with flow adjustment.

2. Capacities and Characteristics:

a. Pop-up Height: As directed.
b. Nozzle: ABS or Brass as directed.
c. Flow: As directed.
d. Arc: As directed.
e. Radius: As directed.
f. Inlet: As directed.

G. Plastic, Pop-up Spray Sprinklers:
1. Description:

a. Body Material: ABS.
b. Nozzle: ABS or Brass as directed.
c. Retraction Spring: Stainless steel.
d. Internal Parts: Corrosion resistant.
e. Pattern: Fixed, with flow adjustment.
f. Nozzle: ABS or Brass as directed.
g. Flow: As directed.
h. Pop-up Height: 4 inches (100 mm) aboveground to nozzle.
i. Arc: As directed.
j. Radius: As directed
k. Inlet: As directed.

H. Plastic Shrub Sprinklers:
1. Description:

a. Body Material: ABS or other plastic.
b. Pattern: Fixed, with flow adjustment.

2. Capacities and Characteristics:

a. Configuration: As directed.
b. Flow: As directed.
c. Arc: As directed.
d. Radius: As directed.
e. Mounting Height: Inches aboveground to nozzle as directed.
f. Inlet: As directed.

2.7 QUICK COUPLERS

A. Description: Factory-fabricated, bronze or brass, two-piece assembly. Include coupler water-seal valve; removable upper body with spring-loaded or weighted, rubber-covered cap; hose swivel with ASME B1.20.7, 3/4-11.5NH threads for garden hose on outlet; and operating key.

1. Locking-Top Option: Vandal-resistant locking feature. Include one or two matching key(s) as directed.

2.8 CONTROLLERS

A. Description:

1. Controller Stations for Automatic Control Valves: Each station is variable from approximately 5 to 60 minutes. Include switch for manual or automatic operation of each station.
2. Exterior Control Enclosures: NEMA 250, Type 4, weatherproof, with locking cover and two matching keys; include provision for grounding.

    a. Body Material: As directed.
    b. Mounting: Freestanding type for concrete base or Surface type for wall as directed.

3. Interior Control Enclosures: NEMA 250, Type 12, drip-proof, with locking cover and two matching keys.

    a. Body Material: As directed.
    b. Mounting: Freestanding type for concrete base or Surface type for wall as directed.

4. Control Transformer: 24-V secondary, with primary fuse.
5. Timing Device: Adjustable, 24-hour, 14-day clock, with automatic operations to skip operation any day in timer period, to operate every other day, or to operate two or more times daily.

    a. Manual or Semiautomatic Operation: Allows this mode without disturbing preset automatic operation.
    b. Nickel-Cadmium Battery and Trickle Charger: Automatically powers timing device during power outages.
    c. Surge Protection: Metal-oxide-varistor type on each station and primary power.

6. Moisture Sensor: Adjustable from one to seven days, to shut off water flow during rain.
7. Wiring: UL 493, Type UF multiconductor, with solid-copper conductors; insulated cable; suitable for direct burial.

    a. Feeder-Circuit Cables: No. 12 AWG minimum, between building and controllers.
    b. Low-Voltage, Branch-Circuit Cables: No. 14 AWG minimum, between controllers and automatic control valves; color-coded different from feeder-circuit-cable jacket color; with jackets of different colors for multiple-cable installation in same trench.

c. Splicing Materials: Manufacturer's packaged kit consisting of insulating, spring-type connector or crimped joint and epoxy resin moisture seal; suitable for direct burial.

8. Concrete Base: Reinforced precast concrete not less than 36 by 24 by 4 inches (900 by 600 by 100 mm) thick, and 6 inches (150 mm) greater in each direction than overall dimensions of controller. Include opening for wiring.

2.9 BOXES FOR AUTOMATIC CONTROL VALVES

A. Plastic Boxes:

1. Description: Box and cover, with open bottom and openings for piping; designed for installing flush with grade.

a. Size: As required for valves and service.
b. Shape: As directed.
c. Sidewall Material: PE or PE, ABS, or FRP, as directed.
d. Cover Material: PE or PE, ABS, or FRP, as directed.

1) Lettering: "VALVE BOX or IRRIGATION" as directed

B. Drainage Backfill: Cleaned gravel or crushed stone, graded from ¾- inch (19 mm) minimum to 3 inches (75 mm) maximum.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavating, trenching, and backfilling are specified in Section 312000 "Earth Moving."

B. Install warning tape directly above pressure piping, 12 inches (300 mm) below finished grades, except 6 inches (150 mm) below subgrade under pavement and slabs.

C. Drain Pockets: Excavate to sizes indicated. Backfill with cleaned gravel or crushed stone, graded from 3/4 to 3 inches (19 to 75 mm), to 12 inches (300 mm) below grade. Cover gravel or crushed stone with sheet of asphalt-saturated felt and backfill remainder with excavated material.

D. Provide minimum cover over top of underground piping according to the following:

1. Irrigation Main Piping: Minimum depth of 36 inches (900 mm) below finished grade, or not less than 18 inches (450 mm) below average local frost depth, whichever is deeper.
2. Circuit Piping: 12 inches (300 mm).
3. Drain Piping: 12 inches (300 mm).
4. Sleeves: 24 inches (600 mm).

3.2 PIPING INSTALLATION

A. Location and Arrangement: Drawings indicate location and arrangement of piping systems. Install piping as indicated unless deviations are approved on Coordination Drawings.

B. Install piping at minimum uniform slope of 0.5 percent down toward drain valves.

C. Install piping free of sags and bends.

D. Install groups of pipes parallel to each other, spaced to permit valve servicing.

E. Install fittings for changes in direction and branch connections.

F. Install unions adjacent to valves and to final connections to other components with NPS 2 (DN 50) or smaller pipe connection.

G. Install flanges adjacent to valves and to final connections to other components with NPS 2-1/2 (DN 65) or larger pipe connection.

H. Install underground thermoplastic piping according to ASTM D2774 and ASTM F690.

I. Install expansion loops in control-valve boxes for plastic piping.

J. Lay piping on solid subbase, uniformly sloped without humps or depressions.

K. Install ductile-iron piping according to AWWA C600.

L. Install PVC piping in dry weather when temperature is above 40 deg F (5 deg C). Allow joints to cure at least 24 hours at temperatures above 40 deg F (5 deg C) before testing.

3.3 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Flanged Joints: Select rubber gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

E. Ductile-Iron Piping Gasketed Joints: Comply with AWWA C600 and AWWA M41.

F. Copper-Tubing Brazed Joints: Construct joints according to CDA's "Copper Tube Handbook," using copper-phosphorus brazing filler metal.

G. Copper-Tubing Soldered Joints: Apply ASTM B813 water-flushable flux to tube end unless otherwise indicated. Construct joints according to ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy (0.20 percent maximum lead content) complying with ASTM B32.

H. PE Piping Fastener Joints: Join with insert fittings and bands or fasteners according to piping manufacturer's written instructions.

I. PVC Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements.
2. PVC Pressure Piping: Join schedule number, ASTM D1785, PVC pipe and PVC socket fittings according to ASTM D2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D2855.
3. PVC Non-pressure Piping: Join according to ASTM D2855.

3.4 VALVE INSTALLATION

A. Underground Curb Valves: Install in curb-valve casings with tops flush with grade.

B. Underground Iron Gate Valves, Resilient Seat: Comply with AWWA C600 and AWWA M44. Install in valve casing with top flush with grade.

1. Install valves and PVC pipe with restrained, gasketed joints.

C. Aboveground Valves: Install as components of connected piping system.

D. Throttling Valves: Install in underground piping in boxes for automatic control valves.

E. Drain Valves: Install in underground piping in boxes for automatic control valves.

3.5 SPRINKLER INSTALLATION

A. Install sprinklers after hydrostatic test is completed.

B. Install sprinklers at manufacturer's recommended heights.

C. Locate part-circle sprinklers to maintain a minimum distance of 4 inches (100 mm) from walls and 2 inches (50 mm) from other boundaries unless otherwise indicated.

3.6 AUTOMATIC IRRIGATION-CONTROL SYSTEM INSTALLATION

A. Equipment Mounting: Install interior controllers as directed.

1. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Equipment Mounting: Install exterior freestanding controllers on precast concrete bases.

1. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Install control cable in same trench as irrigation piping and at least 2 inches (51 mm) below or beside piping. Provide conductors of size not smaller than recommended by controller manufacturer. Install cable in separate sleeve under paved areas.

3.7 IDENTIFICATION

A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

B. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplates and signs on each automatic controller.

1. Text: In addition to identifying unit, distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.

C. Warning Tapes: Arrange for installation of continuous, underground, detectable warning tapes over underground piping during backfilling of trenches. See Section 312000 "Earth Moving" for warning tapes.

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, operate controllers and automatic control valves to confirm proper system operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Any irrigation product will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.9 ADJUSTING

A. Adjust settings of controllers.

B. Adjust automatic control valves to provide flow rate at rated operating pressure required for each sprinkler circuit.

C. Adjust sprinklers and devices, except those intended to be mounted aboveground, so they will be flush with, or not more than 1/2 inch (13 mm) above, finish grade.

3.10 PIPING SCHEDULE

A. Install components having pressure rating equal to or greater than system operating pressure.

B. Piping in control-valve boxes and aboveground may be joined with flanges or unions instead of joints indicated.

C. Aboveground irrigation main piping, NPS 4 (DN 100) and smaller, shall be one of the following:

1. Galvanized-steel pipe and galvanized-steel pipe nipples; galvanized, gray-iron threaded fittings; and threaded joints.
2. As directed Type L (Type B) or Type M (Type C) hard copper tube, wrought- or cast-copper fittings, and brazed or soldered joints.
3. As directed Schedule 40 or Schedule 80, PVC pipe; socket-type PVC fittings; and solvent-cemented joints.
4. Schedule 80, PVC pipe; Schedule 80, threaded PVC fittings; and threaded joints.

D. Underground irrigation main piping, NPS 4 (DN 100) and smaller, shall be one of the following:

1. NPS 3 and NPS 4 (DN 80 and DN 100) ductile-iron, push-on-joint pipe; ductile-iron, push-on-joint fittings and gaskets; and gasketed joints.
2. Type L (Type B) soft copper tube, wrought-copper fittings, and brazed joints.
3. As directed Schedule 40 or Schedule 80, PVC pipe and socket fittings, and solvent-cemented joints.
4. Schedule 80, PVC pipe; Schedule 80, threaded PVC fittings; and threaded joints.
5. SDR 21, PVC, pressure-rated pipe; Schedule 80, PVC socket fittings; and solvent-cemented joints.

E. Circuit piping, NPS 2 (DN 50) and smaller, shall be one of the following:

1. As directed SIDR 7 or SIDR 9, PE, controlled ID pipe; insert fittings for PE pipe; and fastener joints.
2. Schedule 40, PVC pipe and socket fittings; and solvent-cemented joints.
3. SDR 26, PVC, pressure-rated pipe; Schedule 40, PVC socket fittings; and solvent-cemented joints.

F. Circuit piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100), shall be one of the following:

1. As directed SIDR 7 or SIDR 9, PE, controlled ID pipe; insert fittings for PE pipe; and banded or fastener joints.
2. Schedule 40, PVC pipe and socket fittings; and solvent-cemented joints.
3. SDR 26, PVC, pressure-rated pipe; Schedule 40, PVC socket fittings; and solvent-cemented joints.

G. Underground Branches and Offsets at Sprinklers and Devices: Schedule 80, PVC pipe; threaded PVC fittings; and threaded joints.

1. Option: Plastic swing-joint assemblies, with offsets for flexible joints, manufactured for this application.

H. Risers to Aboveground Sprinklers and Specialties: As directed Type L (Type B) or Type M (Type C) hard copper tube, wrought-copper fittings, and brazed or soldered joints.

I. Risers to Aboveground Sprinklers and Specialties: Schedule 80, PVC pipe and socket fittings; and solvent-cemented joints.

J. Drain piping shall be one of the following:

1. SIDR 9, 11.5, or 15, PE, controlled ID pipe; insert fittings for PE pipe; and banded or fastener joints.
2. Schedule 40, PVC pipe and socket fittings; and solvent-cemented joints.
3. SDR 21, 26, or 32.5, PVC, pressure-rated pipe; Schedule 40, PVC socket fittings; and solvent-cemented joints.

3.11 VALVE SCHEDULE

A. Underground, Shutoff-Duty Valves: Use the following:

1. NPS 2 (DN 50) and Smaller: Curb valve, curb-valve casing, and shutoff rod.
2. NPS 3 (DN 80) and Larger: Iron gate valve, resilient seated; iron gate valve casing; and operating wrench(es).

B. Aboveground, Shutoff-Duty Valves:

1. NPS 2 (DN 50) and Smaller: As directed.
2. NPS 2-1/2 (DN 65) and Larger: Iron ball valve.

C. Throttling-Duty Valves:

1. NPS 2 (DN 50) and Smaller: As directed Bronze or Plastic automatic control valve.
2. NPS 2 (DN 50) and Smaller: As directed.
3. NPS 2-1/2 and NPS 3 (DN 65 and DN 80): As directed Bronze or Plastic automatic control valve.
4. NPS 2-1/2 and NPS 3 (DN 65 and DN 80): Iron ball valve.

D. Drain Valves:

1. NPS 1/2 and NPS 3/4 (DN 15 and DN 20): Automatic drain valve.
2. NPS 1/2 and NPS 3/4 (DN 15 and DN 20): As directed.

3. NPS 1 to NPS 2 (DN 25 to DN 50): As directed.

END OF SECTION 328400

SECTION 329113 - SOIL PREPARATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes planting soils specified by composition of the mixes.

B. Related Requirements:

1. Section 311000 "Site Clearing" for topsoil stripping and stockpiling.
2. Section 329700 "Vegetated Roof Assemblies" for growing media (soil).

1.2 DEFINITIONS

A. Duff Layer: A surface layer of soil, typical of forested areas, that is composed of mostly decayed leaves, twigs, and detritus.

B. Imported Soil: Soil that is transported to Project site for use.

C. Manufactured Soil: Soil produced by blending soils, sand, stabilized organic soil amendments, and other materials to produce planting soil.

D. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified as specified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.

E. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

F. Subsoil: Soil beneath the level of subgrade; soil beneath the topsoil layers of a naturally occurring soil profile, typified by less than 1 percent organic matter and few soil organisms.

G. Surface Soil: Soil that is present at the top layer of the existing soil profile. In undisturbed areas, surface soil is typically called "topsoil"; but in disturbed areas such as urban environments, the surface soil can be subsoil.

H. USCC: U.S. Composting Council.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Samples: For each bulk-supplied material in sealed containers labeled with content, source, and date obtained; providing an accurate representation of composition, color, and texture.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent, state-operated, or university-operated laboratory; experienced in soil science, soil testing, and plant nutrition; with the experience and capability to conduct the testing indicated; and that specializes in types of tests to be performed.

PART 2 - PRODUCTS

2.1 MATERIALS

2.2 PLANTING SOILS SPECIFIED BY COMPOSITION

A. Planting-Soil Type: Existing, on-site surface soil, with the duff layer, if any, retained; and stockpiled on-site; modified to produce viable planting soil. Blend existing, on-site surface soil with the following soil amendments and fertilizers in the following quantities to produce planting soil:

1. Ratio of Loose Compost to Soil: As directed.
2. Ratio of Loose Sphagnum or Muck Peat to Soil: As directed.
3. Ratio of Loose Wood Derivatives Soil: As directed.
4. Weight of Lime: per 1000 sq. ft. (100 sq. m) per 6 inches (150 mm) of soil depth.
5. Weight of Sulfur or Iron Sulfate: per 1000 sq. ft. (100 sq. m) per 6 inches (150 mm) of soil depth.
6. Weight of Agricultural Gypsum: per 1000 sq. ft. (100 sq. m) per 6 inches (150 mm) of soil depth.
7. Weight of Superphosphate: per 1000 sq. ft. (100 sq. m) per 6 inches (150 mm) of soil depth.
8. Weight of Commercial Fertilizer: per 1000 sq. ft. (100 sq. m) per 6 inches (150 mm) of soil depth.
9. Weight of Slow-Release Fertilizer: per 1000 sq. ft. (100 sq. m) per 6 inches (150 mm) of soil depth.

B. Planting-Soil Type: As directed imported, naturally formed soil from off-site sources and consisting of sandy loam, loam, silt loam, loamy sand or sand soil according to USDA textures; and modified to produce viable planting soil.

1. Sources: Take imported, unamended soil from sources that are naturally well-drained sites where topsoil occurs at least 4 inches (100 mm) deep, not from agricultural land, bogs, or marshes; and that do not contain undesirable organisms; disease-causing plant pathogens; or obnoxious weeds and invasive plants including, but not limited to, quackgrass, Johnsongrass, poison ivy, nutsedge, nimblewill, Canada thistle, bindweed, bentgrass, wild garlic, ground ivy, perennial sorrel, and bromegrass.
2. Additional Properties of Imported Soil before Amending: Soil reaction of pH 6 to 7 and minimum of 2, 4 or 6 percent organic-matter content as directed, friable, and with sufficient structure to give good tilth and aeration.
3. Unacceptable Properties: Clean soil of the following:

    a. Unacceptable Materials: Concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, and other extraneous materials that are harmful to plant growth.
    b. Unsuitable Materials: Stones, roots, plants, sod, clay lumps, and pockets of coarse sand that exceed a combined maximum of 8 percent by dry weight of the imported soil.
    c. Large Materials: Stones, clods, roots, clay lumps, and pockets of coarse sand exceeding 2 inches (50 mm) or 3 inches (75 mm) in any dimension as directed.

4. Amended Soil Composition: Blend imported, unamended soil with the following soil amendments and fertilizers in the following quantities to produce planting soil:

    a. Ratio of Loose Compost to Soil: As directed.
    b. Ratio of Loose Sphagnum or Muck Peat to Soil: by volume.
    c. Ratio of Loose Wood Derivatives to Soil: by volume.
    d. Weight of Lime: per 1000 sq. ft. (100 sq. m) per 6 inches (150 mm) of soil depth.
    e. Weight of Sulfur or Iron Sulfate: per 1000 sq. ft. (100 sq. m) per 6 inches (150 mm) of soil depth.
    f. Weight of Agricultural Gypsum: per 1000 sq. ft. (100 sq. m) per 6 inches (150 mm) of soil depth.
    g. Weight of Superphosphate: per 1000 sq. ft. (100 sq. m) per 6 inches (150 mm) of soil depth.
    h. Weight of Commercial Fertilizer: per 1000 sq. ft. (100 sq. m) per 6 inches (150 mm) of soil depth.
    i. Weight of Slow-Release Fertilizer: per 1000 sq. ft. (100 sq. m) per 6 inches (150 mm) of soil depth.

C. Planting-Soil Type: Manufactured soil consisting of manufacturer's basic topsoil, sandy loam according to USDA textures, blended in a manufacturing facility with sand, stabilized organic soil amendments, and other materials to produce viable planting soil.

1. Additional Properties of Manufacturer's Basic Soil before Amending: Soil reaction of pH 6 to 7 and minimum of 2, 4 or 6 percent organic-matter content as directed, friable, and with sufficient structure to give good tilth and aeration.
2. Unacceptable Properties: Manufactured soil shall not contain the following:

    a. Unacceptable Materials: Concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar,

roofing compound, acid, and other extraneous materials that are harmful to plant growth.

b. Unsuitable Materials: Stones, roots, plants, sod, clay lumps, and pockets of coarse sand that exceed a combined maximum of 5 percent by dry weight of the manufactured soil.

c. Large Materials: Stones, clods, roots, clay lumps, and pockets of coarse sand exceeding 1-1/2 inches (38 mm) or 2 inches (50 mm) in any dimension as directed.

3. Blend manufacturer's basic soil with the following soil amendments and fertilizers in the following quantities to produce planting soil:

a. Ratio of Loose Compost to Soil: As directed.
b. Ratio of Loose Sphagnum or Muck Peat to Soil: As directed.
c. Ratio of Loose Wood Derivatives Soil: As directed.
d. Volume of Sand: As directed.
e. Volume of Perlite: As directed.
f. Weight of Lime: As directed.
g. Weight of Sulfur or Iron Sulfate: As directed.
h. Weight of Agricultural Gypsum: As directed.
i. Weight of Superphosphate: As directed.
j. Weight of Commercial Fertilizer: As directed.
k. Weight of Slow-Release Fertilizer: As directed.

2.3 INORGANIC SOIL AMENDMENTS

A. Lime: ASTM C602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:

1. Class: T, with a minimum of 99 percent passing through a No. 8 (2.36-mm) sieve and a minimum of 75 percent passing through a No. 60 (0.25-mm) sieve.
2. Class: O, with a minimum of 95 percent passing through a No. 8 (2.36-mm) sieve and a minimum of 55 percent passing through a No. 60 (0.25-mm) sieve.
3. Form: Provide lime in form of ground as directed.

B. Sulfur: Granular, biodegradable, and containing a minimum of 90 percent elemental sulfur, with a minimum of 99 percent passing through a No. 6 (3.35-mm) sieve and a maximum of 10 percent passing through a No. 40 (0.425-mm) sieve.

C. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur.

D. Perlite: Horticultural perlite, soil amendment grade.

E. Agricultural Gypsum: Minimum 90 percent calcium sulfate, finely ground with 90 percent passing through a No. 50 (0.30-mm) sieve.

F. Sand: Clean, washed, natural or manufactured, free of toxic materials, and according to ASTM C33/C33M.

2.4 ORGANIC SOIL AMENDMENTS

A. Compost: Well-composted, stable, and weed-free organic matter produced by composting feedstock, and bearing USCC's "Seal of Testing Assurance," and as follows:

1. Feedstock: As directed.
2. Reaction: pH of 5.5 to 8.
3. Soluble-Salt Concentration: Less than 4 dS/m.
4. Moisture Content: 35 to 55 percent by weight.
5. Organic-Matter Content: 30 to 40 or 50 to 60 percent of dry weight as directed.
6. Particle Size: As directed.

B. Sphagnum Peat: Partially decomposed sphagnum peat moss, finely divided or of granular texture with 100 percent passing through a 1/2-inch (13-mm) sieve, a pH of 3.4 to 4.8, and a soluble-salt content measured by electrical conductivity of maximum 5 dS/m.

C. Muck Peat: Partially decomposed moss peat, native peat, or reed-sedge peat, finely divided or of granular texture with 100 percent passing through a 1/2-inch (13-mm) sieve, a pH of 6 to 7.5, a soluble-salt content measured by electrical conductivity of maximum 5 dS/m, having a water-absorbing capacity of 1100 to 2000 percent, and containing no sand.

D. Wood Derivatives: Shredded and composted, nitrogen-treated sawdust, ground bark, or wood waste; of uniform texture and free of chips, stones, sticks, soil, or toxic materials.

E. Manure: Well-rotted, unleached, stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed, debris, and material harmful to plant growth.

2.5 FERTILIZERS

A. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of 20, 33 or 50 percent available phosphoric acid as directed.

B. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:

1. Composition: 1 lb/1000 sq. ft. (0.5 kg/100 sq. m) of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.
2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified testing agency.

C. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:

1. Composition: 20 percent nitrogen, 10 percent phosphorous, and 10 percent potassium, by weight.
2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified testing agency.

PART 3 - EXECUTION

3.1 GENERAL

A. Place planting soil and fertilizers according to requirements in other Specification Sections.

B. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in planting soil.

3.2 PREPARATION OF UNAMENDED, ON-SITE SOIL BEFORE AMENDING

A. Excavation: Excavate soil from designated area(s) to a depth of 6 inches (150 mm) and stockpile until amended.

B. Unacceptable Materials: Clean soil of concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, and other extraneous materials that are harmful to plant growth.

C. Unsuitable Materials: Clean soil to contain a maximum of 8 percent by dry weight of stones, roots, plants, sod, clay lumps, and pockets of coarse sand.

D. Screening: Pass unamended soil through a 2-inch (50-mm) or 3-inch (75-mm) sieve to remove large materials as directed.

3.3 PLACING AND MIXING PLANTING SOIL OVER EXPOSED SUBGRADE

A. General: Apply and mix unamended soil with amendments on-site to produce required planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.

B. Subgrade Preparation: As directed, Till subgrade to a minimum depth of 4 inches (100 mm), 6 inches (150 mm), 8 inches (200 mm), 12 inches (300 mm) or 18 inches (450 mm). As directed Remove stones larger than 1-1/2 inches (38 mm), 2 inches (50 mm) or 3 inches (75 mm) in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

C. Mixing: As directed Spread unamended soil to total depth of 4 inches (100 mm), of 6 inches (150 mm), of 8 inches (200 mm) or of 12 inches (300 mm) , but not less than required to meet finish grades after mixing with amendments and natural settlement. Do not spread if soil or subgrade is frozen, muddy, or excessively wet.

1. Amendments: Apply soil amendments, except compost, and fertilizer, if required, evenly on surface, and thoroughly blend them with unamended soil to produce planting soil.

a. Mix lime and sulfur with dry soil before mixing fertilizer.
b. Mix fertilizer with planting soil no more than seven days before planting.

2. Lifts: As directed Apply and mix unamended soil and amendments in lifts not exceeding 8 inches (200 mm) or 12 inches (300 mm) in loose depth for material compacted by compaction equipment, and not more than 4 inches (100 mm) or 6 inches (150 mm) in loose depth for material compacted by hand-operated tampers.

D. Compaction: Compact each blended lift of planting soil to 75 to 82 percent of maximum Standard Proctor density according to ASTM D698 and tested in-place except where a different compaction value is indicated on Drawings.

E. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.4 PLACING MANUFACTURED PLANTING SOIL OVER EXPOSED SUBGRADE

A. General: Apply manufactured soil on-site in its final, blended condition. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.

B. Subgrade Preparation: As directed, Till subgrade to a minimum depth of 4 inches (100 mm), 6 inches (150 mm), 8 inches (200 mm), 12 inches (300 mm) or 18 inches (450 mm). As directed Remove stones larger than 1-1/2 inches (38 mm), 2 inches (50 mm) or 3 inches (75 mm) in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

C. Application: As directed, Spread planting soil to total depth of 4 inches (100 mm), of 6 inches (150 mm), of 8 inches (200 mm), of 12 inches (300 mm) or indicated on Drawings, but not less than required to meet finish grades after natural settlement. Do not spread if soil or subgrade is frozen, muddy, or excessively wet.

1. Lifts: As directed Apply planting soil in lifts not exceeding 8 inches (200 mm) or 12 inches (300 mm) in loose depth for material compacted by compaction equipment, and not more than 4 inches (100 mm) or 6 inches (150 mm) in loose depth for material compacted by hand-operated tampers.

D. Compaction: Compact each lift of planting soil to 75 to 82 percent of maximum Standard Proctor density according to ASTM D698 except where a different compaction value is indicated on Drawings.

E. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.5 BLENDING PLANTING SOIL IN PLACE

A. General: Mix amendments with in-place, unamended soil to produce required planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.

B. Preparation: As directed, Till unamended, existing soil in planting areas to a minimum depth of 4 inches (100 mm), of 6 inches (150 mm), of 8 inches (200 mm), of 12 inches (300 mm), of 18 inches (450 mm) or indicated on Drawings. As directed Remove stones larger than 1-1/2 inches

(38 mm), 2 inches (50 mm) or 3 inches (75 mm) in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

C. Mixing: Apply soil amendments, except compost, and fertilizer, if required, evenly on surface, and thoroughly blend them into full depth of unamended, in-place soil to produce planting soil.

1. Mix lime and sulfur with dry soil before mixing fertilizer.
2. Mix fertilizer with planting soil no more than seven days before planting.

D. Compaction: Compact blended planting soil to 75 to 82 percent of maximum Standard Proctor density according to ASTM D698 except where a different compaction value is indicated on Drawings.

E. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.6 APPLYING COMPOST TO SURFACE OF PLANTING SOIL

A. Application: As directed, apply compost component of planting-soil mix 4 inches (100 mm) of compost or 6 inches (150 mm) of compost to surface of in-place planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.

B. Finish Grading: Grade surface to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.7 FIELD QUALITY CONTROL

A. Testing Agency: As directed Owner will engage or Engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests and inspections:

1. Compaction: Test planting-soil compaction after placing each lift and at completion using a densitometer or soil-compaction meter calibrated to a reference test value based on laboratory testing according to ASTM D698. As directed Space tests at no less than one for each 1000 sq. ft. (100 sq. m) or 2000 sq. ft. (200 sq. m) of in-place soil or part thereof.

C. Soil will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. Label each sample and test report with the date, location keyed to a site plan or other location system, visible conditions when and where sample was taken, and sampling depth.

3.8 PROTECTION AND CLEANING

A. Protection Zone: Identify protection zones according to Section 015639 "Temporary Tree and Plant Protection."

B. Protect areas of in-place soil from additional compaction, disturbance, and contamination. Prohibit the following practices within these areas except as required to perform planting operations:

1. Storage of construction materials, debris, or excavated material.
2. Parking vehicles or equipment.
3. Vehicle traffic.
4. Foot traffic.
5. Erection of sheds or structures.
6. Impoundment of water.
7. Excavation or other digging unless otherwise indicated.

C. Remove surplus soil and waste material including excess subsoil, unsuitable materials, trash, and debris and legally dispose of them off Owner's property unless otherwise indicated.

1. Dispose of excess subsoil and unsuitable materials on-site where directed by Owner.

END OF SECTION 329113

SECTION 329115 - SOIL PREPARATION (PERFORMANCE SPECIFICATION)

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes planting soils specified according to performance requirements of the mixes.

B. Related Requirements:

1. Section 077273 "Vegetated Roof Systems" for growing media (soil).
2. Section 311000 "Site Clearing" for topsoil stripping and stockpiling.

1.2 DEFINITIONS

A. CEC: Cation exchange capacity.

B. Duff Layer: A surface layer of soil, typical of forested areas, that is composed of mostly decayed leaves, twigs, and detritus.

C. Imported Soil: Soil that is transported to Project site for use.

D. Manufactured Soil: Soil produced by blending soils, sand, stabilized organic soil amendments, and other materials to produce planting soil.

E. Organic Matter: The total of organic materials in soil exclusive of undecayed plant and animal tissues, their partial decomposition products, and the soil biomass; also called "humus" or "soil organic matter."

F. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified as specified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.

G. RCRA Metals: Hazardous metals identified by the EPA under the Resource Conservation and Recovery Act.

H. SSSA: Soil Science Society of America.

I. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.

J. Subsoil: Soil beneath the level of subgrade; soil beneath the topsoil layers of a naturally occurring soil profile, typified by less than 1 percent organic matter and few soil organisms.

K. Surface Soil: Soil that is present at the top layer of the existing soil profile. In undisturbed areas, surface soil is typically called "topsoil"; but in disturbed areas such as urban environments, the surface soil can be subsoil.

L. USCC: U.S. Composting Council.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals: As directed.

C. Samples: For each bulk-supplied material in sealed containers labeled with content, source, and date obtained; providing an accurate representation of composition, color, and texture.

1.5 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent, state-operated, or university-operated laboratory; experienced in soil science, soil testing, and plant nutrition; with the experience and capability to conduct the testing indicated; and that specializes in types of tests to be performed.

PART 2 - PRODUCTS

2.1 MATERIALS

2.2 PLANTING SOILS SPECIFIED ACCORDING TO PERFORMANCE REQUIREMENTS

A. Planting-Soil Type: Existing, on-site surface soil, with the duff layer, if any, retained; and stockpiled on-site; modified to produce viable planting soil. Using preconstruction soil analyses and materials specified in other articles of this Section, amend existing, on-site surface soil to become planting soil complying with the following requirements:

1. Particle Size Distribution by USDA Textures: Classified as sandy loam, loam, silt loam, loamy sand or sand soil according to USDA textures.
2. Fragment Size Distribution:

    a. Fine Fragments: As directed.
    b. Medium Fragments: As directed.
    c. Coarse Fragments: As directed.
    d. Sticks and Roots: As directed.
    e. Debris and Other Foreign Materials: As directed.

3. Percentage of Organic Matter: As directed.
4. Soil Reaction: pH of 6 to 7.
5. CEC of Total Soil: As directed.
6. Soluble-Salt Content: 5 to 10 dS/m measured by electrical conductivity.
7. Bulk Density: As directed.
8. Total Porosity: As directed.
9. Macro Porosity: As directed.
10. Fertility: As directed.
11. Microbiological Content: As directed.
12. RCRA Metals: Below maximum limits established by the EPA.
13. Phytotoxicity: Below phytotoxicity limits established by SSSA.

B. Planting-Soil Type: As directed imported, naturally formed soil from off-site sources and consisting of sandy loam, loam, silt loam, loamy sand or sand soil according to USDA textures; and modified to produce viable planting soil. Amend imported soil with materials specified in other articles of this Section to become planting soil complying with the following requirements:

1. Sources: Take imported, unamended soil from sources that are naturally well-drained sites where topsoil occurs at least 4 inches (100 mm) deep, not from agricultural land, bogs, or marshes; and that do not contain undesirable organisms; disease-causing plant pathogens; or obnoxious weeds and invasive plants including, but not limited to, quackgrass, Johnsongrass, poison ivy, nutsedge, nimblewill, Canada thistle, bindweed, bentgrass, wild garlic, ground ivy, perennial sorrel, and bromegrass.
2. Additional Properties of Imported Soil before Amending: As directed minimum of 2, 4 or 6 percent organic-matter content, friable, and with sufficient structure to give good tilth and aeration. Clean soil to be of the following:

    a. Unacceptable Materials: Concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, and other extraneous materials that are harmful to plant growth.
    b. Unsuitable Materials: Stones, roots, plants, sod, clay lumps, and pockets of coarse sand that exceed a combined maximum of 8 percent by dry weight of the imported soil.
    c. Large Materials: Stones, clods, roots, clay lumps, and pockets of coarse sand exceeding 2 inches (50 mm) or 3 inches (75 mm) in any dimension as directed.

3. Fragment Size Distribution:

    a. Fine Fragments: As directed.
    b. Medium Fragments: As directed.
    c. Coarse Fragments: As directed.
    d. Sticks and Roots: As directed.
    e. Debris and Other Foreign Materials: As directed.

4. Percentage of Organic Matter: As directed.
5. Soil Reaction: pH of 6 to 7.
6. CEC of Total Soil: As directed.
7. Soluble-Salt Content: 5 to 10 dS/m measured by electrical conductivity.
8. Bulk Density: As directed.

9. Total Porosity: As directed.
10. Macro Porosity: As directed.
11. Fertility: As directed.
12. Microbiological Content: As directed.
13. RCRA Metals: Below maximum limits established by the EPA.
14. Phytotoxicity: Below phytotoxicity limits established by SSSA.

C. Planting-Soil Type: As directed manufactured soil consisting of manufacturer's basic topsoil, sandy loam according to USDA textures, blended in a manufacturing facility with sand, stabilized organic soil amendments, and other materials as specified in other articles of this Section to produce viable planting soil.

1. Basic Properties: Manufactured soil shall not contain the following:

   a. Unacceptable Materials: Concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, and other extraneous materials that are harmful to plant growth.
   b. Unsuitable Materials: Stones, roots, plants, sod, clay lumps, and pockets of coarse sand that exceed a combined maximum of 5 percent by dry weight of the manufactured soil.
   c. Large Materials: Stones, clods, roots, clay lumps, and pockets of coarse sand exceeding 1-1/2 inches (38 mm) or 2 inches (50 mm) in any dimension as directed.

2. Fragment Size Distribution:

   a. Fine Fragments: As directed.
   b. Medium Fragments: As directed.
   c. Coarse Fragments: As directed.
   d. Sticks and Roots: As directed.
   e. Debris and Other Foreign Materials: As directed.

3. Percentage of Organic Matter: As directed.
4. Soil Reaction: pH of 6 to 7.
5. CEC of Total Soil: As directed.
6. Soluble-Salt Content: 5 to 10 dS/m measured by electrical conductivity.
7. Bulk Density: As directed.
8. Total Porosity: As directed.
9. Macro Porosity: As directed.
10. Fertility: As directed.
11. Microbiological Content: As directed.
12. RCRA Metals: Below maximum limits established by the EPA.
13. Phytotoxicity: Below phytotoxicity limits established by SSSA.

2.3 INORGANIC SOIL AMENDMENTS

A. Lime: ASTM C602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent.

B. Sulfur: Granular, biodegradable, and containing a minimum of 90 percent elemental sulfur, with a minimum of 99 percent passing through a No. 6 (3.35-mm) sieve and a maximum of 10 percent passing through a No. 40 (0.425-mm) sieve.

C. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur.

D. Agricultural Gypsum: Minimum 90 percent calcium sulfate, finely ground with 90 percent passing through a No. 50 (0.30-mm) sieve.

E. Sand: Clean, washed, natural or manufactured, free of toxic materials, and according to ASTM C33/C33M.

2.4 ORGANIC SOIL AMENDMENTS

A. Compost: Well-composted, stable, and weed-free organic matter produced by composting feedstock, and bearing USCC's "Seal of Testing Assurance," and as follows:

1. Feedstock: As directed.
2. Reaction: pH of 5.5 to 8.
3. Soluble-Salt Concentration: Less than 4 dS/m.
4. Moisture Content: 35 to 55 percent by weight.
5. Organic-Matter Content: As directed 30 to 40 or 50 to 60 percent of dry weight.
6. Particle Size: As directed.

B. Sphagnum Peat: Partially decomposed sphagnum peat moss, finely divided or of granular texture, a pH of 3.4 to 4.8, and a soluble-salt content measured by electrical conductivity of maximum 5 dS/m.

C. Muck Peat: Partially decomposed moss peat, native peat, or reed-sedge peat, finely divided or of granular texture, a pH of 6 to 7.5, a soluble-salt content measured by electrical conductivity of maximum 5 dS/m, having a water-absorbing capacity of 1100 to 2000 percent, and containing no sand.

D. Wood Derivatives: Shredded and composted, nitrogen-treated sawdust, ground bark, or wood waste; of uniform texture and free of chips, stones, sticks, soil, or toxic materials.

E. Manure: Well-rotted, unleached, stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed, debris, and material harmful to plant growth.

2.5 FERTILIZERS

A. Superphosphate: Commercial, phosphate mixture, soluble.

B. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium.

C. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium.

PART 3 - EXECUTION

3.1 GENERAL

A. Place planting soil and fertilizers according to requirements in other Specification Sections.

B. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in planting soil.

3.2 PREPARATION OF UNAMENDED, ON-SITE SOIL BEFORE AMENDING

A. Excavation: Excavate soil from designated area(s) to a depth of 6 inches (150 mm) and stockpile until amended.

B. Unacceptable Materials: Clean soil of concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, and other extraneous materials that are harmful to plant growth.

C. Unsuitable Materials: Clean soil to contain a combined maximum of 8 percent by dry weight of stones, roots, plants, sod, clay lumps, and pockets of coarse sand.

D. Screening: Pass unamended soil through a 2-inch (50-mm) or 3-inch (75-mm) sieve to remove large materials as directed.

3.3 PLACING AND MIXING PLANTING SOIL OVER EXPOSED SUBGRADE

A. General: Apply and mix unamended soil with amendments on-site to produce required planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.

B. Subgrade Preparation: As directed.

C. Mixing: As directed.

1. Amendments: Apply soil amendments, except compost, and fertilizer, if required, evenly on surface, and thoroughly blend them with unamended soil to produce planting soil.

    a. Mix lime and sulfur with dry soil before mixing fertilizer.
    b. Mix fertilizer with planting soil no more than seven days before planting.

2. Lifts: As directed apply and mix unamended soil and amendments in lifts not exceeding 8 inches (200 mm) or 12 inches (300 mm) in loose depth for material compacted by compaction equipment, and not more than 4 inches (100 mm) or 6 inches (150 mm) in loose depth for material compacted by hand-operated tampers.

D. Compaction: Compact each blended lift of planting soil to 75 to 82 percent of maximum Standard Proctor density according to ASTM D698 except where a different compaction value is indicated on Drawings.

E. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.4 PLACING MANUFACTURED PLANTING SOIL OVER EXPOSED SUBGRADE

A. General: Apply manufactured soil on-site in its final, blended condition. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.

B. Subgrade Preparation: As directed.

C. Application: As directed.

1. Lifts: As directed apply planting soil in lifts not exceeding 8 inches (200 mm) or 12 inches (300 mm) in loose depth for material compacted by compaction equipment, and not more than 4 inches (100 mm) or 6 inches (150 mm) in loose depth for material compacted by hand-operated tampers.

D. Compaction: Compact each lift of planting soil to 75 to 82 percent of maximum Standard Proctor density according to ASTM D698 except where a different compaction value is indicated on Drawings.

E. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.5 BLENDING PLANTING SOIL IN PLACE

A. General: Mix amendments with in-place, unamended soil to produce required planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.

B. Preparation: As directed.

C. Mixing: Apply soil amendments, except compost, and fertilizer, if required, evenly on surface, and thoroughly blend them into full depth of unamended, in-place soil to produce planting soil.

1. Mix lime and sulfur with dry soil before mixing fertilizer.
2. Mix fertilizer with planting soil no more than seven days before planting.

D. Compaction: Compact blended planting soil to 75 to 82 percent of maximum Standard Proctor density according to ASTM D698 except where a different compaction value is indicated on Drawings.

E. Finish Grading: Grade planting soil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.6 APPLYING COMPOST TO SURFACE OF PLANTING SOIL

A. Application: As directed apply compost component of planting-soil mix 4 inches (100 mm) of compost or 6 inches (150 mm) of compost to surface of in-place planting soil. Do not apply materials or till if existing soil or subgrade is frozen, muddy, or excessively wet.

B. Finish Grading: Grade surface to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.7 FIELD QUALITY CONTROL

A. Testing Agency: As directed owner will engage or Engage a qualified testing agency to perform tests and inspections.

B. Perform the following tests and inspections:

1. Compaction: Test planting-soil compaction after placing each lift and at completion using a densitometer or soil-compaction meter calibrated to a reference test value based on laboratory testing according to ASTM D698. As directed space tests at no less than one for each 1000 sq. ft. (100 sq. m) or 2000 sq. ft. (200 sq. m) of in-place soil or part thereof.
2. Performance Testing: For each amended planting-soil type, demonstrating compliance with specified performance requirements. Perform testing according to "Soil-Sampling Requirements" and "Testing Requirements" articles.

C. Soil will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. Label each sample and test report with the date, location keyed to a site plan or other location system, visible conditions when and where sample was taken, and sampling depth.

3.8 PROTECTION AND CLEANING

A. Protection Zone: Identify protection zones according to Section 015639 "Temporary Tree and Plant Protection."

B. Protect areas of in-place soil from additional compaction, disturbance, and contamination. Prohibit the following practices within these areas except as required to perform planting operations:

1. Storage of construction materials, debris, or excavated material.
2. Parking vehicles or equipment.
3. Vehicle traffic.
4. Foot traffic.
5. Erection of sheds or structures.
6. Impoundment of water.
7. Excavation or other digging unless otherwise indicated.

C. Remove surplus soil and waste material including excess subsoil, unsuitable materials, trash, and debris and legally dispose of them off Owner's property unless otherwise indicated.

1. Dispose of excess subsoil and unsuitable materials on-site where directed by Owner.

END OF SECTION 329115

SECTION 329200 - TURF AND GRASSES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Seeding.
2. Sodding.

1.2 DEFINITIONS

A. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. This includes insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. It also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.

B. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth. As directed see Section 329113 "Soil Preparation" or Section 329115 "Soil Preparation (Performance Specification)" and drawing designations for planting soils.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 INFORMATIONAL SUBMITTALS

A. Certification of grass seed.

1. Certification of each seed mixture for turfgrass sod.

B. Product certificates.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape Installer whose work has resulted in successful turf establishment.

1. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
2. Personnel Certifications: Installer's field supervisor shall have certification in one of the following categories from the National Association of Landscape Professionals:

a. Landscape Industry Certified Technician - Exterior.
b. Landscape Industry Certified Lawn Care Manager.
c. Landscape Industry Certified Lawn Care Technician.

3. Pesticide Applicator: State licensed, commercial.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Seed and Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of compliance with state and Federal laws, as applicable.

B. Sod: Harvest, deliver, store, and handle sod according to requirements in "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation" sections in TPI's "Guideline Specifications to Turfgrass Sodding." Deliver sod within 24 hours of harvesting and in time for planting promptly. Protect sod from breakage and drying.

PART 2 - PRODUCTS

2.1 SEED

A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Rules for Testing Seeds" for purity and germination tolerances.

B. Seed Species:

1. Quality: State-certified seed of grass species as listed below for solar exposure.
2. Quality: Seed of grass species as listed below for solar exposure, with not less than 85 percent germination, not less than 95 percent pure seed, and not more than 0.5 percent weed seed:
3. Full Sun: As directed.
4. Sun and Partial Shade: Proportioned by weight as follows: As directed

5. Shade: Proportioned by weight as follows: As directed.

C. Grass-Seed Mix: Proprietary seed mix as follows:

1. Products: Subject to compliance with requirements as directed.

2.2 TURFGRASS SOD

A. Turfgrass Sod: As directed certified, Approved or Number 1 Quality/Premium, including limitations on thatch, weeds, diseases, nematodes, and insects, complying with "Specifications for Turfgrass Sod Materials" in TPI's "Guideline Specifications to Turfgrass Sodding." Furnish viable sod of uniform density, color, and texture that is strongly rooted and capable of vigorous growth and development when planted.

B. Turfgrass Species: Sod of grass species as follows:

1. Full Sun: As directed.
2. Sun and Partial Shade: Proportioned by weight as follows: As directed.
3. Shade: Proportioned by weight as follows: As directed.

2.3 FERTILIZERS

A. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:

1. Composition: 1 lb/1000 sq. ft. (0.45 kg/92.9 sq. m) of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.

B. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:

1. Composition: 20 percent nitrogen, 10 percent phosphorous, and 10 percent potassium, by weight.

2.4 MULCHES

A. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley.

B. Sphagnum Peat Mulch: Partially decomposed sphagnum peat moss, finely divided or of granular texture, and with a pH range of 3.4 to 4.8.

C. Muck Peat Mulch: Partially decomposed moss peat, native peat, or reed-sedge peat, finely divided or of granular texture, with a pH range of 6 to 7.5, and having a water-absorbing capacity of 1100 to 2000 percent, and containing no sand.

D. Compost Mulch: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1-inch (25-mm) sieve; soluble salt content of 2 to 5 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:

2.5 PESTICIDES

A. General: Pesticide, registered and approved by the EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

PART 3 - EXECUTION

3.1 TURF AREA PREPARATION

A. General: Prepare planting area for soil placement and mix planting soil according to Section 329113 "Soil Preparation" or Section 329115 "Soil Preparation (Performance Specification)" as directed.

B. Reduce elevation of planting soil to allow for soil thickness of sod.

C. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

D. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

3.2 SEEDING

A. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph (8 km/h).

1. Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.
2. Do not use wet seed or seed that is moldy or otherwise damaged.
3. Do not seed against existing trees. Limit extent of seed to outside edge of planting saucer.

B. Sow seed at a total rate as directed.

C. Rake seed lightly into top 1/8 inch (3 mm) of soil, roll lightly, and water with fine spray.

D. Protect seeded areas with slopes not exceeding 1:6 by spreading straw mulch. Spread uniformly at a minimum rate of 2 tons/acre (42 kg/92.9 sq. m) to form a continuous blanket 1-1/2 inches (38 mm) in loose thickness over seeded areas.

1. Anchor straw mulch by crimping into soil with suitable mechanical equipment.

E. As directed protect seeded areas from hot, dry weather or drying winds by applying compost mulch, peat mulch or planting soil within 24 hours after completing seeding operations. Soak areas, scatter mulch uniformly to a thickness of 3/16 inch (4.8 mm), and roll surface smooth.

3.3 SODDING

A. Lay sod within 24 hours of harvesting. Do not lay sod if dormant or if ground is frozen or muddy.

B. Lay sod to form a solid mass with tightly fitted joints. Butt ends and sides of sod; do not stretch or overlap. Stagger sod strips or pads to offset joints in adjacent courses. Avoid damage to soil or sod during installation. Tamp and roll lightly to ensure contact with soil, eliminate air

pockets, and form a smooth surface. Work sifted soil or fine sand into minor cracks between pieces of sod; remove excess to avoid smothering sod and adjacent grass.

1. Lay sod across slopes exceeding 1:3.
2. Anchor sod on slopes exceeding 1:6 with wood pegs or steel staples spaced as recommended by sod manufacturer but not less than two anchors per sod strip to prevent slippage.

C. Saturate sod with fine water spray within two hours of planting. During first week after planting, water daily or more frequently as necessary to maintain moist soil to a minimum depth of 1-1/2 inches (38 mm) below sod.

3.4 TURF MAINTENANCE

A. General: Maintain and establish turf by watering, fertilizing, weeding, mowing, trimming, replanting, and performing other operations as required to establish healthy, viable turf. Roll, regrade, and replant bare or eroded areas and remulch to produce a uniformly smooth turf. Provide materials and installation the same as those used in the original installation.

B. Mow turf as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than one-third of grass height. Remove no more than one-third of grass-leaf growth in initial or subsequent mowings.

3.5 SATISFACTORY TURF

A. Turf installations shall meet the following criteria as determined by Architect:

1. Satisfactory Seeded Turf: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding 90 percent over any 10 sq. ft. (0.92 sq. m) and bare spots not exceeding 5 by 5 inches (125 by 125 mm).
2. Satisfactory Sodded Turf: At end of maintenance period, a healthy, well-rooted, even-colored, viable turf has been established, free of weeds, open joints, bare areas, and surface irregularities.

B. Use specified materials to reestablish turf that does not comply with requirements, and continue maintenance until turf is satisfactory.

END OF SECTION 329200

SECTION 329300 - PLANTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Plants.
2. Tree-watering devices.
3. Landscape edgings.

B. Related Requirements:

1. Section 329600 "Transplanting" for transplanting non-nursery-grown trees.

1.2 DEFINITIONS

A. Backfill: The earth used to replace or the act of replacing earth in an excavation.

B. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. Pesticides include insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. They also include substances or mixtures intended for use as a plant regulator, defoliant, or desiccant. Some sources classify herbicides separately from pesticides.

C. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth. As directed see Section 329113 "Soil Preparation" or Section 329115 "Soil Preparation (Performance Specification)" for drawing designations for planting soils.

D. Root Flare: Also called "trunk flare." The area at the base of the plant's stem or trunk where the stem or trunk broadens to form roots; the area of transition between the root system and the stem or trunk.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples of each type of mulch.

1.5 INFORMATIONAL SUBMITTALS

A. Product certificates.

B. Sample warranty.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: Recommended procedures to be established by Owner for maintenance of plants during a calendar year.

1.7 QUALITY ASSURANCE

A. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.

1. Pesticide Applicator: State licensed, commercial.

B. Provide quality, size, genus, species, and variety of plants indicated, complying with applicable requirements in ANSI Z60.1.

1.8 DELIVERY, STORAGE, AND HANDLING

A. As directed deliver bare-root stock plants within 24 hours or 36 hours of digging. Immediately after digging up bare-root stock, pack root system in wet straw, hay, or other suitable material to keep root system moist until planting. Transport in covered, temperature-controlled vehicles, and keep plants cool and protected from sun and wind at all times.

B. Do not prune trees and shrubs before delivery. Protect bark, branches, and root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Provide protective covering of plants during shipping and delivery. Do not drop plants during delivery and handling.

C. Handle planting stock by root ball.

D. Store bulbs, corms, and tubers in a dry place at 60 to 65 deg F (16 to 18 deg C) until planting.

E. Deliver plants after preparations for planting have been completed, install immediately. If planting is delayed more than six hours after delivery, set plants and trees in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.

1.9 WARRANTY

A. Special Warranty: Installer agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.

1. Failures include, but are not limited to, the following:

    a. Death and unsatisfactory growth, except for defects resulting from abuse, lack of adequate maintenance, or neglect by Owner.
    b. Structural failures including plantings falling or blowing over.

2. Warranty Periods: As directed from date of planting completion or Substantial Completion.

    a. Trees, Shrubs, Vines, and Ornamental Grasses: 12 months.
    b. Ground Covers, Biennials, Perennials, and Other Plants: As directed.
    c. Annuals: As directed Three or Two months.

PART 2 - PRODUCTS

2.1 PLANT MATERIAL

A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated in Plant List, Plant Schedule, or Plant Legend indicated on Drawings and complying with ANSI Z60.1; and with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.

B. Root-Ball Depth: Furnish trees and shrubs with root balls measured from top of root ball, which begins at root flare according to ANSI Z60.1. Root flare shall be visible before planting.

C. Annuals and Biennials: Provide healthy, disease-free plants of species and variety shown or listed, with well-established root systems reaching to sides of the container to maintain a firm ball, but not with excessive root growth encircling the container. Provide only plants that are acclimated to outdoor conditions before delivery and that are in bud but not yet in bloom.

2.2 FERTILIZERS

A. Planting Tablets: Tightly compressed chip-type, long-lasting, slow-release, commercial-grade planting fertilizer in tablet form. Tablets shall break down with soil bacteria, converting nutrients into a form that can be absorbed by plant roots.

1. Size: As directed.
2. Nutrient Composition: 20 percent nitrogen, 10 percent phosphorous, and 5 percent potassium, by weight plus micronutrients.

2.3 MULCHES

A. Organic Mulch: As directed.

B. Mineral Mulch: As directed.

1. Size Range: As directed 1-1/2 inches (38 mm) maximum, 3/4 inch (19 mm) minimum or 3/4 inch (19 mm) maximum, 1/4 inch (6.4 mm) minimum.
2. Color: As directed uniform tan-beige color range acceptable to Architect or readily available natural gravel color range.

2.4 WEED-CONTROL BARRIERS

A. Nonwoven Geotextile Filter Fabric: Polypropylene or polyester fabric, 3 oz./sq. yd. (101g/sq. m) minimum, composed of fibers formed into a stable network so that fibers retain their relative position. Fabric shall be inert to biological degradation and resist naturally encountered chemicals, alkalis, and acids.

B. Composite Fabric: Woven, needle-punched polypropylene substrate bonded to a nonwoven polypropylene fabric, 4.8 oz./sq. yd. (162 g/sq. m).

2.5 PESTICIDES

A. General: Pesticide registered and approved by the EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

2.6 LANDSCAPE EDGINGS

A. Wood Edging: Of sizes indicated on Drawings, and wood stakes as follows:

1. Species: As directed western red cedar, all heart or Southern pine with specified wood pressure-preservative treatment.
2. Stakes: Same species as edging, 1-by-2-inch nominal (19-by-38-mm actual) by 18 inches (450 mm) long, with galvanized nails for anchoring edging.

B. Steel Edging: Standard commercial-steel edging, fabricated in sections of standard lengths, with loops stamped from or welded to face of sections to receive stakes.
1. Edging Size: As directed.
2. Finish: As directed Zinc coated or Unfinished.

C. Aluminum Edging: Standard-profile extruded-aluminum edging, ASTM B221 (ASTM B221M), Alloy 6063-T6, fabricated in standard lengths with interlocking sections with loops stamped from face of sections to receive stakes.
1. Edging Size: As directed.
2. Finish: As directed.

D. Plastic Edging: As directed standard black polyethylene or vinyl edging, V-lipped bottom or horizontally grooved, extruded in standard lengths, with 9-inch (225-mm) steel angle or plastic stakes.
1. Edging Size: As directed 0.1 inch (2.5 mm) thick by 5 inches (125 mm) deep or 0.07 inch (1.8 mm) thick by 5 inches (125 mm) deep.

2.7 TREE-WATERING DEVICES

A. Slow-Release Watering Device: Standard product manufactured for drip irrigation of plants and emptying its water contents over an extended time period; manufactured from UV-light-stabilized nylon-reinforced polyethylene sheet, PVC, or HDPE plastic.

PART 3 - EXECUTION

3.1 PLANTING AREA ESTABLISHMENT

A. General: Prepare planting area for soil placement and mix planting soil according to Section 329113 "Soil Preparation" or Section 329115 "Soil Preparation (Performance Specification)" as directed

B. Placing Planting Soil: As directed.

C. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

3.2 EXCAVATION FOR TREES AND SHRUBS

A. Planting Pits and Trenches: Excavate circular planting pits.

1. Excavate planting pits with sides sloping inward at a 45-degree angle. Excavations with vertical sides are unacceptable. Trim perimeter of bottom leaving center area of bottom raised slightly to support root ball and assist in drainage away from center. Do not further disturb base. Ensure that root ball will sit on undisturbed base soil to prevent settling. Scarify sides of planting pit smeared or smoothed during excavation.
2. Excavate approximately three times as wide as ball diameter.
3. Excavate at least 12 inches (300 mm) wider than root spread and deep enough to accommodate vertical roots for bare-root stock.
4. Do not excavate deeper than depth of the root ball, measured from the root flare to the bottom of the root ball.

B. Backfill Soil: Subsoil and topsoil removed from excavations may or may not be used as backfill soil unless otherwise indicated.

3.3 TREE, SHRUB, AND VINE PLANTING

A. Inspection: At time of planting, verify that root flare is visible at top of root ball according to ANSI Z60.1. If root flare is not visible, remove soil in a level manner from the root ball to where the top-most root emerges from the trunk. After soil removal to expose the root flare, verify that root ball still meets size requirements.

B. Roots: Remove stem girdling roots and kinked roots. Remove injured roots by cutting cleanly; do not break.

C. As directed set each plant plumb and in center of planting pit or trench with root flare 1 inch (25 mm) above or 2 inches (50 mm) above adjacent finish grades.

1. Backfill: Planting soil. For trees, use excavated soil for backfill.
2. Balled and Burlapped Stock: After placing some backfill around root ball to stabilize plant, carefully cut and remove burlap, rope, and wire baskets from tops of root balls and from sides, but do not remove from under root balls. Remove pallets, if any, before setting. Do not use planting stock if root ball is cracked or broken before or during planting operation.
3. Balled and Potted and Container-Grown Stock: Carefully remove root ball from container without damaging root ball or plant.
4. Fabric Bag-Grown Stock: Carefully remove root ball from fabric bag without damaging root ball or plant. Do not use planting stock if root ball is cracked or broken before or during planting operation.
5. Bare-Root Stock: Support stem of each plant and spread roots without tangling or turning toward surface. Plumb before backfilling and maintain plumb while working. Carefully work backfill around roots by hand. Bring roots into close contact with the soil.
6. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
7. Place planting tablets equally distributed around each planting pit when pit is approximately one-half filled. Place tablets beside the root ball about 1 inch (25 mm) from root tips; do not place tablets in bottom of the hole.
    a. Bare-Root Stock: Place tablets beside soil-covered roots; do not place tablets touching the roots.
    b. Quantity: Two per plant or three for each caliper inch of plant as directed.
8. Continue backfilling process. Water again after placing and tamping final layer of soil.

D. Slopes: When planting on slopes, set the plant so the root flare on the uphill side is flush with the surrounding soil on the slope; the edge of the root ball on the downhill side will be above the surrounding soil. Apply enough soil to cover the downhill side of the root ball.

3.4 TREE, SHRUB, AND VINE PRUNING

A. Remove only dead, dying, or broken branches. Do not prune for shape.

B. Prune, thin, and shape trees, shrubs, and vines as directed by Architect.

C. Prune, thin, and shape trees, shrubs, and vines according to standard professional horticultural and arboricultural practices. Unless otherwise indicated by Architect, do not cut tree leaders; remove only injured, dying, or dead branches from trees and shrubs; and prune to retain natural character.

D. Do not apply pruning paint to wounds.

3.5 GROUND COVER AND PLANT PLANTING

A. Set out and space ground cover and plants other than trees, shrubs, and vines as directed.

B. Use planting soil for backfill.

C. Dig holes large enough to allow spreading of roots.

D. Work soil around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water.

E. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.

F. Protect plants from hot sun and wind; remove protection if plants show evidence of recovery from transplanting shock.

3.6 PLANTING AREA MULCHING

A. Install weed-control barriers before mulching according to manufacturer's written instructions. As directed completely cover area to be mulched, overlapping edges a minimum of 6 inches (150 mm) or 12 inches (300mm) and secure seams with galvanized pins.

B. Mulch backfilled surfaces of planting areas and other areas indicated.

1. Trees and Treelike Shrubs in Turf Areas: As directed apply organic or mineral mulch ring of 2-inch (50-mm) or 3-inch (75-mm) average thickness, with 12-inch (300-mm), 24-inch (600-mm) or 36-inch (900-mm) radius around trunks or stems. Do not place mulch within 3 inches (75 mm) or 6 inches (150 mm) of trunks or stems.
2. Organic Mulch and Mineral Mulch in Planting Areas: As directed apply 2-inch (50-mm) or 3-inch (75-mm) average thickness of organic mulch extending 12 inches (300 mm) beyond edge of individual planting pit or trench and over whole surface of planting area, and finish level with adjacent finish grades. Do not place mulch within 3 inches (75 mm) or 6 inches (150 mm) of trunks or stems.

3.7 EDGING INSTALLATION

A. Wood Edging: Install edging where indicated. Mitre cut joints and connections at a 45-degree angle. Fasten each cut joint or connection with two galvanized nails. Anchor with wood stakes spaced up to 36 inches (900 mm) apart, driven at least 1 inch (25 mm) below top elevation of edging. Use two galvanized nails per stake to fasten edging, of length as needed to penetrate both edging and stake and provide 1/2-inch (13-mm) clinch at point. Predrill stakes if needed to avoid splitting. Replace stakes that crack or split during installation process.

B. Steel Edging: Install steel edging where indicated according to manufacturer's written instructions. Anchor with steel stakes spaced approximately 30 inches (760 mm) apart, driven below top elevation of edging.

C. Aluminum Edging: Install aluminum edging where indicated according to manufacturer's written instructions. As directed anchor with aluminum stakes spaced approximately 36 inches (900 mm) or 48 inches (1200 mm) apart, driven below top elevation of edging.

D. Plastic Edging: Install plastic edging where indicated according to manufacturer's written instructions. As directed anchor with steel stakes spaced approximately 36 inches (900 mm) or 48 inches (1200 mm) apart, driven through upper base grooves or V-lip of edging.

E. Shovel-Cut Edging: Separate mulched areas from turf areas, curbs, and paving with a 45-degree, 4- to 6-inch- (100- to 150-mm-) deep, shovel-cut edge as indicated.

3.8 INSTALLING SLOW-RELEASE WATERING DEVICE

A. Provide one device for each tree.

3.9 PLANT MAINTENANCE

A. Maintain plantings by pruning, cultivating, watering, weeding, fertilizing, mulching, restoring planting saucers, resetting to proper grades or vertical position, and performing other operations as required to establish healthy, viable plantings.

B. Fill in, as necessary, soil subsidence that may occur because of settling or other processes. Replace mulch materials damaged or lost in areas of subsidence.

C. Apply treatments as required to keep plant materials, planted areas, and soils free of pests and pathogens or disease. Use integrated pest management practices when possible to minimize use of pesticides and reduce hazards. Treatments include physical controls such as hosing off foliage, mechanical controls such as traps, and biological control agents.

D. Apply pesticides and other chemical products and biological control agents according to authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

E. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plantings.

F. At time of Substantial Completion, verify that tree-watering devices are in good working order and leave them in place. Replace improperly functioning devices.

3.10 MAINTENANCE SERVICE

A. Maintenance Service: Provide maintenance by skilled employees of landscape Installer. Maintain as required in "Plant Maintenance" Article. Begin maintenance immediately after plants are installed and continue until plantings are acceptably healthy and well established, but for not less than maintenance period below:

1. Maintenance Period for Trees and Shrubs: As directed 12, Six or Three months from date of planting completion or Substantial Completion.
2. Maintenance Period for Ground Cover and Other Plants: Six or Three months from date of planting completion or Substantial Completion as directed.

END OF SECTION 329300

SECTION 329600 - TRANSPLANTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes transplanting non-nursery-grown trees by tree spade.

1.2 DEFINITIONS

A. General: See definitions in ANSI A300 (Part 6) and in ANSI Z60.1 pertaining to field-grown trees, except as otherwise defined in this Section.

B. Caliper: Diameter of a trunk as measured by a diameter tape or the average of the smallest and largest diameters at a height 6 inches (150 mm) above the root flair for trees up to, and including, 4-inch (100-mm) size at this height; and as measured at a height of 12 inches (300 mm) above the root flair for trees larger than 4-inch (100-mm) size.

C. Root-Ball Depth: Measured from bottom of trunk flare to the bottom of root ball.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Pruning Schedule: Written schedule prepared by arborist detailing scope and extent of pruning each tree in preparation for and subsequent to transplanting.

1.5 INFORMATIONAL SUBMITTALS

A. Certification: From arborist, certifying that transplanted trees have been protected during construction and that trees were promptly and properly treated and repaired when damaged.

B. Maintenance Recommendations: From arborist, recommended procedures to be established by Owner for care and protection of trees after completing the Work.

C. Existing Conditions: Documentation of existing trees indicated to be transplanted, which establishes preconstruction conditions that might be misconstrued as damage caused by construction activities.

D. Tree-maintenance reports.

1.6 QUALITY ASSURANCE

A. Tree-Service Firm Qualifications: An experienced landscaping contractor or tree-moving firm that has successfully completed transplanting work similar to that required for this Project and that will assign an experienced, qualified arborist to Project site during execution of the Work.

1. Arborist Qualifications: Certified Arborist as certified by ISA, licensed arborist in jurisdiction where Project is located, current member of ASCA, or registered Consulting Arborist as designated by ASCA.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Protect bark, branches, and root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees in such a manner as to destroy their natural shape.

B. Completely cover foliage when transporting trees while they are in foliage.

C. Handle trees by root ball. Do not drop trees.

D. Move trees after preparations for planting have been completed and install immediately. If planting is delayed more than six hours after moving, set trees in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.

1.8 FIELD CONDITIONS

A. Field Measurements: Verify final grade elevations and final locations of trees and construction contiguous with trees by field measurements before proceeding with transplanting work. Perform transplanting only after finish grades are established.

B. Seasonal Restrictions: Transplant trees during the following in-season periods:

1. Spring: As directed.
2. Summer: As directed.
3. Fall: As directed.
4. Winter: As directed.

1.9 MAINTENANCE SERVICE

A. Initial Maintenance Service: Provide tree maintenance by skilled employees of tree-service firm and as required in Part 3. As directed begin maintenance immediately after preparatory pruning or trees are installed and continue until plantings are healthy and well established but for not less than maintenance period below.

1. Maintenance Period: As directed, 12 or 18 months from date of transplanting completion or Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. General Performance: As directed, transplanted trees shall be healthy and resume vigorous growth within one year or two years of transplanting without dieback due to defective extracting, handling, planting, maintenance, or other defects in the Work.

2.2 PLANTING MATERIALS

A. Backfill Soil: As directed, excavated soil, Excavated soil mixed with planting soil or planting soil of suitable moisture content and granular texture for placing and compacting in planting pit around tree, and free of stones, roots, plants, sod, clods, clay lumps, pockets of coarse sand, concrete slurry, concrete layers or chunks, cement, plaster, building debris, and other extraneous materials harmful to plant growth.

1. Mixture: Well-blended mix of two parts excavated soil to one part planting soil.
2. Planting Soil: As directed planting soil as specified in Section 329113 "Soil Preparation" Or Section 329115 "Soil Preparation (Performance Specification)."

2.3 WATERING DEVICES

A. Watering Pipe: PVC pipe 4 inches (100 mm) in diameter, site-cut to length as required, and with snug-fitting removable cap.

B. Slow-Release Watering Device: Standard product manufactured for drip-irrigation of plants and emptying its water contents over a period of 2 to 9 hours; manufactured from UV-light stabilized nylon-reinforced polyethylene sheet, PVC, or HDPE plastic.

2.4 MISCELLANEOUS PRODUCTS

A. Organic Mulch: As directed.

B. Mineral Mulch: As directed.

C. Anti-desiccant: Water-insoluble emulsion, permeable moisture retarder, film forming, for trees. Deliver in original, sealed, and fully labeled containers and mix according to manufacturer's written instructions.

D. Burlap: Non-synthetic, biodegradable.

E. Pesticides: Pesticide registered and approved by EPA, acceptable to authorities having jurisdiction, and of type recommended in writing by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

F. Planting Tablets: Tightly compressed chip type, long-lasting, slow-release, commercial-grade planting fertilizer in tablet form. Tablets shall break down with soil bacteria, converting nutrients into a form that can be absorbed by plant roots.

1. Size: As directed.
2. Nutrient Composition: 20 percent nitrogen, 10 percent phosphorous, and 5 percent potassium, by weight plus micronutrients.

G. Weed-Control Barriers:

1. Nonwoven Geotextile Filter Fabric: Polypropylene or polyester fabric, 3 oz./sq. yd. (101 g/sq. m) minimum.
2. Composite Fabric: Woven, needle-punched polypropylene substrate bonded to a nonwoven polypropylene fabric, 4.8 oz./sq. yd. (162 g/sq. m).

PART 3 - EXECUTION

3.1 PREPARATION

A. Utility Locator Service: Notify utility locator service for area where Project is located before beginning excavation.

B. Lay out individual transplant locations and areas for multiple plantings and obtain Architect's acceptance of layout before transplanting.

C. Apply anti-desiccant to trees uniformly, using power spray to provide an adequate film over trunks (before wrapping), branches, stems, twigs, and foliage to protect during extracting, handling, and transportation.

1. If deciduous trees are moved in full leaf, spray with anti-desiccant before extracting and again two weeks after transplanting.

D. Wrap trees with burlap fabric over trunks, branches, stems, twigs, and foliage to protect from wind and other damage during extracting, handling, and transporting.

3.2 PREPARATORY PRUNING

A. Root Pruning: Perform preparatory root pruning under direction of arborist as far in advance of extracting each tree as the Project Schedule allows.

B. Crown Pruning (Tip Pruning):

1. Do not perform preparatory crown pruning (tip pruning).
2. As directed perform preparatory crown pruning as shown on Drawings, under direction of arborist or as directed by arborist. Follow procedures as specified in "Crown Pruning" Article.

3.3 EXCAVATING PLANTING PITS

A. General: Excavate under supervision of the arborist. Keep excavations covered or otherwise protected until replanting trees.

B. As directed subsoil and topsoil removed from excavations may or may not be used as planting soil.

C. Obstructions: Notify Architect if unexpected rock or obstructions detrimental to trees are encountered in excavations.

D. Seepage: Notify Architect if subsoil conditions evidence unexpected water seepage into tree-planting pits.

3.4 EXTRACTING TREES

A. General: Extract trees under supervision of the arborist.

B. Orientation Marking: Mark the north side of each tree with non-permanent paint before extracting.

C. Root-Ball Width: Minimum 10 inches (250 mm) of root-ball diameter, or least dimension for non-round root balls, for each inch (25 mm) of tree caliper being transplanted.

1. Out-of-Season Planting: If planting before or after the in-season period for tree, provide a minimum root-ball diameter of 12 inches (305 mm) for each inch (25 mm) of tree caliper being transplanted.

D. Root-Ball Depth: As determined by the arborist for each species and size of tree and for site conditions at original and planting locations.

E. Digging:

1. Dig and clear a pit with tree spade to the depth of the root system.
2. Cut exposed roots manually with sharp pruning instruments; do not break, tear, chop, or slant the cuts. Do not paint or apply sealants on cut root ends.
3. Cover roots with burlap and keep them moist until planted.

F. Extracting with Tree Spade: Use the same tree spade to extract the tree as will be used to transport and plant the tree.

3.5 PLANTING

A. Planting Standard: Perform planting according to ANSI A300 (Part 6) unless otherwise indicated.

B. Before planting, verify that root flare is visible at top of root ball. If root flare is not visible, remove soil in a level manner from the root ball to where the top-most root emerges from the trunk. After soil removal to expose the root flare, verify that root ball still meets size requirements.

C. Ensure that root flare is visible after planting.

D. Remove injured roots by cutting cleanly; do not break. Do not paint or apply sealants on cut root ends.

E. Orientation: Position the tree so that its north side, marked before extracting, is facing north in its new location.

F. As directed set tree plumb and in center of planting pit with bottom or top of root flare 1 inch (25 mm) or 2 inches (50 mm) above adjacent finish grades.

1. Use specified backfill soil for backfill.
2. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
3. Redirect exposed root ends downward in backfill areas where possible. Hand-expose roots as required to bend and redirect them without breaking.
4. Place planting tablets in each planting pit when pit is approximately one-half filled; in amounts recommended by arborist. Place tablets beside the root ball about 1 inch (25 mm) from root tips; do not place tablets in bottom of the hole.
5. Continue backfilling process. Water again after placing and tamping final layer of soil.

G. Watering Pipe: As directed during backfilling, install watering pipe 4 feet (1220 mm) deep into the planting pit outside the root ball with top of pipe 1 inch (25 mm) above the mulched surface.

H. Planting with Tree Spade: Use the same tree spade for planting as was used to extract and transport the tree.

I. Slopes: When planting on slopes, set the tree so the root flare on the uphill side is flush with the surrounding soil on the slope; the edge of the root ball on the downhill side will be above the surrounding soil. Apply enough soil to cover the downhill side of the root ball.

3.6 CROWN PRUNING

A. As directed prune branches under direction of arborist or as directed by arborist.

1. Prune to remove only injured, broken, dying, or dead branches. Do not prune for shape.
2. Do not remove or reduce living branches to compensate for root loss caused by cutting root system or to improve natural tree form.
3. Pruning Standards: Perform pruning according to ANSI A300 (Part 1).

3.7 TREE STABILIZATION

A. As directed stabilize tree as directed by arborist.

3.8 MULCHING

A. Install weed-control barriers before mulching according to manufacturer's written instructions. As directed completely cover area to be mulched, overlapping edges a minimum of 6 inches (150 mm) or 12 inches (300 mm) and secure seams with galvanized pins.

B. Organic Mulch: As directed apply 2-inch (50-mm) or 3-inch (75-mm) average thickness of organic mulch extending 12 inches (300 mm) beyond edge of individual planting pit and over whole surface of planting area, and finish level with adjacent finish grades. Do not place mulch within 3 inches (75 mm) or 6 inches (150 mm) of trunks or stems.

C. Mineral Mulch in Planting Areas: As directed apply 2-inch (50-mm) or 3-inch (75-mm) average thickness of mineral mulch extending 12 inches (300 mm) beyond edge of individual planting pit and over whole surface of planting area, and finish level with adjacent finish grades. Do not place mulch within 3 inches (75 mm) or 6 inches (150 mm) of trunks or stems.

3.9 INSTALLING SLOW-RELEASE WATERING DEVICE

A. Provide one device for each tree.

B. Place device on top of the mulch at base of tree and fill with water according to manufacturer's written instructions.

3.10 TREE MAINTENANCE

A. Perform tree maintenance as recommended by arborist. Maintain arborist observation of transplanting work.

B. Maintain trees by pruning, cultivating, watering, weeding, fertilizing, mulching, restoring planting saucers, adjusting and repairing tree-stabilization devices, resetting to proper grades or vertical position, and performing other operations as required to establish healthy, viable plantings. Treat as required to keep trees free of insects and disease.

C. From time of preparatory root pruning or tree extraction measure soil moisture adjacent to edge of each root ball weekly. Record findings and weather conditions.

D. Fill areas of soil subsidence with backfill soil. Replenish mulch materials damaged or lost in areas of subsidence.

E. Apply treatments as required to keep tree materials, planted areas, and soils free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards. Treatments include physical controls such as hosing off foliage, mechanical controls such as traps, and biological control agents.

F. Pesticide Application: Apply pesticides and other chemical products and biological control agents in accordance with authorities having jurisdiction and manufacturer's written instructions. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

G. Reports: Have arborist prepare monthly inspection reports.

3.11 REPAIR AND REPLACEMENT

A. General: Repair or replace transplanted trees and other plants indicated to remain or be relocated that are damaged by construction operations, in a manner recommended by the arborist and approved by Architect.

1. Submit details of proposed pruning and repairs.
2. Perform repairs of damaged trunks, branches, and roots within 24 hours according to arborist's written instructions.
3. Replace trees and other plants that cannot be repaired and restored to full-growth status, as determined by Architect.

B. Remove and replace trees that are more than 25 percent dead or in an unhealthy condition before the end of the corrections period or are damaged during construction operations that Architect determines are incapable of restoring to normal growth pattern.

1. Provide new trees of same size and species as those being replaced.

3.12 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Except for materials indicated to be recycled, remove surplus soil, excess excavated material, waste materials, displaced plants, trash, and debris, and legally dispose of them off Owner's property.

END OF SECTION 329600

SECTION 330500 - COMMON WORK RESULTS FOR UTILITIES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Piping joining materials.
2. Dielectric fittings.
3. Sleeves.
4. Identification devices.
5. Grout.
6. Piping system common requirements.
7. Equipment installation common requirements.
8. Concrete bases.
9. Metal supports and anchorages.

1.2 DEFINITIONS

A. Exposed Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions.

B. Concealed Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

1.3 ACTION SUBMITTALS

A. Product Data: For the following:

1. Dielectric fittings.
2. Identification devices.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.5 QUALITY ASSURANCE

A. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Steel Piping Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. Comply with ASME A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.

PART 2 - PRODUCTS

2.1 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch (3.2-mm) maximum thickness, unless otherwise indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

2. AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

D. Solder Filler Metals: ASTM B32, lead-free alloys. Include water-flushable flux according to ASTM B813.

E. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

F. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

G. Solvent Cements for Joining Plastic Piping:

1. ABS Piping: ASTM D2235.
2. CPVC Piping: ASTM F493.
3. PVC Piping: ASTM D2564. Include primer according to ASTM F656.
4. PVC to ABS Piping Transition: ASTM D3138.

H. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

2.2 DIELECTRIC FITTINGS

A. Dielectric Fittings, General: Assembly of copper alloy and ferrous materials or ferrous material body with separating nonconductive insulating material suitable for system fluid, pressure, and temperature.

B. Dielectric Unions:
1. Description: Factory fabricated, union, NPS 2 (DN 50) and smaller.

a. Pressure Rating: As directed 150 psig (1035 kPa) minimum or 250 psig (1725 kPa) at 180 deg F (82 deg C).
b. End Connections: Solder-joint copper alloy and threaded ferrous; threaded ferrous.

C. Dielectric Flanges:
1. Description: Factory-fabricated, bolted, companion-flange assembly, NPS 2-1/2 to NPS 4 (DN 65 to DN 100) and larger.

a. Pressure Rating: As directed 150 psig (1035 kPa) minimum, 175 psig (1200 kPa) minimum or 300 psig (2070 kPa).
b. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric Couplings:
1. Description: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining, NPS 3 (DN 80) and smaller.

a. Pressure Rating: 300 psig (2070 kPa) at 225 deg F (107 deg C).
b. End Connections: Threaded.

E. Dielectric Nipples:
1. Description: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining.

a. Pressure Rating: 300 psig (2070 kPa) at 225 deg F (107 deg C).
b. End Connections: Threaded or grooved.

2.3 SLEEVES

A. Mechanical sleeve seals for pipe penetrations are specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

B. Galvanized-Steel Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

C. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, galvanized, plain ends.

D. Cast-Iron Sleeves: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

E. Molded PVC Sleeves: Permanent, with nailing flange for attaching to wooden forms.

F. PVC Pipe Sleeves: ASTM D1785, Schedule 40.

G. Molded PE Sleeves: Reusable, PE, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

2.4 IDENTIFICATION DEVICES

A. Equipment Nameplates: Metal permanently fastened to equipment with data engraved or stamped.

1. Data: Manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and essential data.
2. Location: Accessible and visible.

B. Snap-on Plastic Pipe Markers: Manufacturer's standard preprinted, semirigid, snap-on type. Include color-coding according to ASME A13.1, unless otherwise indicated.

C. Pressure-Sensitive Pipe Markers: Manufacturer's standard preprinted, color-coded, pressure-sensitive-vinyl type with permanent adhesive.

D. Pipes with OD, Including Insulation, Less Than 6 Inches (150 mm): Full-band pipe markers, extending 360 degrees around pipe at each location.

E. Pipes with OD, Including Insulation, 6 Inches (150 mm) and Larger: Either full-band or strip-type pipe markers, at least three times letter height and of length required for label.

F. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length.

1. Arrows: Either integrally with piping system service lettering to accommodate both directions of flow, or as separate unit on each pipe marker to indicate direction of flow.

G. Plastic Tape: Manufacturer's standard color-coded, pressure-sensitive, self-adhesive vinyl tape, at least 3 mils (0.08 mm) thick.

1. Width: 1-1/2 inches (40 mm) on pipes with OD, including insulation, less than 6 inches (150 mm); 2-1/2 inches (65 mm) for larger pipes.
2. Color: Comply with ASME A13.1, unless otherwise indicated.

H. Valve Tags: Stamped or engraved with 1/4-inch (6.4-mm) letters for piping system abbreviation and 1/2-inch (13-mm) sequenced numbers. Include 5/32-inch (4-mm) hole for fastener.

1. Material: 0.032-inch- (0.8-mm-) thick, polished brass or aluminum.
2. Material: 0.0375-inch- (1-mm-) thick stainless steel.
3. Material: 3/32-inch- (2.4-mm-) thick plastic laminate with 2 black surfaces and a white inner layer.
4. Material: Valve manufacturer's standard solid plastic.
5. Size: 1-1/2 inches (40 mm) in diameter, unless otherwise indicated.
6. Shape: As indicated for each piping system.

I. Valve Tag Fasteners: Brass, wire-link or beaded chain; or brass S-hooks.

J. Engraved Plastic-Laminate Signs: ASTM D709, Type I, cellulose, paper-base, phenolic-resin-laminate engraving stock; Grade ES-2, black surface, black phenolic core, with white melamine subcore, unless otherwise indicated. Fabricate in sizes required for message. Provide holes for mechanical fastening.

1. Engraving: Engraver's standard letter style, of sizes and with terms to match equipment identification.
2. Thickness: 1/16 inch (1.6 mm) or 1/8 inch (3 mm), unless otherwise indicated.
3. Thickness: 1/16 inch (1.6 mm), for units up to 20 sq. in. (130 sq. cm) or 8 inches (200 mm) in length, and 1/8 inch (3 mm) for larger units.
4. Fasteners: Self-tapping, stainless-steel screws or contact-type permanent adhesive.

K. Plastic Equipment Markers: Manufacturer's standard laminated plastic, in the following color codes:

1. Green: Cooling equipment and components.
2. Yellow: Heating equipment and components.
3. Brown: Energy reclamation equipment and components.
4. Blue: Equipment and components that do not meet criteria above.
5. Hazardous Equipment: Use colors and designs recommended by ASME A13.1.
6. Terminology: Match schedules as closely as possible. Include the following:

    a. Name and plan number.
    b. Equipment service.
    c. Design capacity.
    d. Other design parameters such as pressure drop, entering and leaving conditions, and speed.

7. Size: 2-1/2 by 4 inches (65 by 100 mm) for control devices, dampers, and valves; 4-1/2 by 6 inches (115 by 150 mm) for equipment.

2.5 GROUT

A. Description: ASTM C1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post hardening, volume adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 DIELECTRIC FITTING APPLICATIONS

A. Dry Piping Systems: Connect piping of dissimilar metals with the following:

1. NPS 2 (DN 50) and Smaller: Dielectric unions.
2. NPS 2-1/2 (DN 65) and Larger: Dielectric flanges.

B. Wet Piping Systems: Connect piping of dissimilar metals with the following:

1. NPS 2 (DN 50) and Smaller: Dielectric couplings or dielectric nipples.
2. NPS 2-1/2 (DN 65) and Larger: Dielectric nipples.

3.2 PIPING INSTALLATION

A. Install piping according to the following requirements and utilities Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on the Coordination Drawings.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping to permit valve servicing.

E. Install piping at indicated slopes.

F. Install piping free of sags and bends.

G. Install fittings for changes in direction and branch connections.

H. Select system components with pressure rating equal to or greater than system operating pressure.

I. Sleeves are not required for core-drilled holes.

J. Permanent sleeves are not required for holes formed by removable PE sleeves.

K. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.

1. Cut sleeves to length for mounting flush with both surfaces.

    a. Exception: Extend sleeves installed in floors of equipment areas or other wet areas 2 inches (50 mm) above finished floor level.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.

    a. PVC or Steel Pipe Sleeves: For pipes smaller than NPS 6 (DN 150).
    b. Steel Sheet Sleeves: For pipes NPS 6 (DN 150) and larger, penetrating gypsum-board partitions.

L. Verify final equipment locations for roughing-in.

M. Refer to equipment specifications in other Sections for roughing-in requirements.

3.3 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and utilities Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

E. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

F. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

G. Grooved Joints: Assemble joints with grooved-end pipe coupling with coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.

H. Soldered Joints: Apply ASTM B813 water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy (0.20 percent maximum lead content) complying with ASTM B32.

I. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

J. Pressure-Sealed Joints: Assemble joints for plain-end copper tube and mechanical pressure seal fitting with proprietary crimping tool to according to fitting manufacturer's written instructions.

K. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements.
2. ABS Piping: Join according to ASTM D2235 and ASTM D2661 appendixes.
3. CPVC Piping: Join according to ASTM D2846/D2846M Appendix.
4. PVC Pressure Piping: Join schedule number ASTM D1785, PVC pipe and PVC socket fittings according to ASTM D2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D2855.
5. PVC Nonpressure Piping: Join according to ASTM D2855.
6. PVC to ABS Nonpressure Transition Fittings: Join according to ASTM D3138 Appendix.

L. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D3139.

M. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D3212.

N. Plastic Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D2657.

1. Plain-End PE Pipe and Fittings: Use butt fusion.
2. Plain-End PE Pipe and Socket Fittings: Use socket fusion.

O. Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

3.4 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.
3. Install dielectric fittings at connections of dissimilar metal pipes.

3.5 EQUIPMENT INSTALLATION

A. Install equipment level and plumb, unless otherwise indicated.

B. Install equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference with other installations. Extend grease fittings to an accessible location.

C. Install equipment to allow right of way to piping systems installed at required slope.

3.6 IDENTIFICATION

A. Piping Systems: Install pipe markers on each system. Include arrows showing normal direction of flow.

1. Plastic markers, with application systems. Install on insulation segment if required for hot noninsulated piping.
2. Locate pipe markers on exposed piping according to the following:

a. Near each valve and control device.
b. Near each branch, excluding short takeoffs for equipment and terminal units. Mark each pipe at branch if flow pattern is not obvious.
c. Near locations where pipes pass through walls or floors or enter inaccessible enclosures.
d. At manholes and similar access points that permit view of concealed piping.
e. Near major equipment items and other points of origination and termination.

B. Equipment: Install engraved plastic-laminate sign or equipment marker on or near each major item of equipment.

1. Lettering Size: Minimum 1/4 inch (6.4 mm) high for name of unit if viewing distance is less than 24 inches (610 mm), 1/2 inch (13 mm) high for distances up to 72 inches (1800 mm), and proportionately larger lettering for greater distances. Provide secondary lettering two-thirds to three-fourths of size of principal lettering.
2. Text of Signs: Provide name of identified unit. Include text to distinguish among multiple units, inform user of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.

C. Adjusting: Relocate identifying devices that become visually blocked by work of this or other Divisions.

3.7 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

1. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
7. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed

3.8 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Section 055000 "Metal Fabrications" for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor piped utility materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.9 GROUTING

A. Mix and install grout for equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

END OF SECTION 330500

SECTION 331113 – POTABLE WATER SUPPLY WELLS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Well casings.
2. Grout.
3. Water well screens.
4. Pack materials.
5. Line-shaft or Submersible well pumps.

1.2 ACTION SUBMITTALS

A. Product Data: For each type and size of well pump.

B. Shop Drawings: For well pumps.

1. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Field Quality-Control Reports:

1. For each well pump, include the following:

a. Substrata formations.
b. Water-bearing formations.
c. Water levels.
d. Laboratory water analysis.
e. Well-screen analysis.
f. Performance test data.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1. Project Record Documents: Record the following data for each water supply well:

a. Casings: Material, diameter, thickness, weight per foot (m) of length, and depth below grade.
b. Screen: Material, construction, diameter, and opening size.
c. Pumping Test: Static water level, maximum safe yield, and drawdown at maximum yield.

d. Log: Formation log indicating strata encountered.
e. Alignment: Certification that well is aligned and plumb within specified tolerances.

1.5 FIELD CONDITIONS

A. Well Drilling Water: As directed Owner will provide or Provide temporary water and piping for drilling purposes. Provide necessary piping for water supply.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with AWWA A100 for water supply wells.

2.2 PERFORMANCE REQUIREMENTS

A. Minimum Tested Water Supply Well Performance Capacity: Capacity in gpm (L/s) as directed.

2.3 WELL CASINGS

A. Steel Casing: AWWA C200, single ply, steel pipe with threaded ends and threaded couplings for threaded joints.

B. ABS Casing: As directed ASTM F480, ABS, Schedule 40 or 80 bell-and-spigot pipe and couplings for solvent-cemented joints.

C. PVC Casing: As directed ASTM F480 and NSF 14, PVC, Schedule 40 or 80 bell-and-spigot pipe and couplings for solvent-cemented joints. Include NSF listing mark "NSF wc."

D. Pitless Adapter: Fitting, of shape required to fit onto casing, with waterproof seals.

E. Pitless Unit: Factory-assembled equipment that includes pitless adapter.

F. Well Seals: Casing cap, with holes for piping and cables, that fits into top of casing and is removable, waterproof, and vermin proof.

2.4 GROUT

A. Cement: ASTM C150/C150M, Type II.

B. Aggregates: ASTM C33/C33M, fine and coarse grades.

C. Water: Potable.

2.5 WATER WELL SCREENS

A. Screen Material: Fabricated of ASTM A666, Type 304 stainless steel, welded; with continuous-slot, V-shaped openings that widen inwardly or tube; with slotted or perforated surface as directed and designed for well-screen applications.

1. Screen Couplings: Butt-type, stainless-steel coupling rings.
2. Screen Fittings: Screen, with necessary fittings, closes bottom and makes tight seal between top of screen and well casing.
3. Maximum Entering Velocity: 0.1 fps (0.03 m/s).

2.6 PACK MATERIALS

A. Coarse, uniformly graded filter sand, maximum 1/8 inch (3 mm) in diameter.

B. Fine gravel, maximum 1/4 inch (6 mm) in diameter.

2.7 LINE-SHAFT WELL PUMPS

A. Description: Line-shaft, water or oil-lubricated as directed, vertical-turbine well pump.

B. Standards: HI 2.1-2.2 and HI 2.3.

C. Impeller Material: Stainless steel, Carbon steel or Bronze as directed.

D. Pump Base: Cast iron or fabricated steel.

E. Column Pipe: ASTM A53/A53M, Schedule 40, galvanized-steel pipe with threaded ends and cast-iron or steel threaded couplings.

F. Capacities and Characteristics:

1. Capacity: As directed gpm (L/s).
2. Discharge Head: As driected psig (kPa).
3. Discharge Size: As directed NPS (DN).
4. Speed: As directed rpm.
5. Motor Horsepower: As directed.
6. Lift: As directed feet (m).
7. Pressure Rating: As directed psig (kPa).
8. Volts: As directed.
9. Phases: As directed.
10. Hertz: As directed.
11. Full-Load Amperes: As directed.
12. Minimum Circuit Ampacity: As directed.
13. Maximum Overcurrent Protection: As directed.

2.8 SUBMERSIBLE WELL PUMPS

A. Description: Submersible, vertical-turbine well pump.

B. Standards: HI 2.1-2.2 and HI 2.3.

C. Impeller Material: Stainless steel or Silicon bronze as directed.

D. Motor: Capable of continuous operation under water, with protected submersible power cable.

E. Column Pipe: ASTM A53/A53M, Schedule 40, galvanized-steel pipe with threaded ends and cast-iron or steel threaded couplings.

F. Discharge Piping: ASTM D2239, SIDR Numbers 5.3, 7, or 9 PE pipe; made with PE compound number required to give pressure rating not less than 160 psig (1100 kPa) or 200 psig (1380 kPa) as directed. Include NSF listing mark "NSF pw."

1. Insert Fittings for PE Pipe: ASTM D2609, made of PA, PP, or PVC with serrated, male insert ends matching inside of pipe. Include bands or crimp rings.

G. Capacities and Characteristics:

1. Capacity: As directed gpm (L/s).
2. Discharge Head: As directed psig (kPa).
3. Discharge Size: As directed NPS (DN).
4. Speed: As directed.
5. Motor Horsepower: As directed.
6. Lift: As directed feet (m).
7. Pressure Rating: As directed psig (kPa).
8. Volts: As directed.
9. Phases: As directed.
10. Hertz: As directed.
11. Full-Load Amperes: As directed.
12. Minimum Circuit Ampacity: As directed.
13. Maximum Overcurrent Protection: As directed amperage.

2.9 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 220513 "Common Motor Requirements for Plumbing Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in electrical Sections.

PART 3 - EXECUTION

3.1 PREPARATION

A. Pilot-Hole Data: Review pilot-hole test analysis furnished by Owner.

B. Neighborhood Well Data: Review operating and test analyses.

3.2 INSTALLATION

A. Construct well using rotary drilling or reverse-rotary drilling method as directed.

B. Take samples of substrata formation at 10-foot (3-m) intervals and at changes in formation throughout entire depth of each water supply well. Carefully preserve samples on-site in glass jars properly labeled for identification.

C. Excavate for mud pit or provide aboveground structure, acceptable to authorities having jurisdiction, to allow settlement of cuttings and circulation of drill fluids back to well without discharging to on-site waterways.

D. Enlarge pilot hole and install permanent casing, screen, and grout. Install first section of casing with hardened steel driving shoe of an OD slightly larger than casing couplings if threaded couplings are used.

E. Set casing and liners round, plumb, and true to line.

F. Join casing pipe as follows:

1. Ream ends of pipe and remove burrs.
2. Remove scale, slag, dirt, and debris from inside and outside casing before installation.
3. Cut bevel in ends of casing pipe and make threaded joints.
4. Clean and make solvent-cemented joints.

G. Mix grout in proportions of 1 cu. ft. (0.03 cu. m) or a 94-lb (42.6-kg) sack of cement with 5 to 6 gal. (19 to 23 L) of water. Bentonite clay may be added in amounts of 3 to 5 lb/cu. ft. (1.4 to 2.3 kg/0.03 cu. m) for a 94-lb (42.6-kg) sack of cement. If bentonite clay is added, water may be increased to 6.5 gal./cu. ft. (25 L/0.03 cu. m) of cement.

H. Place grout continuously, from bottom to top surface, to ensure filling of annular space in one operation. Do not perform other operations in well within 72 hours after grouting of casing. When quick-setting cement is used, this period may be reduced to 24 hours.

I. Provide permanent casing with temporary well cap. Install with top of casing 36 inches (910 mm) above finished grade.

J. Develop wells to maximum yield per foot (m) of drawdown.

1. Extract maximum practical quantity of sand, drill fluid, and other fine materials from water-bearing formation.
2. Avoid settlement and disturbance of strata above water-bearing formation.

3. Do not disturb sealing around well casings.
4. Continue developing wells until water contains no more than 2 ppm of sand by weight when pumped at maximum testing rate.

K. Install line-shaft or submersible well pumps according to HI 2.4 as directed and provide access for periodic maintenance.

1. Before lowering permanent pump into well, lower a dummy pump that is slightly longer and wider than permanent pump to determine that permanent pump can be installed. Correct alignment problems.
2. Before lowering permanent pump into well, start pump to verify correct rotation.
3. Securely tighten discharge piping joints.
4. Locate line-shaft well pump near well bottom; locate motor above grade. Install driver plate to correctly align motor and pump.
5. Connect motor to submersible pump and locate near well bottom.

a. Connect power cable while connection points are dry and undamaged.
b. Do not damage power cable during installation; use cable clamps that do not have sharp edges.
c. Install water-sealed surface plate that will support pump and piping.

3.3 CONNECTIONS

A. Piping installation requirements are specified in Section 221113 "Facility Water Distribution Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

1. Connect piping between well pump and water piping.
2. Connect water distribution system in trench to well pipe at pitless adapter unit.
3. Connect building water distribution to well pipe inside well house.

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 WELL ABANDONMENT

A. Comply with AWWA A100 when abandoning water supply wells. Fill and seal holes and casings, and restore ground surface to finished grade.

B. Follow well-abandonment procedures of authorities having jurisdiction. Restore ground surface to finished grade.

3.5 FIELD QUALITY CONTROL

A. Test Preparation: Clean water supply wells of foreign substances. Swab casings using alkalis, if necessary, to remove foreign substances.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Plumbness and Alignment Testing: Comply with AWWA A100.
2. Furnish samples of water-bearing formation to testing laboratory and well-screen manufacturer for mechanical sieve analysis.
3. Prepare reports on static level of ground water, level of water for various pumping rates, and depth to water-bearing strata.
4. Performance Test Preparation: Start well pump and adjust controls and pressure setting. Replace damaged and malfunctioning controls and equipment.
5. Performance Testing: Conduct final pumping tests after wells have been constructed, cleaned, and tested for plumbness and alignment.

    a. Arrange to conduct tests, with seven days' advance notice, after test pump and auxiliary equipment have been installed. Note water-level elevations referred to for each assigned datum in wells.
    b. Provide discharge piping to conduct water to locations where disposal will not create a nuisance or endanger adjacent property. Comply with requirements of authorities having jurisdiction.
    c. Provide and maintain equipment of adequate size and type for measuring flow of water, such as weir box, orifice, or water meter.
    d. Measure elevation to water level in wells.
    e. Perform two bailer or air-ejection tests to determine expected yield. Test at depths with sufficient quantity of water to satisfy desired yields.
    f. Test Pump: Variable capacity test pump with capacity equal to maximum expected yields at pressure equal to drawdown in wells, plus losses in pump columns and discharge pipes.
    g. Start and adjust test pumps and equipment to required pumping rates.
    h. Record readings of water levels in wells and pumping rates at 30-minute maximum intervals throughout 24-hour minimum period.
    i. Record maximum yields when drawdown is 60 inches (1500 mm) above top of suction screens after designated times.
    j. Operate pumping units continuously for eight hours after maximum drawdown is reached.
    k. Record returning water levels in wells and plot curves of well recovery rates.
    l. Remove sand, stones, and other foreign materials that may become deposited in wells after completing final tests.

C. Water supply well will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. Water Analysis Testing:

1. As directed Owner will engage or Engage a qualified testing agency to make bacteriological, physical, and chemical analyses of water from each finished well and report the results. Make analyses according to requirements of authorities having jurisdiction.
2. Analyze water sample from each finished well for bacteriological, physical, and chemical quality and report the results. Make analyses according to requirements of authorities having jurisdiction.

3.6 CLEANING

A. Disinfect water supply wells according to AWWA A100 and AWWA C654 before testing well pumps.

B. Follow water supply well disinfection procedures required by authorities having jurisdiction before testing well pumps.

3.7 PROTECTION

A. Water Quality Protection: Prevent well contamination, including undesirable physical and chemical characteristics.

B. Ensure that mud pit will not leak or overflow into streams or wetlands. When well is accepted, remove mud and solids in mud pit from Project site and restore site to finished grade.

C. Provide casings, seals, sterilizing agents, and other materials to eliminate contamination; shut off contaminated water.

D. Exercise care to prevent breakdown or collapse of strata overlaying that from which water is to be drawn.

E. Protect water supply wells to prevent tampering and introducing foreign matter. Retain temporary well cap until installation is complete.

END OF SECTION 331113

SECTION 334200 - STORMWATER CONVEYANCE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Ductile-iron culvert pipe and fittings.
2. PE pipe and fittings.
3. PVC pipe and fittings.
4. Concrete pipe and fittings.
5. Non-pressure transition couplings.
6. Expansion joints.
7. Cleanouts.
8. Encasement for piping.
9. Manholes.
10. Polymer-concrete, channel drainage systems.
11. Catch basins.
12. Stormwater inlets.
13. Stormwater detention structures.
14. Pipe outlets.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Manholes: Include plans, elevations, sections, details, frames, and covers.
2. Catch basins and stormwater inlets. Include plans, elevations, sections, details, frames, covers, and grates.
3. Stormwater Detention Structures: Include plans, elevations, sections, details, frames, covers, design calculations, and concrete design-mix reports.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show pipe sizes, locations, and elevations. Show other piping in same trench and clearances from storm drainage system piping. Indicate interface and spatial relationship between manholes, piping, and proximate structures.

B. Profile Drawings: Show system piping in elevation. Draw profiles at horizontal scale of not less than 1 inch equals 50 feet (1:500) and vertical scale of not less than 1 inch equals 5 feet (1:50). Indicate manholes and piping. Show types, sizes, materials, and elevations of other utilities crossing system piping.

C. Product Certificates: For each type of cast-iron soil pipe and fitting.

D. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

PART 2 - PRODUCTS

2.1 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings:

1. Marked with CISPI collective trademark and NSF certification mark.
2. Class: ASTM A74, Service class.

B. Gaskets: ASTM C564, rubber.

C. Caulking Materials: ASTM B29, pure lead and oakum or hemp fiber.

2.2 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings:

1. Marked with CISPI collective trademark and NSF certification mark.
2. Standard: ASTM A888 or CISPI 301.

B. CISPI, Hubless-Piping Couplings:
1. Description: Stainless-steel corrugated shield; stainless-steel bands and tightening devices; and rubber sleeve with integral, center pipe stop.
2. Standards:

a. ASTM C1277 and CIPSI 310 for couplings.
b. ASTM C564 for gaskets.

C. Heavy-Duty, Hubless-Piping Couplings:
1. Description: Stainless-steel shield; stainless-steel bands and tightening devices; and rubber sleeve with integral, center pipe stop.
2. Standards:

a. ASTM C1277 and ASTM C1540 for couplings.
b. ASTM C564 for rubber gaskets.

D. Cast-Iron, Hubless-Piping Couplings:
1. Description: Two-piece, cast-iron housing; stainless-steel bolts and nuts; and rubber sleeve with integral, center pipe stop.
2. Standards:

a. ASTM C1277 for couplings.

b. ASTM A48/A48M for cast-iron castings.
c. ASTM C564 for gaskets.

2.3 DUCTILE-IRON, CULVERT PIPE AND FITTINGS

A. Pipe: ASTM A716, for push-on joints.

B. Standard Fittings: AWWA C110/A21.10, ductile or gray iron, for push-on joints.

C. Compact Fittings: AWWA C153/A21.53, for push-on joints.

D. Gaskets: AWWA C111/A21.11, rubber.

2.4 CORRUGATED-PE PIPE AND FITTINGS

A. Corrugated-PE Drainage Pipe and Fittings NPS 3 to NPS 10 (DN 80 to DN 250): AASHTO M 252, Type S, with smooth waterway for coupling joints.

B. Corrugated-PE Pipe and Fittings NPS 12 to NPS 60 (DN 300 to DN 1500): AASHTO M 294, Type S, with smooth waterway for coupling joints.

C. Corrugated-PE Silttight Couplings: PE sleeve with ASTM D1056, Type 2, Class A, Grade 2 gasket material that mates with pipe and fittings.

D. Corrugated-PE Soiltight Couplings: AASHTO M 294, corrugated, matching pipe and fittings.

2.5 PVC PIPE AND FITTINGS

A. NSF Marking: Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-drain" for plastic storm drain and "NSF-sewer" for plastic storm sewer piping.

B. PVC Corrugated Sewer Piping:

1. Pipe: ASTM F949, PVC, corrugated pipe with bell-and-spigot ends for gasketed joints.
2. Fittings: ASTM F949, PVC molded or fabricated, socket type.
3. Gaskets: ASTM F477, elastomeric seals.

C. Adhesive Primer: ASTM F656.

2.6 CONCRETE PIPE AND FITTINGS

A. Nonreinforced-Concrete Sewer Pipe and Fittings: ASTM C14 (ASTM C14M), Class 1, Class 2 or Class 3, with bell-and-spigot or tongue-and-groove ends and gasketed joints with ASTM C443 (ASTM C443M), rubber gaskets, sealant joints with ASTM C990 (ASTM C990M), bitumen or butyl-rubber sealant as directed.

B. Reinforced-Concrete Sewer Pipe and Fittings: ASTM C76 (ASTM C76M).

1. Bell-and-spigot or tongue-and-groove ends and gasketed joints with ASTM C443 (ASTM C443M), rubber gaskets or sealant joints with ASTM C990 (ASTM C990M), bitumen or butyl-rubber sealant
2. Class I, Wall A or B as directed.
3. Class II, Wall A, B or C as directed.
4. Class III, Wall A, B or C as directed.
5. Class IV, Wall A, B or C as directed.
6. Class V, Wall B or C as directed.

2.7 NONPRESSURE TRANSITION COUPLINGS

A. Comply with ASTM C1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground non-pressure piping. Include ends of same sizes as piping to be joined, and corrosion-resistant-metal tension band and tightening mechanism on each end.

B. Sleeve Materials:

1. For Concrete Pipes: ASTM C443 (ASTM C443M), rubber.
2. For Cast-Iron Soil Pipes: ASTM C564, rubber.
3. For Fiberglass Pipes: ASTM F477, elastomeric seal or ASTM D5926, PVC.
4. For Plastic Pipes: ASTM F477, elastomeric seal or ASTM D5926, PVC.
5. For Dissimilar Pipes: ASTM D5926, PVC or other material compatible with pipe materials being joined.

C. Unshielded, Flexible Couplings:
1. Description: Elastomeric sleeve with stainless-steel shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.

D. Shielded, Flexible Couplings:
1. Description: ASTM C1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.

E. Ring-Type, Flexible Couplings:
1. Description: Elastomeric compression seal with dimensions to fit inside bell of larger pipe and for spigot of smaller pipe to fit inside ring.

2.8 EXPANSION JOINTS

A. Ductile-Iron, Flexible Expansion Joints:
1. Description: Compound fitting with combination of flanged and mechanical-joint ends complying with AWWA C110/A21.10 or AWWA C153/A21.53. Include two gasketed ball-joint sections and one or more gasketed sleeve sections, rated for 250-psig (1725-kPa) minimum working pressure and for offset and expansion indicated.

B. Ductile-Iron Expansion Joints:
1. Description: Three-piece assembly of telescoping sleeve with gaskets and restrained-type, ductile iron or steel with protective coating; bell-and-spigot end sections complying with AWWA C110/A21.10 or AWWA C153/A21.53.

2. Pressure Rating: 250-psig (1725-kPa) minimum working pressure and for expansion indicated.

2.9 CLEANOUTS

A. Cast-Iron Cleanouts:
1. Description: ASME A112.36.2M, round, gray-iron housing with clamping device and round, secured, scoriated, gray-iron cover. Include gray-iron ferrule with inside caulk or spigot connection and countersunk, tapered-thread, brass closure plug.
2. Top-Loading Classification(s): Light Duty, Medium Duty, Heavy Duty and Extra-Heavy Duty.
3. Sewer Pipe Fitting and Riser to Cleanout: ASTM A74, Service class, cast-iron soil pipe and fittings.

B. PVC Cleanouts:
1. Description: PVC body with PVC threaded plug. Include PVC sewer pipe fitting and riser to cleanout of same material as sewer piping.

2.10 ENCASEMENT FOR PIPING

A. Standard: ASTM A674 or AWWA C105/A21.5.

B. Material: Linear low-density polyethylene film of 0.008-inch (0.20-mm) or cross-laminated HDPE film of 0.004-inch (0.10-mm) minimum thickness.

C. Form: Sheet or tube.

D. Color: Black or natural.

2.11 MANHOLES

A. Standard Precast Concrete Manholes:

1. Description: ASTM C478 (ASTM C478M), precast, reinforced concrete, of depth indicated, with provision for sealant joints.
2. Diameter: 48 inches (1200 mm) minimum unless otherwise indicated.
3. Ballast: Increase thickness of precast concrete sections or add concrete to base section as required to prevent flotation.
4. Base Section: 6-inch (150-mm) minimum thickness for floor slab and 4-inch (102-mm) minimum thickness for walls and base riser section, and separate base slab or base section with integral floor.
5. Riser Sections: 4-inch (102-mm) minimum thickness, and lengths to provide depth indicated.
6. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated, and top of cone of size that matches grade rings.
7. Joint Sealant: ASTM C990 (ASTM C990M), bitumen or butyl rubber.
8. Resilient Pipe Connectors: ASTM C923 (ASTM C923M), cast or fitted into manhole walls, for each pipe connection.

9. Steps: As directed Individual FRP steps or FRP ladder or Individual FRP steps; FRP ladder; or ASTM A615/A615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D4101, PP or ASTM A615/A615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D4101, PP, wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of manhole to finished grade is less than 60 (1500) inches (mm).
10. Adjusting Rings: Interlocking HDPE rings with level or sloped edge in thickness and diameter matching manhole frame and cover, and of height required to adjust manhole frame and cover to indicated elevation and slope. Include sealant recommended by ring manufacturer.
11. Grade Rings: Reinforced-concrete rings, 6- to 9-inch (150- to 225-mm) total thickness, to match diameter of manhole frame and cover, and height as required to adjust manhole frame and cover to indicated elevation and slope.

2.12 CONCRETE

A. General: Cast-in-place concrete in accordance with ACI 318 (ACI 318M), ACI 350 (ACI 350M), and the following:

1. Cement: ASTM C150/C150M, Type II.
2. Fine Aggregate: ASTM C33/C33M, sand.
3. Coarse Aggregate: ASTM C33/C33M, crushed gravel.
4. Water: Potable.

B. Portland Cement Design Mix: 4000 psi (27.6 MPa) minimum, with 0.45 maximum water/cementitious materials ratio.

1. Reinforcing Fabric: ASTM A1064/A1064M, steel, welded wire fabric, plain.
2. Reinforcing Bars: ASTM A615/A615M, Grade 60 (420 MPa) deformed steel.

C. Manhole Channels and Benches: Factory or field formed from concrete. Portland cement design mix, 4000 psi (27.6 MPa) minimum, with 0.45 maximum water/cementitious materials ratio. Include channels and benches in manholes.

1. Channels: Concrete invert, formed to same width as connected piping, with height of vertical sides to three-fourths of pipe diameter. Form curved channels with smooth, uniform radius and slope.

    a. Invert Slope: 1 or 2 percent through manhole as directed.

2. Benches: Concrete, sloped to drain into channel.

    a. Slope: 4 or 8 percent as directed.

D. Ballast and Pipe Supports: Portland cement design mix, 3000 psi (20.7 MPa) minimum, with 0.58 maximum water/cementitious materials ratio.

1. Reinforcing Fabric: ASTM A1064/A1064M, steel, welded wire fabric, plain.

2. Reinforcing Bars: ASTM A615/A615M, Grade 60 (420 MPa) deformed steel.

2.13 POLYMER-CONCRETE, CHANNEL DRAINAGE SYSTEMS

A. Narrow, Sloped-Invert, Polymer-Concrete Channel Drainage Systems:
1. Description: Modular system of channel sections, grates, and appurtenances; designed so grates fit into channel recesses without rocking or rattling.
2. Channel Sections: Narrow, interlocking-joint, sloped-invert, polymer-concrete modular units with end caps.

    a. Include rounded bottom, with built-in invert slope of 0.6 percent and with outlets in number, sizes, and locations indicated.
    b. Include extension sections necessary for required depth.
    c. Dimensions: 4-inch (102-mm) inside width. Include number of units required to form total lengths indicated.
    d. Frame: As directed Gray-iron or galvanized steel for grates or Not required.

3. Grates: As directed Manufacturer's designation "heavy or medium duty," with slots or perforations, and of width and thickness that fit recesses in channel sections.

    a. Material: Ductile iron, Fiberglass, Galvanized steel, Gray iron or Stainless steel as directed.

        1) Locking Mechanism: As directed Manufacturer's standard device for securing grates to channel sections or Not required.

4. Covers: Solid ductile or gray iron, of width and thickness that fit recesses in channel sections, and of lengths indicated.
5. Supports, Anchors, and Setting Devices: Manufacturer's standard unless otherwise indicated.
6. Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.

B. Narrow, Level-Invert, Polymer-Concrete Channel Drainage Systems:
1. Description: Modular system of channel sections, grates, and appurtenances; designed so grates fit into channel recesses without rocking or rattling.
2. Channel Sections: Narrow, interlocking-joint, precast, polymer-concrete modular units with end caps.

    a. Include rounded bottom, with level invert and with NPS 4 (DN 100) outlets in number and locations indicated.
    b. Dimensions: 5 (127) inch (mm) inside width and 9-3/4 (248) inches (mm) deep. Include number of units required to form total lengths indicated.

        1) Frame: As directed Gray-iron or galvanized steel for grates or Not required.

3. Grates: As directed Manufacturer's designation "heavy or medium duty," with slots or perforations, and of width and thickness that fit recesses in channel sections.

a. Material: Ductile iron, Fiberglass, Galvanized steel, Gray iron or Stainless steel as directed.
b. Locking Mechanism: As directed Manufacturer's standard device for securing grates to channel sections or Not required.

4. Covers: Solid ductile or gray iron, of width and thickness that fit recesses in channel sections, and of lengths indicated.
5. Supports, Anchors, and Setting Devices: Manufacturer's standard unless otherwise indicated.
6. Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.

C. Wide, Level-Invert, Polymer-Concrete Channel Drainage Systems:

1. Description: Modular system of channel sections, grates, and appurtenances; designed so grates fit into channel recesses without rocking or rattling.
2. Channel Sections: Wide, interlocking-joint, precast, polymer-concrete modular units with end caps.

a. Include flat or rounded bottom, with level invert and with outlets in number, sizes, and locations indicated.
b. Dimensions: 8 (203) inch (mm) inside width and 13-3/4 (350) inches (mm) deep. Include number of units required to form total lengths indicated.

1) Frame: As directed Gray iron or galvanized steel for grates or Not required.

3. Grates: As directed Manufacturer's designation "heavy or medium duty," with slots or perforations, and of width and thickness that fit recesses in channel sections.

a. Material: As directed Ductile iron, Fiberglass, Galvanized steel, Gray iron or Stainless steel.
b. Locking Mechanism: As directed Manufacturer's standard device for securing grates to channel sections or Not required.

4. Covers: Solid ductile or gray iron, of width and thickness that fit recesses in channel sections, and of lengths indicated.
5. Supports, Anchors, and Setting Devices: Manufacturer's standard unless otherwise indicated.
6. Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.

D. Drainage Specialties: Precast, polymer-concrete units.

1. Large Catch Basins:

a. 24-by-12-inch (610-by-305-mm) polymer-concrete body, with outlets in quantities and sizes indicated.
b. Gray-iron slotted grate.
c. Frame: Include gray-iron or steel frame for grate.

2. Small Catch Basins:

a. 19- to 24-inch by approximately 6-inch (483- to 610-mm by approximately 150-mm) polymer-concrete body, with outlets in quantities and sizes indicated.
b. Gray-iron slotted grate.
c. Frame: Include gray-iron or steel frame for grate.

3. Oil Interceptors:

a. Polymer-concrete body with interior baffle and four steel support channels and two 1/4-inch- (6.4-mm-) thick, steel-plate covers.
b. Capacity: As directed 140 gal. (530 L), 200 gal. (757 L) or 260 gal. (984 L).
c. Inlet and Outlet: As directed NPS 4 (DN 100) or NPS 6 (DN 150).

4. Sediment Interceptors:

a. 27-inch (686-mm) square, polymer-concrete body, with outlets in quantities and sizes indicated.
b. 24-inch (610-mm) square, gray-iron frame and slotted grate.

2.14 CATCH BASINS

A. Standard Precast Concrete Catch Basins:

1. Description: ASTM C478 (ASTM C478M), precast, reinforced concrete, of depth indicated, with provision for sealant joints.
2. Base Section: 6-inch (150-mm) minimum thickness for floor slab and 4-inch (102-mm) minimum thickness for walls and base riser section, and separate base slab or base section with integral floor.
3. Riser Sections: 4-inch (102-mm) minimum thickness, 48-inch (1200-mm) diameter, and lengths to provide depth indicated.
4. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated. Top of cone of size that matches grade rings.
5. Joint Sealant: ASTM C990 (ASTM C990M), bitumen or butyl rubber.
6. Adjusting Rings: Interlocking rings with level or sloped edge in thickness and shape matching catch basin frame and grate. Include sealant recommended by ring manufacturer.
7. Grade Rings: Include two or three reinforced-concrete rings, of 6- to 9-inch (150- to 225-mm) total thickness, that match 24-inch (610-mm) diameter frame and grate.
8. Steps: Individual FRP steps or FRP ladder or Individual FRP steps; FRP ladder; or ASTM A615/A615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D4101, PP or ASTM A615/A615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D4101, PP, wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of catch basin to finished grade is less than 60 (1500) inches (mm).
9. Pipe Connectors: ASTM C923 (ASTM C923M), resilient, of size required, for each pipe connecting to base section.

B. Frames and Grates: ASTM A536, Grade 60-40-18, ductile iron designed for A-16 (AASHTO HS20-44), structural loading. Include flat grate with small square or short-slotted drainage openings.

1. Size: 24 by 24 inches (610 by 610 mm) minimum unless otherwise indicated.
2. Grate Free Area: Approximately 50 percent unless otherwise indicated.

C. Frames and Grates: ASTM A536, Grade 60-40-18, ductile iron designed for A-16 (AASHTO HS20-44), structural loading. Include 24-inch (610-mm) ID by 7- to 9-inch (175- to 225-mm) riser with 4-inch- (102-mm-) minimum width flange, and 26-inch- (660-mm-) diameter flat grate with small square or short-slotted drainage openings.

1. Grate Free Area: Approximately 50 percent unless otherwise indicated.

2.15 STORMWATER INLETS

A. Curb Inlets: Made with vertical curb opening, of materials and dimensions in accordance with utility standards.

B. Gutter Inlets: Made with horizontal gutter opening, of materials and dimensions in accordance with utility standards. Include heavy-duty frames and grates.

C. Combination Inlets: Made with vertical curb and horizontal gutter openings, of materials and dimensions in accordance with utility standards. Include heavy-duty frames and grates.

D. Frames and Grates: Heavy duty, in accordance with utility standards.

2.16 PIPE OUTLETS

A. Head Walls: Cast-in-place reinforced concrete, with apron and tapered sides.

B. Riprap Basins: Broken, irregularly sized and shaped, graded stone in accordance with NSSGA's "Quarried Stone for Erosion and Sediment Control."

1. Average Size: NSSGA No. R-3, screen opening 2 inches (51 mm).
2. Average Size: NSSGA No. R-4, screen opening 3 inches (76 mm).
3. Average Size: NSSGA No. R-5, screen opening 5 inches (127 mm).

C. Filter Stone: In accordance with NSSGA's "Quarried Stone for Erosion and Sediment Control," No. FS-2, No. 4 screen opening, average-size graded stone.

D. Energy Dissipaters: In accordance with NSSGA's "Quarried Stone for Erosion and Sediment Control," No. A-1, 3-ton (2721-kg) average weight armor stone, unless otherwise indicated.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavation, trenching, and backfilling are specified in Section 312000 "Earth Moving."

3.2 PIPING INSTALLATION

A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take into account design considerations. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.

B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings in accordance with manufacturer's written instructions for use of lubricants, cements, and other installation requirements.

C. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.

D. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.

E. When installing pipe under streets or other obstructions that cannot be disturbed, use pipe-jacking process of microtunneling.

F. Install gravity-flow, non-pressure drainage piping in accordance with the following:

1. Install piping pitched down in direction of flow.
2. Install piping NPS 6 (DN 150) and larger with restrained joints at tee fittings and at changes in direction. Use corrosion-resistant rods, pipe or fitting manufacturer's proprietary restraint system, or cast-in-place concrete supports or anchors.
3. As directed Install piping with 36- (915-), 48- (1220-), 60- (1520-) or 72- (1830-) inch-(mm-) minimum cover.
4. Install hub-and-spigot, cast-iron soil piping in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook."
5. Install hubless cast-iron soil piping in accordance with CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook."
6. Install ductile-iron piping and special fittings in accordance with AWWA C600 or AWWA M41.
7. Install PE corrugated sewer piping in accordance with ASTM D2321.
8. Install PVC sewer piping in accordance with ASTM D2321 and ASTM F1668.
9. Install nonreinforced-concrete sewer piping in accordance with ASTM C1479 and ACPA's "Concrete Pipe Installation Manual."
10. Install reinforced-concrete sewer piping in accordance with ASTM C1479 and ACPA's "Concrete Pipe Installation Manual."

G. Install corrosion-protection piping encasement over the following underground metal piping in accordance with ASTM A674 or AWWA C105/A21.5:

1. Hub-and-spigot, cast-iron soil pipe and fittings.
2. Hubless cast-iron soil pipe and fittings.
3. Ductile-iron pipe and fittings.
4. Expansion joints.

3.3 PIPE JOINT CONSTRUCTION

A. Join gravity-flow, non-pressure drainage piping in accordance with the following:

1. Join hub-and-spigot, cast-iron soil piping with gasketed joints in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
2. Join hub-and-spigot, cast-iron soil piping with caulked joints in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead and oakum caulked joints.
3. Join hubless cast-iron soil piping in accordance with CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.
4. Join ductile-iron culvert piping in accordance with AWWA C600 for push-on joints.
5. Join ductile-iron piping and special fittings in accordance with AWWA C600 or AWWA M41.
6. Join corrugated-PE piping in accordance with ASTM D3212 for push-on joints.
7. Join PVC corrugated sewer piping in accordance with ASTM D2321 for elastomeric-seal joints.
8. Join nonreinforced-concrete sewer piping in accordance with ASTM C14 (ASTM C14M) and ACPA's "Concrete Pipe Installation Manual" for rubber-gasketed joints.
9. Join reinforced-concrete sewer piping in accordance with ACPA's "Concrete Pipe Installation Manual" for rubber-gasketed joints.
10. Join dissimilar pipe materials with non-pressure-type flexible couplings.

B. Join force-main pressure piping in accordance with the following:

1. Join PVC pressure piping in accordance with AWWA M23 for gasketed joints.
2. Join dissimilar pipe materials with pressure-type couplings.

3.4 CLEANOUT INSTALLATION

A. Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts and cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.

1. Use Light-Duty, top-loading classification cleanouts in earth or unpaved foot-traffic areas.
2. Use Medium-Duty, top-loading classification cleanouts in paved foot-traffic areas.
3. Use Heavy-Duty, top-loading classification cleanouts in vehicle-traffic service areas.
4. Use Extra-Heavy-Duty, top-loading classification cleanouts in roads.

B. Set cleanout frames and covers in earth in cast-in-place concrete block, 18 by 18 by 12 (450 by 450 by 300) inches (mm) deep. Set with tops 1 (25) inch(es) (mm) above surrounding earth grade.

C. Set cleanout frames and covers in concrete pavement and roads with tops flush with pavement surface.

3.5 MANHOLE INSTALLATION

A. General: Install manholes, complete with appurtenances and accessories indicated.

B. Install precast concrete manhole sections with sealants in accordance with ASTM C891.

C. Where specific manhole construction is not indicated, follow manhole manufacturer's written instructions.

D. Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops 3 (76) inches (mm) above finished surface elsewhere unless otherwise indicated.

3.6 CATCH BASIN INSTALLATION

A. Construct catch basins to sizes and shapes indicated.

B. Set frames and grates to elevations indicated.

3.7 STORMWATER INLET AND OUTLET INSTALLATION

A. Construct inlet head walls, aprons, and sides of reinforced concrete, as indicated.

B. Construct riprap of broken stone, as indicated.

C. Install outlets that spill onto grade, anchored with concrete, where indicated.

D. Install outlets that spill onto grade, with flared end sections that match pipe, where indicated.

E. Construct energy dissipaters at outlets, as indicated.

3.8 CONCRETE PLACEMENT

A. Place cast-in-place concrete in accordance with ACI 318 (ACI 318M).

3.9 CHANNEL DRAINAGE SYSTEM INSTALLATION

A. Install with top surfaces of components, except piping, flush with finished surface.

B. Assemble channel sections to form slope down toward drain outlets. Use sealants, adhesives, fasteners, and other materials recommended by system manufacturer.

C. Embed channel sections and drainage specialties in 4 (102) inch (mm) minimum concrete around bottom and sides.

D. Fasten grates to channel sections if indicated.

E. Assemble channel sections with flanged or interlocking joints.

F. Embed channel sections in 4 (102) inch (mm) minimum concrete around bottom and sides.

3.10 CONNECTIONS

A. Connect non-pressure, gravity-flow drainage piping in building's storm building drains specified in Section 221413 "Facility Storm Drainage Piping."

B. Connect force-main piping to building's storm drainage force mains specified in Section 221413 "Facility Storm Drainage Piping." Terminate piping where indicated.

C. Make connections to existing piping and underground manholes.

1. Use commercially manufactured wye fittings for piping branch connections. Remove section of existing pipe; install wye fitting into existing piping; and encase entire wye fitting, plus 6-inch (150-mm) overlap, with not less than 6 inches (150 mm) of concrete with 28-day compressive strength of 3000 psi (20.7 MPa).
2. Make branch connections from side into existing piping, NPS 4 to NPS 20 (DN 100 to DN 500). Remove section of existing pipe, install wye fitting into existing piping, and encase entire wye with not less than 6 inches (150 mm) of concrete with 28-day compressive strength of 3000 psi (20.7 MPa).
3. Make branch connections from side into existing piping, NPS 21 (DN 525) or larger, or to underground manholes and structures by cutting into existing unit and creating an opening large enough to allow 3 inches (76 mm) of concrete to be packed around entering connection. Cut end of connection pipe passing through pipe or structure wall to conform to shape of and be flush with inside wall unless otherwise indicated. On outside of pipe, manhole, or structure wall, encase entering connection in 6 inches (150 mm) of concrete for minimum length of 12 inches (300 mm) to provide additional support of collar from connection to undisturbed ground.

    a. Use concrete that will attain a minimum 28-day compressive strength of 3000 psi (20.7 MPa) unless otherwise indicated.
    b. Use epoxy-bonding compound as interface between new and existing concrete and piping materials.

4. Protect existing piping, manholes, and structures to prevent concrete or debris from entering while making tap connections. Remove debris or other extraneous material that may accumulate.

D. Connect to sediment interceptors specified in Section 221323 "Sanitary Waste Interceptors."

E. Pipe couplings, expansion joints, and deflection fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

1. Use non-pressure-type flexible couplings where required to join gravity-flow, non-pressure sewer piping unless otherwise indicated.

    a. As directed Unshielded or Shielded flexible couplings for same or minor difference OD pipes.
    b. Unshielded, increaser/reducer-pattern, flexible couplings for pipes with different OD.
    c. Ring-type flexible couplings for piping of different sizes where annular space between smaller piping's OD and larger piping's ID permits installation.

3.11 CLOSING ABANDONED STORM DRAINAGE SYSTEMS

A. Abandoned Piping: Close open ends of abandoned underground piping indicated to remain in place. Include closures strong enough to withstand hydrostatic and earth pressures that may result after ends of abandoned piping have been closed. Use either procedure below:

1. Close open ends of piping with at least 8 (203) inch (mm) thick, brick masonry bulkheads.
2. Close open ends of piping with threaded metal caps, plastic plugs, or other acceptable methods suitable for size and type of material being closed. Do not use wood plugs.

B. Abandoned Manholes and Structures: Excavate around manholes and structures as required and use one procedure below:

1. Remove manhole or structure and close open ends of remaining piping.
2. Remove top of manhole or structure down to at least 36 (915) inches (mm) below final grade. Fill to within 12 (300) inches (mm) of top with stone, rubble, gravel, or compacted dirt. Fill to top with concrete.

C. Backfill to grade in accordance with Section 312000 "Earth Moving."

3.12 IDENTIFICATION

A. Materials and their installation are specified in Section 312000 "Earth Moving." Arrange for installation of green warning tape directly over piping and at outside edge of underground structures.

1. Use warning tape or detectable warning tape over ferrous piping.
2. Use detectable warning tape over nonferrous piping and over edges of underground structures.

3.13 FIELD QUALITY CONTROL

A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches (610 mm) of backfill is in place, and again at completion of Project.

1. Submit separate reports for each system inspection.
2. Defects requiring correction include the following:

a. Alignment: Less than full diameter of inside of pipe is visible between structures.
b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
c. Damage: Crushed, broken, cracked, or otherwise damaged piping.
d. Infiltration: Water leakage into piping.
e. Exfiltration: Water leakage from or around piping.

3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
4. Reinspect and repeat procedure until results are satisfactory.

B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.

1. Do not enclose, cover, or put into service before inspection and approval.
2. Test completed piping systems in accordance with requirements of authorities having jurisdiction.
3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
4. Submit separate report for each test.
5. Gravity-Flow Storm Drainage Piping: Test in accordance with requirements of authorities having jurisdiction, UNI-B-6, and the following:

a. Exception: Piping with soiltight joints unless required by authorities having jurisdiction.
b. Option: Test plastic piping in accordance with ASTM F1417.

C. Leaks and loss in test pressure constitute defects that must be repaired.

D. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

3.14 CLEANING

A. Clean interior of piping of dirt and superfluous materials. Flush with potable water or Flush with water as directed.

END OF SECTION 334200

SECTION 334600 - SUBDRAINAGE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Perforated-wall pipe and fittings.
2. Geotextile filter fabrics.

1.2 ACTION SUBMITTALS

A. Product Data: For geotextile filter fabrics.

PART 2 - PRODUCTS

2.1 PERFORATED-WALL PIPES AND FITTINGS

A. Perforated PE Pipe and Fittings: ASTM F405 or AASHTO M 252, Type CP; corrugated, for coupled joints.

2.2 SOIL MATERIALS

A. Soil materials are specified in Section 312000 "Earth Moving."

2.3 WATERPROOFING FELTS

A. Material: Comply with ASTM D226, Type I, asphalt or ASTM D227, coal-tar-saturated organic felt.

2.4 GEOTEXTILE FILTER FABRICS

A. Description: Fabric of PP or polyester fibers or combination of both, with flow rate range from 110 to 330 gpm/sq. ft. (4480 to 13 440 L/min. per sq. m) when tested according to ASTM D4491.

B. Structure Type: Nonwoven, needle-punched continuous filament.

1. Survivability: AASHTO M 288 Class 2.
2. Styles: Flat and sock.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavating, trenching, and backfilling are specified in Section 312000 "Earth Moving."

3.2 FOUNDATION DRAINAGE INSTALLATION

A. Place impervious fill material on subgrade adjacent to bottom of footing after concrete footing forms have been removed. Place and compact impervious fill to dimensions indicated, but not less than 6 inches (150 mm) deep and 12 inches (300 mm) wide.

B. Lay flat-style geotextile filter fabric in trench and overlap trench sides.

C. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than 4 inches (100 mm).

D. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with adhesive or tape.

E. Install drainage piping as indicated in Part 3 "Piping Installation" Article for foundation subdrainage.

F. Add drainage course to width of at least 6 inches (150 mm) on side away from wall and to top of pipe to perform tests.

G. After satisfactory testing, cover drainage piping to width of at least 6 inches (150 mm) on side away from footing and above top of pipe to within 12 inches (300 mm) of finish grade.

H. Install drainage course and wrap top of drainage course with flat-style geotextile filter fabric.

I. As directed Place layer of flat-style geotextile filter fabric or waterproofing felt over top of drainage course, overlapping edges at least 4 inches (100 mm).

J. Place backfill material over compacted drainage course. Place material in loose-depth layers not exceeding 6 inches (150 mm). Thoroughly compact each layer. Final backfill to finish elevations and slope away from building.

3.3 UNDERSLAB DRAINAGE INSTALLATION

A. Excavate for underslab drainage system after subgrade material has been compacted but before drainage course has been placed. Include horizontal distance of at least 6 inches (150 mm) between drainage pipe and trench walls. Grade bottom of trench excavations to required slope, and compact to firm, solid bed for drainage system.

B. Lay flat-style geotextile filter fabric in trench and overlap trench sides.

C. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than 4 inches (100 mm).

D. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with adhesive or tape.

E. Install drainage piping as indicated in Part 3 "Piping Installation" Article for underslab subdrainage.

F. Add drainage course to width of at least 6 inches (150 mm) on side away from wall and to top of pipe to perform tests.

G. After satisfactory testing, cover drainage piping with drainage course to elevation of bottom of slab, and compact and wrap top of drainage course with flat-style geotextile filter fabric.

3.4 PIPING INSTALLATION

A. Install piping beginning at low points of system, true to grades and alignment indicated, with unbroken continuity of invert. Bed piping with full bearing in filtering material. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions and other requirements indicated.

1. Foundation Subdrainage: Install piping level and with a minimum cover of 36 inches (915 mm) unless otherwise indicated.
2. Underslab Subdrainage: Install piping level.
3. Retaining-Wall Subdrainage: When water discharges at end of wall into stormwater piping system, install piping level and with a minimum cover of 36 inches (915 mm) unless otherwise indicated.
4. Lay perforated pipe with perforations down.
5. Excavate recesses in trench bottom for bell ends of pipe. Lay pipe with bells facing upslope and with spigot end entered fully into adjacent bell.

B. Use increasers, reducers, and couplings made for different sizes or materials of pipes and fittings being connected. Reduction of pipe size in direction of flow is prohibited.

C. Install thermoplastic piping according to ASTM D2321.

3.5 PIPE JOINT CONSTRUCTION

A. Join perforated PE pipe and fittings with couplings according to ASTM D3212 with loose banded, coupled, or push-on joints.

B. Special Pipe Couplings: Join piping made of different materials and dimensions with special couplings made for this application. Use couplings that are compatible with and fit materials and dimensions of both pipes.

3.6 BACKWATER VALVE INSTALLATION

A. Comply with requirements for backwater valves specified in Section 334100 "Storm Utility Drainage Piping."

B. Install horizontal backwater valves in header piping downstream from perforated subdrainage piping.

C. Install horizontal backwater valves in piping in manholes or pits where indicated.

3.7 CLEANOUT INSTALLATION

A. Comply with requirements for cleanouts specified in Section 334100 "Storm Utility Drainage Piping."

B. Cleanouts for Foundation and Retaining-Wall Subdrainage:

1. Install cleanouts from piping to grade. Locate cleanouts at beginning of piping run and at changes in direction. Install fittings so cleanouts open in direction of flow in piping.
2. In vehicular-traffic areas, use NPS 4 (DN 100) cast-iron soil pipe and fittings for piping branch fittings and riser extensions to cleanout. Set cleanout frames and covers in a cast-in-place concrete anchor, 18 by 18 by 12 inches (450 by 450 by 300 mm) deep. Set top of cleanout flush with grade.
3. As directed In nonvehicular-traffic areas, use NPS 4 (DN 100) cast-iron or PVC pipe and fittings for piping branch fittings and riser extensions to cleanout. Set cleanout frames and covers in a cast-in-place concrete anchor, 12 by 12 by 4 inches (300 by 300 by 100 mm) deep. Set top of cleanout 1 inch (25 mm) or 2 inches (50 mm) above grade.
4. Comply with requirements for concrete specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed

C. Cleanouts for Underslab Subdrainage:

1. Install cleanouts and riser extensions from piping to top of slab. Locate cleanouts at beginning of piping run and at changes in direction. Install fittings so cleanouts open in direction of flow in piping.
2. Use NPS 4 (DN 100) cast-iron soil pipe and fittings for piping branch fittings and riser extensions to cleanout flush with top of slab.

3.8 CONNECTIONS

A. Comply with requirements for piping specified in Section 334100 "Storm Utility Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect low elevations of subdrainage system to building's solid-wall-piping storm drainage system.

C. Where required, connect low elevations of foundation or underslab subdrainage to stormwater sump pumps. Comply with requirements for sump pumps specified in Section 221429 "Sump Pumps."

3.9 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. After installing drainage course to top of piping, test drain piping with water to ensure free flow before backfilling.
2. Remove obstructions, replace damaged components, and repeat test until results are satisfactory.

B. Drain piping will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.10 CLEANING

A. Clear interior of installed piping and structures of dirt and other superfluous material as work progresses. Maintain swab or drag in piping and pull past each joint as it is completed. Place plugs in ends of uncompleted pipe at end of each day or when work stops.

END OF SECTION 334600

SECTION 334713 - POND AND RESERVOIR LINERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes geomembrane liners and floating covers for ponds and reservoirs fabricated from the following:

1. Linear low-density polyethylene (LLDPE).
2. High-density polyethylene (HDPE).
3. Polypropylene (PP).
4. Polyvinyl chloride (PVC).

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Include panel layout, seams, penetrations, perimeter anchorage, and methods of attachment and sealing to other construction. Differentiate between factory and field seams and joints.

C. Samples: For each exposed product and for each color specified.

1.4 INFORMATIONAL SUBMITTALS

A. Product certificates.

B. Product test reports.

C. Source quality-control reports.

D. Field quality-control reports.

E. Sample warranty.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Fabricator of products or An entity that employs installers and supervisors who are trained and approved by manufacturer as directed.

1.7 WARRANTY

A. Manufacturer's Special Warranty: Manufacturer agrees to repair or replace geomembrane liner and floating cover that fail(s) in materials or workmanship within specified warranty period.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Provide geomembrane liners and floating covers that prevent the passage of water and gas.

2.2 LLDPE SHEET MATERIALS

A. LLDPE Sheet: Formulated from virgin PE, compounded for use in hydraulic structures, and formed into uniform sheets with material properties complying with GRI Test Method GM17, non-reinforced, GRI Test Method GM25, reinforced, for thickness indicated.
   1. Minimum Average Sheet Thickness: As directed 20 mils (0.50 mm), 30 mils (0.75 mm), 40 mils (1.00 mm), 50 mils (1.25 mm), 60 mils (1.50 mm), 80 mils (2.00 mm), 100 mils (2.50 mm) or 120 mils (3.00 mm) per ASTM D5199.
   2. Nominal Sheet Thickness: 24 mils (0.61 mm), 36 mils (0.91 mm) or 45 mils (1.10 mm) per ASTM D5199 as directed.
   3. Sheet Texture: One side smooth; other side smooth or textured as directed.

2.3 HDPE SHEET MATERIALS

A. HDPE Sheet: Formulated from virgin PE, compounded for use in hydraulic structures, and formed into uniform sheets with material properties complying with GRI Test Method GM13 for thickness indicated.
   1. Minimum Average Sheet Thickness: As directed 30 mils (0.75 mm), 40 mils (1.00 mm), 50 mils (1.25 mm), 60 mils (1.50 mm), 80 mils (2.00 mm), 100 mils (2.50 mm) or 120 mils (3.00 mm) per ASTM D5199.
   2. Sheet Texture: One side smooth; other side smooth or textured as directed.

2.4 PP SHEET MATERIALS

A. PP Sheet: Formulated from virgin PP, compounded for use in hydraulic structures, and formed into uniform, flexible non-reinforced or reinforced sheets as directed with material properties complying with GRI Test Method GM18 for thickness indicated.
   1. Minimum Average Sheet Thickness: As directed 30 mils (0.75 mm), 40 mils (1.00 mm), 60 mils (1.50 mm), 36 mils (0.91 mm) or 45 mils (1.10 mm) per ASTM D5199.

2. Reinforcing Scrim: One-ply polyester fabric totally encapsulated between two sheets.

   a. Construction: 9 x 9 - 1000 d or 10 x 10 - 1000 d as directed.

3. Sheet Texture: One side smooth; other side smooth or textured.

2.5 PVC SHEET MATERIALS

A. PVC Sheet: Formulated from virgin PVC with plasticizers and other modifiers, compounded for use in hydraulic structures, and formed into uniform, flexible non-reinforced sheets with material properties complying with ASTM D7176 or PGI 1104, "Specification for PVC Geomembranes," for nominal thickness indicated.
   1. Nominal Thickness: As directed 10 mils (0.25 mm), 20 mils (0.51 mm), 30 mils (0.76 mm), 40 mils (1.02 mm), 50 mils (1.3 mm) or 60 mils (1.5 mm).
   2. Sheet Texture: One side smooth; other side smooth, matte or faille textured as directed.

2.6 FLOATING COVER ACCESSORIES

A. Screened Scupper Hoses: Manufacturer's standard.

B. Flotation Blocks: Closed-cell PE foam blocks approximately 4 by 12 inches (102 by 300 mm), 2.2 lb/cu. ft. (35.2 kg/cu. m).

C. Access Hatch: Manufacturer's standard, in size indicated.

2.7 MISCELLANEOUS MATERIALS

A. Adhesives: Provide types of adhesive primers, compounds, solvents, and tapes recommended in writing by geomembrane liner manufacturer for bonding to structures (if required), for sealing of seams in geomembrane liner, and for sealing penetrations through geomembrane liner.

B. Penetration Assemblies: Provide manufacturer's standard factory-fabricated assemblies for sealing penetrations. Include joint sealant recommended in writing by geomembrane liner manufacturer and compatible with geomembrane liner, containment conditions, and materials.

C. Battens: Long-length strips of material indicated, size as indicated on Drawings. Fabricate battens with sharp projections removed and edges eased and then predrilled or punched for anchors. Provide anchors, or other type of attachment, of type and spacing recommended in writing by geomembrane liner manufacturer for attaching geomembrane liner system to substrate and as indicated.

   1. Batten Material: Liner manufacturer's standard system.
   2. Batten Material: Aluminum; with stainless-steel anchors, complete with gasket and sealant compatible with geomembrane liner, containment conditions, and materials.
   3. Batten Material: Stainless steel; with stainless-steel anchors, complete with gasket and sealant compatible with geomembrane liner, containment conditions, and materials.
   4. Batten Material: Plastic compatible with geomembrane liner, cast in place or fastened with stainless-steel anchors, designed to continuously seal geomembrane liner to batten.

D. Sand: ASTM C33/C33M; fine aggregate, natural or manufactured sand.

2.8 FABRICATION

A. Fabricate geomembrane liner and floating cover panels from sheets in sizes as large as possible with factory-sealed seams, consistent with limitations of weight and installation procedures. Minimize field seaming.

B. Fabricate flotation blocks, wrap in geomembrane sheet, and attach to underside of floating cover according to manufacturer's written instructions.

C. Fabricate ballast tubes of sand-filled geomembrane sheet and attach to top surface of floating cover according to manufacturer's written instructions.

D. Install built-in accessories, hatches, access panels, vents, and walkways on geomembrane floating cover.

PART 3 - EXECUTION

3.1 PREPARATION

A. Provide temporary ballast, until edges are permanently secured, that does not damage geomembrane liner or substrate, to prevent uplift of geomembrane liner in areas with prevailing winds.

B. Prepare surfaces of construction penetrating through geomembrane liner according to geomembrane liner manufacturer's written instructions.

C. Remove curing compounds and coatings from concrete surfaces to be sealed to geomembrane liner.

3.2 INSTALLATION

A. Examine anchor trench excavation or concrete perimeter as directed, where geomembrane liner and floating cover will be secured, for substrate conditions indicated above and for correct location and configuration.

B. General: Place geomembrane liner over prepared surfaces to ensure minimum handling. Install according to Shop Drawings and in compliance with geomembrane liner manufacturer's written instructions. Begin placing geomembrane liner at Project's upwind direction and proceed downwind. Install geomembrane liner in a relaxed condition, free from stress and with minimum wrinkles, and in full contact with subgrade. Do not bridge over voids or low areas in the subgrade. Fit closely and seal around inlets, outlets, and other projections through geomembrane liner. Permanently secure edges.

C. Field Seams: Comply with geomembrane liner and floating cover manufacturer's written instructions. Form seams by lapping edges of panels 2 to 4 inches (50 to 102 mm), unless instructions require a larger overlap. Wipe contact surfaces clean and free of dirt, dust, moisture,

and other foreign materials. Use solvent-cleaning methods and grind geomembrane seam surfaces if recommended by geomembrane liner manufacturer. Proceed with seaming at required temperatures for materials and ambient conditions. Continuously bond sheet to sheet to construct single or double seams of width recommended for method of seaming used. Seal or fuse free seam edges. Inspect seams and reseal voids.

1. Thermal Bonding: Use thermal-welding technique recommended by geomembrane liner manufacturer. Apply pressure to smoothly bond surfaces together. Examine for and patch wrinkles and fishmouths.

D. Installation in Anchor Trench: Install geomembrane liner and floating cover in trench according to manufacturer's written instructions. Backfill and compact to lock liner into trench.

E. Attachment to Concrete: Use manufacturer's standard system to suit Project conditions. Support adhesive and geomembrane on minimum 8-inch- (200-mm-) wide concrete substrate unless otherwise indicated.

1. Install batten strips over geomembrane liner and floating cover as indicated on Drawings.
2. Install antichafing strips of geomembrane sheet between geomembrane liner and floating cover according to manufacturer's written instructions.
3. Install floating cover with perimeter fold.

F. Floating Cover Flotation Control: Connect drainage hoses in perimeter fold, sumps, or scuppers to pump or gravity drain system.

G. Liner Repairs: Repair tears, punctures, and other imperfections in geomembrane liner field and seams using patches of geomembrane liner material, liner-to-liner bonding materials, and bonding methods according to geomembrane liner manufacturer's written instructions. Apply bonding solvent or weld to contact surfaces of both patch and geomembrane liner, and press together immediately. Roll to remove wrinkles.

3.3 FIELD QUALITY CONTROL

A. Testing Agency: As directed Owner will engage or Engage a qualified testing agency to perform tests and inspections.

B. Nondestructive Testing: Visually inspect seams and patches. Comply with ASTM D4437 for Air Lance Test, Vacuum Box Testing, or Ultrasonic (High Frequency) Pulse Echo Testing or with GRI Test Method GM6, as applicable to geomembrane liner and floating cover and seam construction. Record locations of failed seams and patches. Individually number and date occurrences and details of leak and remedial action. Repair leaking seams and patches.

C. Destructive Testing: Comply with GRI Test Method GM19, as applicable to geomembrane liner and floating cover and seam construction. Record locations of sample locations and failed seams. Individually number and date occurrences and details of leak and remedial action. Repair leaking seams and patches, and test sample locations.

D. Prepare test and inspection reports.

3.4 DISINFECTION

A. Disinfect the complete installation according to procedures in AWWA C652.

3.5 PROTECTION

A. Protect installed geomembrane liner and floating cover according to manufacturer's written instructions. Repair or replace areas of geomembrane liner damaged by scuffing, punctures, traffic, rough subgrade, or other unacceptable conditions.

B. Before initial filling of pond or placement of earth cover, inspect seams and patched areas to ensure tight, continuously bonded installation. Repair damaged geomembrane liner and seams and reinspect repaired work.

END OF SECTION 334713

SECTION 336313 - UNDERGROUND STEAM AND CONDENSATE DISTRIBUTION PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes underground piping outside the building for distribution of steam and condensate.

1.2 PERFORMANCE REQUIREMENTS

A. Provide components and installation capable of producing steam piping systems with the following minimum working-pressure ratings:

1. Steam Piping: 15 psig (104 kPa), 125 psig (860 kPa) or 250 psig (1720 kPa) as directed.
2. Condensate Piping: 100 psig (690 kPa) at 250 deg F (121 deg C).

1.3 ACTION SUBMITTALS

A. Product Data: For conduit piping

B. Shop Drawings: For underground steam and condensate distribution piping. Signed and sealed by a qualified professional engineer.

1. Calculate requirements for expansion compensation for underground piping.
2. Show expansion compensators, offsets, and loops with appropriate materials to allow piping movement in the required locations. Show anchors and guides that restrain piping movement with calculated loads, show concrete thrust block dimensions.
3. Show pipe sizes, locations, and elevations. Show piping in trench with details showing clearances between piping, show insulation thickness.

1.4 INFORMATIONAL SUBMITTALS

A. Material Test Reports: For conduit piping.

B. Source quality-control reports.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME B31.9, "Building Services Piping or ASME B31.1, "Power Piping," for materials, products, and installation as directed.

B. ASME Compliance: Safety valves and pressure vessels shall bear appropriate ASME labels.

PART 2 - PRODUCTS

2.1 STEEL PIPES AND FITTINGS

A. Steel Pipe: ASTM A53/A53M, Type E, Grade A, wall thickness as indicated in "Piping Application" Article; black with plain ends.

B. Cast-Iron, Threaded Fittings: ASME B16.4, Class 125 and Class 250, standard pattern, with threads according to ASME B1.20.1.

C. Malleable-Iron, Threaded Fittings: ASME B16.3, Class 150 and Class 300, with threads according to ASME B1.20.1.

D. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

E. Steel Welding Fittings: ASME B16.9 and ASTM A234/A234M, seamless or welded.

1. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

F. Nipples: ASTM A733, Standard Weight, seamless, carbon-steel pipe complying with ASTM A53/A53M.

G. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

H. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

2.2 CONDUIT PIPING SYSTEM

A. Conduit Piping System: Factory-fabricated and -assembled, airtight and watertight, drainable, pressure-tested piping with conduit, inner pipe supports, and insulated carrier piping. Fabricate so insulation can be dried in place by forcing dry air through conduit.

B. Carrier Pipe: Steel pipe and fittings, wall thickness as indicated in "Piping Application" Article; black with plain ends.

C. Carrier Pipe Insulation:

1. Mineral-Wool Pipe Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C547, Type I 850 deg F (454 deg C) or Type II as directed, 1200 deg F (649 deg C), Grade A.

    a. Bands: ASTM A666, Type 304, stainless steel, 3/4 inch (19 mm) wide, 0.020 inch (0.5 mm) thick.

2. Calcium Silicate Pipe Insulation: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C533, Type I.

    a. Bands: ASTM A666, Type 304, stainless steel, 3/4 inch (19 mm) wide, 0.020 inch (0.5 mm) thick.

3. Polyisocyanurate Foam Pipe Insulation: Unfaced, preformed, rigid cellular polyisocyanurate material intended for use as thermal insulation.

    a. Comply with ASTM C591, Type I or Type IV, except thermal conductivity (k-value) shall not exceed 0.19 Btu x in./h x sq. ft. x deg F (0.027 W/m x K) at 75 deg F (24 deg C) after 180 days of aging.
    b. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less for thickness up to 1-1/2 inches (38 mm) as tested by ASTM E84.
    c. Fabricate shapes according to ASTM C450 and ASTM C585.

4. Polyurethane Foam Pipe Insulation: Unfaced, preformed, rigid cellular polyurethane material intended for use as thermal insulation.

    a. Comply with ASTM C591, Type I or Type IV, except thermal conductivity (k-value) shall not exceed 0.19 Btu x in./h x sq. ft. x deg F (0.027 W/m x K) at 75 deg F (24 deg C) after 180 days of aging.
    b. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less for thickness up to 1-1/2 inches (38 mm) as tested by ASTM E84.
    c. Fabricate shapes according to ASTM C450 and ASTM C585.

D. Minimum Clearance:

1. Between Carrier Pipe Insulation and Conduit: 1 inch (25 mm).
2. Between Insulation of Multiple Carrier Pipes: 3/16 inch (4.75 mm).
3. Between Bottom of Carrier Pipe Insulation and Conduit: 1 inch (25 mm).

E. Conduit: Spiral wound, steel.

1. Finish: With two coats of fusion-bonded epoxy, minimum 20 mils (0.50 mm) thick.
2. Cover: With polyurethane foam insulation with an HDPE jacket; thickness indicated in "Piping Application" Article.

3. Piping Supports within Conduit: Corrugated galvanized steel with a maximum spacing of 10 feet (3 m).
4. Fittings: Factory-fabricated and -insulated elbows and tees. Elbows may be bent pipe equal to carrier pipe. Tees shall be factory fabricated and insulated, shall be compatible with the carrier pipe.
5. Expansion Offsets and Loops: Size casing to contain piping expansion.
6. Accessories include the following:

    a. Water Shed: Terminal end protector for carrier pipes entering building through floor, 3 inches (75 mm) deep and 2 inches (50 mm) larger than casing; terminate casing 20 inches (500 mm) above the floor level.
    b. Guides and Anchors: Steel plate welded to carrier pipes and to casing, complete with vent and drainage openings inside casing.
    c. End Seals: Steel plate welded to carrier pipes and to casing, complete with drain and vent openings on vertical centerline.
    d. Gland Seals: Packed stuffing box and gland follower mounted on steel plate, welded to end of casing, permitting axial movement of carrier piping, with drain and vent connections on vertical centerline.
    e. Joint Kit: Half-shell, pourable or split insulation and shrink-wrap sleeve.

F. Manholes: Black steel with lifting eyes.

1. Finish: Spray-applied urethane, minimum 30 mils (0.75 mm) thick.
2. Access: 30-inch- (750-mm-) diameter waterproof cover with gasket, ladder, and two 6-inch (150-mm) vents, one high and one low, extending above grade with rain caps.
3. Conduit Stub-Outs and Seals: Welded steel with drain and vent openings.
4. Sump: 12 inches (300 mm) in diameter, 12 inches (300 mm) deep.
5. Floatation Anchor: Oversized bottom keyed into concrete base.

G. Source Quality Control: Factory test the conduit to 15 psig (105 kPa) for a minimum of two minutes with no change in pressure. Factory test the carrier pipe to 150 percent of the operating pressure of system. Furnish test certificates.

PART 3 - EXECUTION

3.1 EARTHWORK

A. See Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING APPLICATION

A. LP Steam Piping:

1. NPS 2 (DN 50) and Smaller: As directed Schedule 40 or Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.
2. NPS 2-1/2 through NPS 12 (DN 65 through DN 300): As directed Schedule 40 or Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

3. NPS 14 through NPS 18 (DN 350 through DN 450): Schedule 30, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
4. NPS 20 (DN 500) and Larger: Schedule 20, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
5. Conduit Piping: As directed Standard weight, Schedule 40 or Schedule 80 steel carrier pipe, with mineral-wool, calcium silicate or polyisocyanurate carrier-pipe insulation and with coated or coated and insulated conduit.

    a. Piping Insulation Thickness: As directed 1 inch (25 mm) or 2 inches (50 mm).
    b. Conduit Insulation Thickness: As directed 1 inch (25 mm) or 2 inches (50 mm).

        1) Insulation: As directed Polyisocyanurate or Polyurethane.
        2) Insulation Thickness: As directed 1 inch (25 mm) or 2 inches (50 mm).

B. HP Steam Piping:

1. NPS 2 (DN 50) and Smaller: As directed Schedule 40 or Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.
2. NPS 2-1/2 through NPS 12 (DN 65 through DN 300): As directed Schedule 40 or Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
3. NPS 14 through NPS 18 (DN 350 through DN 450): Schedule 30, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
4. NPS 20 (DN 500) and Larger: Schedule 20, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
5. Conduit Piping: As directed Standard weight, Schedule 40 or Schedule 80 steel carrier pipe, with mineral-wool, calcium silicate or polyisocyanurate carrier-pipe insulation and with coated, coated and insulated conduit.

    a. Piping Insulation Thickness: As directed 1 inch (25 mm) or 2 inches (50 mm).
    b. Conduit Insulation Thickness: 1 inch (25 mm) or 2 inches (50 mm).

        1) Insulation: As directed Polyisocyanurate or Polyurethane.
        2) Insulation Thickness: As directed 1 inch (25 mm) or 2 inches (50 mm).

C. Condensate Piping:

1. NPS 2 (DN 50) and Smaller: Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.
2. NPS 2-1/2 (DN 65) and Larger: Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
3. Conduit Piping: As directed Standard weight, Schedule 40 or Schedule 80 steel carrier pipe, with mineral-wool, calcium silicate, polyisocyanurate or polyurethane carrier-pipe insulation and with coated or coated and insulated conduit.

    a. Piping Insulation Thickness: 1 inch (25 mm) or 2 inches (50 mm) as directed.
    b. Conduit Insulation Thickness: 1 inch (25 mm) or 2 inches (50 mm) as directed.

3.3 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Remove standing water in the bottom of trench.

C. Bed the pipe on a minimum 6-inch (150-mm) layer of granular fill material with a minimum 6-inch (150-mm) clearance between the pipes.

D. Do not insulate piping or backfill piping trench until field quality-control testing has been completed and results approved.

E. Install piping at uniform grade of 0.2 percent downward in direction of flow or as indicated.

F. Install condensate piping at uniform grade of 0.4 percent downward in direction of flow.

G. In conduits, install drain valves at low points and manual air vents at high points.

H. Install components with pressure rating equal to or greater than system operating pressure.

I. Install piping free of sags and bends.

J. Install fittings for changes in direction and branch connections.

K. See Section 230517 "Sleeves and Sleeve Seals for HVAC Piping" for sleeves and mechanical sleeve seals through exterior building walls.

L. Secure anchors with concrete thrust blocks. Concrete is specified in Section 033000 "Cast-in-Place Concrete."

M. Connect to steam and condensate piping where it passes through the building wall. Steam and condensate piping inside the building is specified in Section 232213 "Steam and Condensate Heating Piping."

3.4 JOINT CONSTRUCTION

A. See Section 330500 "Common Work Results for Utilities" for basic piping joint construction.

B. Join pipe and fittings according to the following requirements and Section 232213 "Steam and Condensate Heating Piping."

C. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

D. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

F. Welded Joints: Construct joints according to AWS D10.12M/D10.12.

G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

H. Conduit Piping Joints: Assemble sections and finish joints with pourable or split insulation, exterior jacket sleeve, and apply shrink-wrap seals.

3.5 IDENTIFICATION

A. Install continuous plastic underground warning tapes during back filling of trenches for underground steam and condensate distribution piping. Locate tapes 6 to 8 inches (150 to 200 mm) below finished grade, directly over piping. See Section 312000 "Earth Moving" for warning-tape materials and devices and their installation.

3.6 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Prepare steam and condensate piping for testing according to ASME B31.1 and ASME B31.9 and as follows:

    a. Leave joints, including welds, uninsulated and exposed for examination during test.
    b. Isolate equipment. Do not subject equipment to test pressure.
    c. Install relief valve set at pressure no more than one-third higher than test pressure.
    d. Fill system with temperature water. Where there is risk of freezing, air or a safe, compatible liquid may be used.
    e. Use vents installed at high points to release trapped air while filling system. Use drip legs installed at low points for complete removal of liquid.

2. Test steam and condensate piping as follows:

    a. Subject steam and condensate piping to hydrostatic test pressure that is not less than 1.5 times the design pressure.
    b. After hydrostatic test pressure has been applied for 10 minutes, examine joints for leakage. Remake leaking joints using new materials and repeat hydrostatic test until no leaks exist.

3. Test conduit as follows:

a. Seal vents and drains and subject conduit to 15 psig (105 kPa) for four hours with no loss of pressure. Repair leaks and retest as required.

B. Prepare test and inspection reports.

END OF SECTION 336313

SECTION 337149.13 - OVERHEAD MEDIUM-VOLTAGE WIRING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Conductors, connectors, and splices.
2. Poles and crossarms.
3. Overhead-line grounding.
4. Hardware and accessories.
5. Surge arresters.
6. Cutouts, switches, and fuses.
7. Pole-mounted distribution transformers.

1.2 DEFINITIONS

A. Sag: The distance measured vertically from a conductor to the straight line joining its two points of support, measured at the midpoint of the span, unless otherwise indicated.

1. Final Sag: The sag of a conductor under specified conditions of loading and temperature applied after it has been subjected, for an appreciable period, to the loading prescribed for the loading district in which it is situated, or equivalent loading, and the loading removed. Final sag includes the effect of inelastic deformation (creep).
2. Initial Unloaded Sag: The sag of a conductor before the application of an external load.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

1.4 INFORMATIONAL SUBMITTALS

A. Listing Documentation: Indicate that products comply with RUS listing requirements specified in "Quality Assurance" Article.

B. Design Data:

1. Time-Current Coordination Curves: Illustrate optimum coordination of protective devices involved in the Work of this Section.

C. Source quality-control reports.

D. Field quality-control reports.

E. Survey records for locations of pole, anchors, and other features for inclusion in Project Record Documents.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: As directed For switches or transformers to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: One additional spare fuse(s) or fuse element(s) for each furnished fuse or fuse element.

1.7 QUALITY ASSURANCE

A. Treatment Technician Qualifications for Field Treatment of Wood Poles and Crossarms: Certified by authorities having jurisdiction over environmental protection at the location of Project for field application of chemicals required.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Overhead-Line Components, Devices, and Accessories: Currently listed in RUS Informational Publication 202-1 without restriction for the intended application.

D. as directed comply with IEEE C2 or CPUC General Order 95, except where stricter requirements are indicated or where local requirements that are stricter apply.

E. Strength of Line and Line Components Selected by Contractor: Provide grades of construction and strength required by IEEE C2 for conditions encountered at Project site for heavy, medium or light line loading unless otherwise indicated.

PART 2 - PRODUCTS

2.1 CONDUCTORS, CONNECTORS, AND SPLICES

A. Conductor Type ACSR: Bare and covered, aluminum conductor, steel reinforced, complying with ASTM B232/B232M.

B. Conductor Type CU: Bare and covered, hard-drawn copper, complying with ASTM B1 and ASTM B8.

C. Conductor Covering: UV resistant, complying with ICEA-S-70-547. HDPE or XLP, 150 mils (3.81 mm) thick.

D. Secondary-Voltage Line Conductors: Aluminum conductor, steel reinforced, complying with ASTM B232/B232M.

E. Secondary-Voltage Line Conductors: Bare hard-drawn copper, complying with ASTM B1 and ASTM B8.

F. Neutral-Supported, Secondary Service-Drop Cable, 600 V and Less: Insulated conductors with bare neutral, complying with ICEA S-76-474, and using the following combination of materials:

1. Conductors and Neutral: As directed Copper with copper-clad-steel neutral or Aluminum with bare Alloy 1350 aluminum neutral or Aluminum with ACSR neutral.
2. Insulation: As directed XLP, complying with NEMA WC 70/ICEA S-95-658 or High-modular-weight, low-density polyethylene or Weather-resistant polyolefin, complying with ICEA S-70-547.

G. Connectors, Splices, and Conductor Securing and Protecting Components: Items include wire clamps, ties, conductor armor, fittings, connectors, and terminals. Listed for the specific applications and conductor types and combinations of materials used. Descriptions as follows for various applications:

1. Copper to Copper: Copper alloy, complying with UL 486A-486B.
2. Aluminum Composition to Aluminum Composition: Aluminum alloy, complying with UL 486A-486B.
3. Copper to Aluminum Composition: Type suitable for this purpose, complying with UL 486A-486B.
4. Connectors and Splices for Secondary Conductors: Listed and labeled for the conditions and materials involved in each application.
5. Taps for Medium-Voltage Line Conductors: Hot-line clamps, screw type, with concealed threads and bare, hard-drawn copper stirrups. Listed for the combination of materials being connected.
6. Splices under Tension: Compression type with strength exceeding the conductors spliced.

2.2 WOOD POLES

A. Comply with ATIS O5.1 and RUS Bulletin 1728F-700, for wood poles pressure treated with creosote, pentachlorophenol, ammoniacal copper arsenate, ammoniacal copper zinc arsenate or chromated copper arsenate as directed.

B. Wood Species: As directed Douglas fir, Lodgepole pine, Western larch or Southern yellow pine.

C. Pole Marking:

1. Manufacturer's Mark: Comply with ATIS O5.1; locate 10 feet (3 m) from the pole butt for poles 50 feet (15 m) long or less.
2. Pole Number: Machine-embossed aluminum, alphanumeric characters not less than 2-1/2 inches (65 mm) high, with aluminum nails.

D. Factory Operations: Machine trim poles by turning smooth, full length. Roof, gain, and bore poles before pressure treatment.

2.3 CROSSARMS

A. Description: As directed Solid-wood distribution type, complying with RUS Bulletin 1728H-701 for specified construction grade or Galvanized, steel angles, and complying with IEEE C2 for required climbing space and wire clearances.

B. Braces: Galvanized, flat, ferrous-metal units; 1/4 inch (6 mm) thick by 1-1/4 inches (30 mm) wide, minimum, with length to suit crossarm dimensions.

2.4 GUYS AND ANCHORS

A. Guy Strand Assemblies: Cable and attachment assemblies shall have uniform minimum breaking strength of the cable.

1. Cable: Seven strands. As directed Zinc-coated steel, complying with ASTM A475, Aluminum-clad steel, complying with ASTM B416 or Copper-clad steel, complying with ASTM B228. Breaking strength shall be not less than 10,000 lb (45 kN).
2. Cable Termination:

    a. Thimble eye.
    b. Hooks and guy strain plates, complying with IEEE C135.1.
    c. Preformed galvanized-steel guy grips, matching material, galvanizing, and strength of the guy strand assembly.

B. Anchor and Anchor-Rod Assemblies: Hot-dip galvanized steel.

1. Power-installed screw-type anchors.

    a. 15-inch (380-mm) screw; with rod 96 inches (2400 mm) long by 1-1/2 inches (38 mm) in diameter. Rated at 10,000 lb (45 kN) when installed.
    b. Guy anchors shall have strength and holding area as required for anchor load and soil conditions at location of that anchor.

2. Anchor size or type as directed.

C. Strain Insulators: Epoxy-bonded fiberglass of length to meet clearance requirements specified in "Guy Installation" Article.

D. Guy Markers: As directed Round, of vinyl or PVC material, white or yellow color, 96 inches (2440 mm) long. Shatter resistant at temperatures below 0 deg F (minus 18 deg C).

2.5 HARDWARE AND ACCESSORIES

A. Description: Ferrous-metal items include, but are not limited to, bolts, nuts, washers, crossarm gains and braces, insulator pins, anchor rods, anchors, eyebolts, staples, and transformer brackets.

1. Comply with IEEE C135.1, IEEE C135.2, ANSI C135.4, ANSI C135.22, and RUS Informational Publication 202-1 listings with the exception that base material shall be malleable iron or ductile iron, and finish shall be hot-dip galvanized.

B. Insulator Brackets: Hot-dip galvanized steel, style as indicated, designed to hold vertical-post-type or pin-type insulators, with one or two-bolt attachment to pole as directed.

C. Secondary Insulator Racks: As directed Hot-dip galvanized steel, style as indicated, with smooth, rounded 12-gage struts designed to support two, three or four spool insulators for attachment of secondary drop conductors. Spool spacing of 4 inches (100 mm), 8 inches (200 mm) or 12 inches (300 mm).

D. Pole Riser Shields: As directed Galvanized steel with boot, backplate or vent.

E. Insulators: Units rated 6 kV and above shall be free from radio interference.

1. Porcelain insulators shall be wet-process type, complying with the following:

a. Pin: ANSI C29.5.
b. Line Post: ANSI C29.7. Include mounting stud of length suitable for each mounting arrangement used.
c. Suspension: ANSI C29.2.
d. Guy Strain: ANSI C29.4.
e. Secondary Spool: ANSI C29.3, Class 53-2.

2. Polymer-composite, fiberglass-reinforced insulators shall comply with the following:

a. Line Post: CEA LWIWG-02.
b. Dead End/Suspension: CEA LWIWG-01.
c. Guy Strain: Fiberglass reinforced, epoxy finished. Designed specifically for use in guy assemblies.

F. Grounding Materials: Comply with Section 260526 "Grounding and Bonding for Electrical Systems," using materials listed by RUS for the intended purpose without restriction.

1. Conductors: No. 4 AWG, minimum; bare, solid, annealed copper, complying with ASTM B8 unless otherwise indicated.
2. Ground Conductor Protectors: PVC or half-round wood molding, fir, pressure treated according to AWPA C25, cypress or cedar as directed.

2.6 SURGE ARRESTERS

A. Distribution-Class Surge Arresters: As directed, Porcelain or Polymer-enclosed, gapless, metal-oxide type with automatic-indicating type, ground-lead disconnection feature, complying with IEEE C62.11 and NEMA LA 1.

B. Intermediate-Class Surge Arresters: As directed Porcelain or Polymer-enclosed, gapless, metal-oxide type, complying with IEEE C62.11 and NEMA LA 1.

1. Voltage Rating: As directed 3, 6, 9, 10, 12, 15, 27, 30 or 36 kV, at the altitude of Project, unless otherwise indicated.

2.7 CUTOUTS, SWITCHES, AND FUSES

A. Description: Medium-voltage disconnect, protective, and bypass units shall be rated for the line-to-line voltage of the systems in which installed, unless higher ratings are indicated. BIL ratings are 45, 60, 75, 95, 150 or 200 kV as directed.

1. Momentary Current Rating of Switching Devices: As directed 20 or 40 kA, asymmetrical at nominal system operating voltage.
2. Fuse Characteristics: Time-current characteristics for each set of fuses selected according to written recommendations of manufacturer of component protected by the fuses and coordinated with upstream and downstream protective devices. Prepare time-current coordination curves according to IEEE 242 that illustrate optimum coordination of devices in this Project.
3. Interrupting Rating of Fuses: Value as directed, symmetrical A at nominal system operating voltage.

B. Fuse Cutouts: As directed Open or enclosed type, rated 100 or 200 A, continuous, complying with ANSI C37.42.

1. Fuses: Enclosed link, Type K or Type T, complying with ANSI C37.42 as directed.
2. Fuse Current Rating: 150 percent of the transformer full-load current unless otherwise indicated.
3. Switching Application: Include switch link instead of fuse.
4. Switch Current Interrupting Rating: Transformer magnetizing current.

C. Fused Switches: Single-pole, manual units.

1. Switch Rating: As directed 400 or 600-A rms continuous and load-current interrupting.
2. Fuses: Dropout-type power fuses.

D. Nonfused Switches: Single-pole, manual units, rated 100, 200, 400 or 600-A rms continuous as directed.

E. Group-Operated, Load-Interrupter Switches: Fused or Nonfused as directed, three-pole, single-throw units, manually operated by handle through insulated mechanical linkage.

1. High-pressure contact type, complying with ANSI C37.32.
2. Factory assembled to suit specific configuration and mounting conditions for this Project.
3. Operating Handle: Padlock equipped.
4. Current Interrupting Rating: Equal to continuous current rating of switch.
5. Fuses: Nondropout power type.

F. Group-Operated, Air-Break (Nonloadbreak) Switches: Three-pole, single-throw units, manually operated by handle through insulated mechanical linkage.

1. Comply with ANSI C37.32.
2. Factory assembled to suit specific configuration and mounting conditions for this Project.
3. Operating Handle: Padlock equipped.
4. Suitable for field conversion to load-interrupter switch by adding interrupter modules.

2.8 DISTRIBUTION TRANSFORMERS

A. Description: Single-phase, two-winding, single or two-bushing as directed, liquid-filled, self-cooled, pole-mounting distribution type, suitable for external fuse and surge suppressor protection; complying with IEEE C 57.12.00, and tested according to IEEE C 57.12.90 and with the following additional requirements:

1. Cooling Class: OA.
2. Temperature Rise: 65 deg C.
3. Insulating Liquid: Mineral oil, ASTM D3487, Type II.
4. Identification: Label the transformer as "non-PCB" and place manufacturer's name and type of fluid on the nameplate.

B. BIL: 95, 75 or 60 kV as directed.

C. Primary Voltage: As directed voltage.

D. Taps: As directed Two, 2.5 percent above and below, Four, 2.5 percent below, high-voltage and full-load rated. Tap changer shall have an external operating handle.

E. Mounting Brackets: As directed Single or Double, integral; suitable for pole mounting, individually or in cluster, or on crossarm.

F. Minimum Efficiency: Class 1, as defined by NEMA TP 1, based on test results that comply with requirements of NEMA TP 2.

G. Bushings: Creepage distance shall exceed nominal value standard for unit rating by at least 75 percent.

H. Hardware: Stainless steel.

I. Tank and Cover: Stainless steel, complying with ASTM A167, Type 304 or 304L, with paint coating exterior finish system complying with IEEE C57.12.28, including manufacturer's standard color finish coat.

J. Show transformer kiloampere capacity using 2-1/2-inch (65-mm) numerals placed near the low-voltage bushings.

2.9 GROUNDING

A. Bare Grounding Conductor and Conductor Protector for Wood Poles:

1. No. 4 AWG minimum, soft-drawn copper.
2. Conductor Protector: Half-round PVC or wood molding; if wood, use pressure-treated fir, cypress, or cedar.

B. Ground Rods: As directed, Copper-clad, Zinc-coated or Stainless steel, sectional type; 3/4 inch by 10 feet (19 mm by 3 m) or 5/8 by 96 inches (16 by 2400 mm) in diameter.

2.10 SOURCE QUALITY CONTROL

A. Factory Tests: Conduct routine tests of transformers and medium-voltage switches according to referenced standards.

B. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 RIGHT-OF-WAY CLEARANCE AND TREE TRIMMING

A. Clear right of way according to Section 015639 "Temporary Tree and Plant Protection" and Section 311000 "Site Clearing."

B. Clear right of way to maintain minimum clearances required by IEEE C2, unless Drawings indicate greater clearances or greater clearances are required by state or local codes or regulations. If no minimum requirements are mandated, maintain a minimum of 15 feet (4.5 m) on both sides horizontally and below medium-voltage conductors and 60 inches (1500 mm) on both sides horizontally and below secondary-voltage conductors. Remove overhanging branches.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Install underground power and metering circuits and those circuits indicated to be in raceways according to Section 260543 "Underground Ducts and Raceways for Electrical Systems" and Section 260513 "Medium-Voltage Cables," and make splices and terminations for those circuits according to the applicable Sections.

B. Engage the services of a licensed surveyor to verify dimensions by field measurement, to identify locations of poles, anchors, and other features, and to verify all clearances. The survey document shall also identify locations of connections to new and existing supply lines and to primary and secondary services. Notify Architect of discrepancies and field conditions that are not indicated and that will affect installation.

C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

D. Apply warning signs and equipment labels according to Section 260553 "Identification for Electrical Systems."

3.3 CONDUCTOR INSTALLATION, GENERAL

A. Handle and string conductors to prevent cuts, gouges, scratches, kinks, flattening, or deformation. Remove damaged sections and splice conductors.

1. String new conductors to "initial" sag values recommended by manufacturer for type and size of conductor except as otherwise indicated.

2. Conductors Reinstalled or Resagged: String to "final" sag values recommended by manufacturer for type and size of conductor except as otherwise indicated.

B. Connections, Splices, and Terminations: Use kits listed for the specific type of connection and combination of materials in the connection or recommended for the specific use by manufacturer of material on which applied.

1. Splice Location: Do not install within 10 feet (3 m) of a support.
2. Line Conductors and Service Drops: Install so strength exceeds ultimate rated strength of conductor.
3. Splices and Terminations of Covered Conductors: Comply with manufacturer's written instructions.

3.4 MEDIUM-VOLTAGE LINE CONDUCTOR INSTALLATION

A. Application: Install bare conductors unless otherwise indicated.

B. Armor Rod: Install to protect conductors if line conductors are supported by insulators.

C. Flat Aluminum Armor Wire: Install to protect conductors if they are supported by, or attached to, galvanized or coated iron or steel clamps or fittings.

D. Support line conductors and taps as follows:

1. Use wire ties for conductor attachment to pin and vertical post insulators unless otherwise indicated.
2. Install wire ties tight against conductor and insulator, and turn ends back and flat against conductor, to eliminate exposed wire ends.
3. Use wire clamps on horizontal post, dead end, and suspension insulators unless otherwise indicated.

3.5 POLE AND CROSSARM INSTALLATION

A. Pole Orientation: Align curve of curved wood poles with straight-line runs of three or more poles. Align gained surfaces perpendicular to runs.

B. Elevation of Line above Grade: Install poles with top at same elevation, unless grade changes dictate elevation change in poles, and according to the following:

1. On level ground, set poles so tops of consecutive poles vary not more than 60 inches (1500 mm) in elevation.
2. Shorten wood poles by cutting off the top and make cuts to shed water. Apply preservative to cuts.

C. Set poles according to the following:

1. Make pole holes vertical, uniform in diameter, and large enough to permit effective use of tamping bars all around. Bore or excavate holes with an average diameter at grade less than twice the diameter of the pole at the same grade.

2. Use minimum depths indicated, except at locations where hole is partly or entirely in rock and if hole is not vertical or has a diameter at grade more than two times the pole diameter at the same level; in these conditions, increase the depth of the hole by the following increments before setting the pole:

    a. Poles up to 35 Feet (10.6 m) Long: 24 inches (600 mm).
    b. Poles 36 to 60 Feet (11 to 18.3 m) Long: 30 inches (760 mm).
    c. Poles 61 to 75 Feet (18.6 to 22.9 m) Long: 36 inches (900 mm).

3. For poles on slopes, indicated hole depth is from finished grade at lowest side of hole.
4. Set poles in alignment and plumb except at dead ends, angles, and points of extra strain; rake poles against conductor strain 1inch (25 mm) minimum, 2 inches (51 mm) maximum, (after conductors are installed at required tension) for each 10 feet (3 m) of pole length. Rake poles so they will not lean or bend in direction of strain when loaded.
5. Backfill holes in 6-inch (150-mm) maximum lifts, and thoroughly tamp each layer before starting the next.
6. Place surplus earth around pole in a conical shape, tamp thoroughly to provide drainage away from pole.
7. Set poles so alternate crossarm gains face in alternate directions, except at terminals and dead ends; place gains on last two poles on side facing terminal or dead end.
8. Poles Set in Concrete Paved Areas: Install poles with minimum of 6-inch- (150-mm-) wide, unpaved gap between the pole and the edge of adjacent concrete slab. Fill unpaved ring with pea gravel to a level 1 inch (25 mm) below top of concrete slab.

D. Field treat factory-treated poles and crossarms as follows:

1. Poles Treated More Than One Year before Installation: Treat portion from 24 inches (600 mm) above ground line to butt.
2. Field-Bored Holes and Field-Cut Gains and Pole Tops: Treat cut portions.
3. Unused Holes: Treat and plug with treated-wood-dowel drive pins.
4. Engage the services of a technician certified according to "Quality Assurance" Article to apply treatment. Comply with requirements in AWPA standards that govern original factory treatment for field-applied treatment and application of chemicals.

E. Crossarm Installation: Set line crossarms at right angle to line for straight runs and for angles 45 degrees and more. Bisect angles less than 45 degrees.

1. Buck Arms: Install at corners and junction poles unless otherwise indicated.
2. Double Crossarms: Install at dead ends, corners, angles, and line crossings.
3. Equipment Arms: Locate below lines and set parallel or at right angles to them, whichever provides best climbing space.
4. Gains: Install factory-cut or metal-pole gains only. Do not cut gains in field without specific written approval.

F. Locate pole numbers to provide maximum visibility from the road or patrol route.

3.6 GUY INSTALLATION

A. Install guys to resist unbalanced loads, including those developed at angles, corners, and dead ends. Install two or more guys if a single guy will not provide adequate strength. Install separate guys if unbalanced loads are separated by 36 inches (900 mm) or more. Comply with IEEE C2.

1. Unless a thimble eye is used, at the pole end, install a minimum of two guy hooks and two guy strain plates.
2. At the anchor end, attach guy strand assembly with preformed grips.

B. Protect guy strands from damage. Replace damaged guy strands. Install guy insulators where required to comply with IEEE C2 clearance requirements.

C. Install guys with a lead-to-height ratio of 1 to 1 unless otherwise indicated. The minimum lead-to-height ratio shall be 1/2 to 1. When less than 1 to 1, increase guy strength by the ratio of the sine of the lead angle indicated to the sine of the lead angle provided.

D. Install screw-type guy anchors aligned in soil with guy. Set with anchor rod pointing at guy attachment on pole and rod projecting 6 to 9 inches (150 to 230 mm) from ground.

E. Install strain insulators to provide a minimum of 12 inches (300 mm) of clearance between the nearest energized surface and the strain insulator fitting farthest from the pole. When loaded to the tension indicated, fiberglass strain insulators shall be loaded to not more than two-thirds of manufacturer's published rating.

F. Guy Markers: Install at anchor end of guys to visually mark the guy wire at all accessible locations. Clamp to guy strand or anchor at top and bottom of marker.

3.7 HARDWARE AND ACCESSORIES INSTALLATION

A. Install washers against wood and under nuts, including eyenuts and locknuts.

B. Install nuts and locknuts wrench-tight on threaded connections.

3.8 INSULATOR INSTALLATION

A. Medium-Voltage Line Application: Install pin or post type, except install suspension type at corners, angles, dead ends, and other locations where horizontal forces exceed rated values for pin or line-post-type units.

1. Install suspension insulators and hardware that have mechanical strength exceeding rated breaking strength of attached conductors.
2. Install horizontal line-post insulators for armless construction.

B. Post-Insulator Conductor Support: Where installed horizontally and for line angles more than 15 degrees, install clamp-top conductor clamps.

C. Install spool-type insulators for secondary lines mounted on clevis attachments or secondary racks.

D. Guy Strain Type: Install porcelain or fiberglass-reinforced units.

3.9 SURGE ARRESTERS

A. Install surge arresters to protect distribution, metering equipment, reclosers, group-operated, load-interrupter switches, aerial-to-underground transitions, and other items indicated as directed.

1. Units Installed 6000 Feet (1800 m) or More above Sea Level: Use arresters specifically rated for this service.

3.10 CUTOUT, SWITCH, AND FUSE INSTALLATION

A. Hook-Stick-Operated Switches: Install to maximize safe operating access.

B. Group-Operated, Load-Interrupter Switches and Air-Break Switches: Install operating handle 42 inches (1067 mm) above finished grade.

3.11 GROUNDING OVERHEAD LINES

A. Comply with IEEE C2 grounding requirements.

B. Install two parallel ground rods if resistance to ground by a single, ground-rod electrode exceeds 25 ohms.

C. Drive ground rods until tops are 12 inches (300 mm) below finished grade in undisturbed earth.

D. Ground-Rod Connections: Install bolted connectors for underground connections and connections to rods.

E. Lightning Arrester Grounding Conductors: Separate from other grounding conductors.

F. Secondary Neutral and Transformer Enclosure: Interconnect and connect to grounding conductor.

G. Protect grounding conductors running on surface of wood poles with molding extended from grade level up to and through communications service and transformer spaces.

3.12 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Furnish instruments and equipment required for tests that comply with NETA Acceptance Testing Specification.
2. Guy Anchors: Test one of each type and capacity installed, plus additional units specifically indicated for testing. Apply rated pull-out force in the same pull direction applied by the guy at the test location.

a. Acceptable Test Results: Denoted by movement of less than 3/8 inch (10 mm) by the holding component of the anchor in the earth or other medium in which it is installed.
b. Replace or reinstall, at Architect's option, all anchors of same type and capacity as anchor type that fails this test.

3. Ground Resistance: Comply with Section 260526 "Grounding and Bonding for Electrical Systems." Measure resistance of each separate grounding electrode, including pole grounds. Also measure resistance of separate grounding electrode systems before bonding together.

    a. Perform tests and obtain acceptable results before energizing any portion of overhead electrical distribution system.
    b. Results and Follow-up: If ground resistance for a single ground electrode or pole ground, tested individually, exceeds 25 ohms, add a ground electrode not less than 10 feet (3 m) away and interconnect with No. 2 AWG, minimum, bare conductor buried at least 12 inches (300 mm) below furnished grade.

4. Aerial Conductor Sag and Tension: Observe procedures used by Contractor to verify that initial stringing sags and tensions comply with IEEE C2 and conductor manufacturer's product data and written recommendations.
5. Neutral-Supported, Secondary Service-Drop Cable: Test for insulation resistance while cable is isolated, before connecting or energizing. Minimum acceptable resistance is 100 megohms.
6. Existing Surge Arresters: Disconnect and measure resistance between line and ground terminals with a megger test rated 600 V or more. Acceptable resistance values are 300 megohms and more.
7. New Surge Arresters, Cutouts, and Switches: Inspect after installation and connection to wiring. Verify that ratings and characteristics match approved submittals and comply with system requirements. Verify that installation complies with requirements and that clearances of units and connecting wiring comply with IEEE C2 requirements.

    a. Verify proper grounding of metallic equipment parts.
    b. Fuses and Disconnect Links: Verify that ratings and characteristics match submittals and comply with system requirements.
    c. Switches:

        1) Manually operate each cutout and switch at least three times, to verify proper operation.
        2) Verify correct contact alignment, blade penetration, travel stops, and arc interrupter operation.

    d. Group-Operated, Load-Interrupter Switches and Air-Break Switches:

        1) Perform mechanical operator tests according to manufacturer's written instructions.
        2) Test resistance to ground of parts to be energized. Acceptable value is 200,000 megohms.
        3) Perform contact-resistance test across all switch blade contacts. Refer to manufacturer's data for acceptable contact resistance.

e. Verify that clearances of energized parts and connecting wires comply with IEEE C2 requirements.

8. Distribution Transformers: Inspect after installation and connection to wiring and verify that ratings and characteristics match approved submittals and comply with system requirements. Verify the integrity and good condition of unit.

a. Inspect for physical damage, cracked insulators, leaks, tightness of connections, and overall mechanical and electrical integrity.
b. Perform preenergizing inspections and tests recommended by manufacturer.
c. Verify proper equipment grounding.
d. Verify that clearances of terminals and connecting wires comply with IEEE C2.

B. Prepare test and inspection reports.

3.13 ADJUSTING

A. Distribution Transformers: Set voltage taps as directed by Architect.

3.14 CLEANING

A. After completing equipment installation, inspect equipment. Remove spots, dirt, and debris. Repair damaged finish to match original finish. For distribution transformer, use tank touchup paint provided by manufacturer.

1. Clean enclosures internally, on completion of installation, according to manufacturer's written instructions.

END OF SECTION 337149.13

SECTION 337753 - MEDIUM-VOLTAGE UTILITY RECLOSERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes medium-voltage utility reclosers.

B. Related Requirements:

1. Section 337149.13 "Overhead Medium-Voltage Wiring" for structural capacity, mounting, protection and disconnecting means, bypass means, and connecting reclosers to overhead wiring.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Design Data:

1. Time-Current Coordination Curves: Illustrate optimum coordination of protective devices involved in the Work of this Section.

B. Source quality-control reports.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA or an NRTL.

1. Testing Agency's Field Supervisor: Certified by NETA or an NRTL to supervise on-site testing.

1.6 PROJECT CONDITIONS

A. Interruption of Existing Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:

1. As directed, notify Engineer, Construction Manager or Owner no fewer than two days in advance of proposed interruption of service.
2. Do not proceed with interruption of service without Engineer's, Construction Manager's or Owner's written permission as directed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PERFORMANCE REQUIREMENTS

A. Automatic, outdoor, single and three-phase, oil or air-insulated, oil-interrupter unit designed for pole-line application as directed.

B. Comply with IEEE C37.60.

2.3 RECLOSERS

A. Control: As directed Hydraulic or Electronic, solid state.

B. Operating Power for Contacts: Stored energy derived internally from source electrical line.

C. Control Power: Internal rechargeable battery or other energy storage device.

D. Ratings: Equal to or greater than rated system voltage.

1. For nominal 15-kV system:

a. Maximum Design Voltage: 15.5 kV.
b. Normal Operating Voltage: 14.4 kV.
c. BIL: As directed 110 or 150 kV.
d. Continuous Current Rating: As directed 560, 630 or 800 kV.
e. Interrupting Current Rating: As directed 12.5 or 16-kA symmetrical.

2. For nominal 27-kV system:

a. Maximum Design Voltage: 27.0 kV.
b. Normal Operating Voltage: 24.9 kV.
c. BIL: 125 kV.
d. Continuous Current Rating: 560, 630 or 800 kV as directed.
e. Interrupting Current Rating: 12.5 or 16-kA symmetrical as directed.

3. For nominal 38 kV system:

    a. Maximum Design Voltage: 15.5 kV.
    b. Normal Operating Voltage: 14.4 kV.
    c. BIL: As directed 150 or 170 kV.
    d. Continuous Current Rating: As directed 560, 630 or 800 kV.
    e. Interrupting Current Rating: As directed 12.5 or 16-kA symmetrical.

E. Minimum Tripping Time-Current Setting and Reclosure Interval: Coordinated with upstream and downstream protective devices and selected according to IEEE 242. Prepare time-current coordination curves that illustrate optimum coordination of devices in Project.

F. Minimum Tripping Time-Current Setting and Reclosure Interval: As directed.

G. Control:

1. Sequence of Operation: As directed Unit senses phase-to-ground or phase overcurrent and trips open, controlled by adjustable time-current settings, then recloses after adjustable time interval. Capability for selecting zero, one, two, or three reclosing cycles on individual phases, followed by lockout, including trip and lockout of nonfaulted phases, after last unsuccessful reclosure.
2. Field Set Operating Modes:

    a. Three-phase trip, three-phase lockout.
    b. Single-phase trip, three-phase lockout.
    c. Single-phase trip, single-phase lockout.
    d. Mode as directed.

H. Current Metering Sensors: Integral with bushings.

I. Ground-Fault Sensing: Solid-state control relay, connected to sense ground faults by measuring the residual component of the three-phase current.

J. Construction:

1. Consisting of three individual single-phase circuit interrupters, each mounted in its own enclosure, mounted in a common enclosure, operated by a common control system.
2. With pole-mounting frame on overhead power lines.

2.4 PROTECTIVE DEVICES

A. Comply with requirements for surge arresters, cutouts, switches, and fuses specified in Section 337149.13 "Overhead Medium-Voltage Wiring."

2.5 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect assembled medium-voltage utility reclosers according to referenced standards. Verify the following:

1. Wiring conforms to connection diagrams.

2. Electrical Operation: Close and trip to test overcurrent response and automatic reclosing.
3. Full functionality of all manual controls on recloser.
4. Contact pole resistance on each phase. Resistance shall not exceed 150 microhms.
5. 60-Hz Voltage Withstand: Comply with IEEE C37.60.
6. Wiring Insulation: Terminal block connections (with foil leads and microprocessor controller in place) shall pass an overvoltage test of 1500-V ac phase to ground.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

A. Ground equipment according to Section 337149.13 "Overhead Medium-Voltage Wiring."

B. Surge Arresters: Install on source and load sides of recloser. Connect both source and load arrester grounds to recloser ground, continue connection to pole ground. Leads connecting to arresters shall be as short as feasible to limit stray inductance and to maximize arrester's effectiveness.

3.2 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Visual Inspection:

1. Compare equipment nameplate data with Drawings and Specifications.
2. Inspect physical and mechanical condition, anchorage, alignment, and grounding.
3. Inspect bolted electrical connections for high resistance using a low-resistance ohmmeter.
4. Inspect bolted electrical connections for high resistance using calibrated torque-wrench method.
5. Inspect bolted electrical connections for high resistance by thermographic survey.
6. Verify level of appropriate insulating liquid.

C. Mechanical Inspection: Test mechanical operation and contact alignment of both the recloser and its operating mechanism.

D. Electrical Inspection:

1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter.
2. Perform insulation-resistance tests on each pole, phase-to-phase and phase-to-ground, with recloser closed and across each open pole for one minute.
3. Perform a contact/pole-resistance test.
4. Inspect targets and indicators.

    a. Determine pickup and dropout of electromechanical targets.
    b. Verify operation of all digital displays.
    c. Set contrast for digital readouts.

5. Set relays according to coordination study or setting sheet supplied by Owner.
6. Remove a sample of insulating liquid if applicable, according to ASTM D923. Sample shall be tested according to the referenced standard.

    a. Dielectric Breakdown Voltage: ASTM D877/D877M.
    b. Color: ASTM D1500.
    c. Visual Condition: ASTM D1524.

E. Operational Tests. Test settings and functions of all protective functions.

1. Verify and record control functions.

    a. Verify that each relay contact performs its intended function in the control scheme, including breaker trip tests, close inhibit tests, 86 lockout tests, and alarm functions.
    b. For microprocessor-based relays, verify all inputs, outputs, internal logic, and timing elements used in protection, metering, and control functions.
    c. Timing Relay:

        1) Determine time delay.
        2) Verify operation of instantaneous contacts.

    d. Instantaneous Overcurrent Relay:

        1) Determine pickup.
        2) Determine dropout.
        3) Determine time delay.

    e. Time Overcurrent:

        1) Determine minimum pickup.
        2) Determine time delays at two points on time-current curve.

    f. Ground Detector Relay: Determine maximum impedance to ground causing relay pickup.
    g. Reclosing Relay:

        1) Determine time delay for each programmed reclosing interval.
        2) Verify lockout for unsuccessful reclosing.
        3) Determine reset time.
        4) Determine close pulse duration.
        5) Verify instantaneous overcurrent lockout.

2. Metering and Instrumentation Tests.

    a. Verify accuracy of meters at all cardinal points.
    b. Calibrate meters according to manufacturer's published data.
    c. Verify all instrument multipliers.
    d. Verify that current transformer and voltage transformer secondary circuits are intact.

F. Prepare test and inspection reports.

END OF SECTION 337753

SECTION 340000 - TRANSPORTATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Perforated-wall pipe and fittings.
2. Geotextile filter fabrics.

1.2 ACTION SUBMITTALS

A. Product Data: For geotextile filter fabrics.

PART 2 - PRODUCTS

2.1 PERFORATED-WALL PIPES AND FITTINGS

A. Perforated PE Pipe and Fittings: ASTM F405 or AASHTO M 252, Type CP; corrugated, for coupled joints.

2.2 SOIL MATERIALS

A. Soil materials are specified in Section 312000 "Earth Moving."

2.3 WATERPROOFING FELTS

A. Material: Comply with ASTM D226, Type I, asphalt or ASTM D227, coal-tar-saturated organic felt.

2.4 GEOTEXTILE FILTER FABRICS

A. Description: Fabric of PP or polyester fibers or combination of both, with flow rate range from 110 to 330 gpm/sq. ft. (4480 to 13 440 L/min. per sq. m) when tested according to ASTM D4491.

B. Structure Type: Nonwoven, needle-punched continuous filament.

1. Survivability: AASHTO M 288 Class 2.
2. Styles: Flat and sock.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavating, trenching, and backfilling are specified in Section 312000 "Earth Moving."

3.2 FOUNDATION DRAINAGE INSTALLATION

A. Place impervious fill material on subgrade adjacent to bottom of footing after concrete footing forms have been removed. Place and compact impervious fill to dimensions indicated, but not less than 6 inches (150 mm) deep and 12 inches (300 mm) wide.

B. Lay flat-style geotextile filter fabric in trench and overlap trench sides.

C. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than 4 inches (100 mm).

D. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with adhesive or tape.

E. Install drainage piping as indicated in Part 3 "Piping Installation" Article for foundation subdrainage.

F. Add drainage course to width of at least 6 inches (150 mm) on side away from wall and to top of pipe to perform tests.

G. After satisfactory testing, cover drainage piping to width of at least 6 inches (150 mm) on side away from footing and above top of pipe to within 12 inches (300 mm) of finish grade.

H. Install drainage course and wrap top of drainage course with flat-style geotextile filter fabric.

I. As directed Place layer of flat-style geotextile filter fabric or waterproofing felt over top of drainage course, overlapping edges at least 4 inches (100 mm).

J. Place backfill material over compacted drainage course. Place material in loose-depth layers not exceeding 6 inches (150 mm). Thoroughly compact each layer. Final backfill to finish elevations and slope away from building.

3.3 UNDERSLAB DRAINAGE INSTALLATION

A. Excavate for underslab drainage system after subgrade material has been compacted but before drainage course has been placed. Include horizontal distance of at least 6 inches (150 mm) between drainage pipe and trench walls. Grade bottom of trench excavations to required slope, and compact to firm, solid bed for drainage system.

B. Lay flat-style geotextile filter fabric in trench and overlap trench sides.

C. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than 4 inches (100 mm).

D. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with adhesive or tape.

E. Install drainage piping as indicated in Part 3 "Piping Installation" Article for underslab subdrainage.

F. Add drainage course to width of at least 6 inches (150 mm) on side away from wall and to top of pipe to perform tests.

G. After satisfactory testing, cover drainage piping with drainage course to elevation of bottom of slab, and compact and wrap top of drainage course with flat-style geotextile filter fabric.

3.4 PIPING INSTALLATION

A. Install piping beginning at low points of system, true to grades and alignment indicated, with unbroken continuity of invert. Bed piping with full bearing in filtering material. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions and other requirements indicated.

1. Foundation Subdrainage: Install piping level and with a minimum cover of 36 inches (915 mm) unless otherwise indicated.
2. Underslab Subdrainage: Install piping level.
3. Retaining-Wall Subdrainage: When water discharges at end of wall into stormwater piping system, install piping level and with a minimum cover of 36 inches (915 mm) unless otherwise indicated.
4. Lay perforated pipe with perforations down.
5. Excavate recesses in trench bottom for bell ends of pipe. Lay pipe with bells facing upslope and with spigot end entered fully into adjacent bell.

B. Use increasers, reducers, and couplings made for different sizes or materials of pipes and fittings being connected. Reduction of pipe size in direction of flow is prohibited.

C. Install thermoplastic piping according to ASTM D2321.

3.5 PIPE JOINT CONSTRUCTION

A. Join perforated PE pipe and fittings with couplings according to ASTM D3212 with loose banded, coupled, or push-on joints.

B. Special Pipe Couplings: Join piping made of different materials and dimensions with special couplings made for this application. Use couplings that are compatible with and fit materials and dimensions of both pipes.

3.6 BACKWATER VALVE INSTALLATION

A. Comply with requirements for backwater valves specified in Section 334100 "Storm Utility Drainage Piping."

B. Install horizontal backwater valves in header piping downstream from perforated subdrainage piping.

C. Install horizontal backwater valves in piping in manholes or pits where indicated.

3.7 CLEANOUT INSTALLATION

A. Comply with requirements for cleanouts specified in Section 334100 "Storm Utility Drainage Piping."

B. Cleanouts for Foundation and Retaining-Wall Subdrainage:

1. Install cleanouts from piping to grade. Locate cleanouts at beginning of piping run and at changes in direction. Install fittings so cleanouts open in direction of flow in piping.
2. In vehicular-traffic areas, use NPS 4 (DN 100) cast-iron soil pipe and fittings for piping branch fittings and riser extensions to cleanout. Set cleanout frames and covers in a cast-in-place concrete anchor, 18 by 18 by 12 inches (450 by 450 by 300 mm) deep. Set top of cleanout flush with grade.
3. As directed In nonvehicular-traffic areas, use NPS 4 (DN 100) cast-iron or PVC pipe and fittings for piping branch fittings and riser extensions to cleanout. Set cleanout frames and covers in a cast-in-place concrete anchor, 12 by 12 by 4 inches (300 by 300 by 100 mm) deep. Set top of cleanout 1 inch (25 mm) or 2 inches (50 mm) above grade.
4. Comply with requirements for concrete specified in Section 033000 "Cast-in-Place Concrete" or Section 033053 "Miscellaneous Cast-in-Place Concrete" as directed

C. Cleanouts for Underslab Subdrainage:

1. Install cleanouts and riser extensions from piping to top of slab. Locate cleanouts at beginning of piping run and at changes in direction. Install fittings so cleanouts open in direction of flow in piping.
2. Use NPS 4 (DN 100) cast-iron soil pipe and fittings for piping branch fittings and riser extensions to cleanout flush with top of slab.

3.8 CONNECTIONS

A. Comply with requirements for piping specified in Section 334100 "Storm Utility Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect low elevations of subdrainage system to building's solid-wall-piping storm drainage system.

C. Where required, connect low elevations of foundation or underslab subdrainage to stormwater sump pumps. Comply with requirements for sump pumps specified in Section 221429 "Sump Pumps."

3.9 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. After installing drainage course to top of piping, test drain piping with water to ensure free flow before backfilling.
2. Remove obstructions, replace damaged components, and repeat test until results are satisfactory.

B. Drain piping will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.10 CLEANING

A. Clear interior of installed piping and structures of dirt and other superfluous material as work progresses. Maintain swab or drag in piping and pull past each joint as it is completed. Place plugs in ends of uncompleted pipe at end of each day or when work stops.

END OF SECTION 334600

SECTION 3471113260000 – METAL GUIDE/GUARD RAILS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Demo and replacement of Guard Rails.
2. Installation of new Guard Rails.
3. Traffic Control

1.2 PREINSTALLATION MEETINGS

A. Preliminary Conference: Before starting removal Work, conduct conference at Project site.

PART 2 - PRODUCTS

2.1 AUXILIARY REROOFING MATERIALS

A. General: Use auxiliary reroofing preparation materials recommended by roofing system manufacturer for intended use and compatible with components of existing and new roofing system.

PART 3 - EXECUTION

3.1 PREPARATION

A. Seal or isolate windows that may be exposed to airborne substances created in removal of existing materials.

B. Shut off rooftop utilities and service piping before beginning the Work.

C. Test existing roof drains to verify that they are not blocked or restricted.

1. Immediately notify Architect of any blockages or restrictions.

D. Coordinate with Owner to shut down air-intake equipment in the vicinity of the Work.

1. Cover air-intake louvers before proceeding with reroofing work that could affect indoor air quality or activate smoke detectors in the ductwork.

E. During removal operations, have sufficient and suitable materials on-site to facilitate rapid installation of temporary protection in the event of unexpected rain.

F. Maintain roof drains in functioning condition to ensure roof drainage at end of each workday.

1. Prevent debris from entering or blocking roof drains and conductors.

a. Use roof-drain plugs specifically designed for this purpose.
b. Remove roof-drain plugs at end of each workday, when no work is taking place, or when rain is forecast.

2. If roof drains are temporarily blocked or unserviceable due to roofing system removal or partial installation of new roofing system, provide alternative drainage method to remove water and eliminate ponding.

a. Do not permit water to enter into or under existing roofing system components that are to remain.

3.2 ROOF TEAR-OFF

A. Notify Owner each day of extent of roof tear-off proposed for that day and obtain authorization to proceed.

B. Lower removed roofing materials to ground and onto lower roof levels, using dust-tight chutes or other acceptable means of removing materials from roof areas.

C. Remove aggregate ballast from roofing. Store aggregate ballast for reuse in manner not to exceed structural loading limitations of roof deck.

D. Remove loose aggregate from aggregate-surfaced, built-up bituminous roofing using a power broom.

E. Remove pavers and accessories from roofing.

1. Store and protect pavers and accessories for reuse in manner not to exceed structural loading limitations of roof deck.
2. Discard cracked pavers.

F. Full Roof Tear-off: Where indicated on Drawings, remove, Remove existing roofing and other roofing system components down to the existing roof deck, concrete fill.

1. Remove substrate board, vapor retarder, roof insulation and cover board.
2. Remove base flashings and counter flashings.
3. Remove perimeter edge flashing and gravel stops.
4. Remove copings.
5. Remove expansion-joint covers.
6. Remove flashings at pipes, curbs, mechanical equipment, and other penetrations.
7. Remove roof drains indicated on Drawings to be removed.
8. Remove wood blocking, curbs, and nailers.
9. Bitumen and felts that are firmly bonded to concrete decks are permitted to remain if felts are dry.

a. Remove unadhered bitumen, unadhered felts, and wet felts.

10. Remove excess asphalt from steel deck.

    a. A maximum of 15 lb/100 sq. ft. (0.72 kg/sq. m) of asphalt is permitted to remain on steel decks.

11. Remove fasteners from deck or cut fasteners off slightly above deck surface.

G. Partial Roof Tear-off: Where indicated on Drawings, remove, Remove existing roofing down to existing cover board, existing insulation and immediately check for presence of moisture.

1. Engage, Owner will engage a qualified testing agency to perform the following test:

    a. Coordinate with Owner's testing agency to schedule times for tests and inspections immediately after removal.

2. Survey exposed substrate that is to remain using infrared color thermography according to ASTM C1153.

    a. Prepare survey report of initial scan indicating locations of entrapped moisture, if any, and area calculations of locations of entrapped moisture.

3. Survey exposed substrate that is to remain using electrical capacitance/impedance testing according to ASTM D7954/D7954M.

    a. Prepare survey report indicating locations of entrapped moisture, if any, and area calculations of locations of entrapped moisture.

4. Survey exposed substrate that is to remain using nuclear hydrogen detection testing according to SPRI/RCI NT-1.

    a. Prepare survey report indicating locations of entrapped moisture, if any, and area calculations of locations of entrapped moisture.

5. Remove wet or damp materials below existing roofing and above deck as directed by Architect.

    a. Removal is paid for by adjusting the Contract Sum according to unit prices included in the Contract Documents.

6. Inspect wood blocking, curbs, and nailers for deterioration and damage.

    a. If wood blocking, curbs, or nailers have deteriorated, immediately notify Architect.
    b. Removal is paid for by adjusting the Contract Sum according to unit prices included in the Contract Documents.

7. Bitumen and felts that are firmly bonded to concrete decks are permitted to remain if felts are dry.

    a. Remove unadhered bitumen, unadhered felts, and wet felts.

8. Remove excess asphalt from steel deck that is exposed by removal of wet or damp materials.

    a. A maximum of 15 lb/100 sq. ft. (0.72 kg/sq. m) of asphalt is permitted to remain on steel decks.

9. Remove fasteners from deck or cut fasteners off slightly above deck surface.

3.3 DECK PREPARATION

A. Inspect deck after tear-off of roofing system.

B. If broken or loose fasteners that secure deck panels to one another or to structure are observed, or if deck appears or feels inadequately attached, immediately notify Architect.

1. Do not proceed with installation until directed by Architect.

C. If deck surface is unsuitable for receiving new roofing or if structural integrity of deck is suspect, immediately notify Architect.

1. Do not proceed with installation until directed by Architect.

D. Provide additional deck securement as indicated on Drawings.

E. Replace steel deck as indicated on Drawings.

F. Replace steel deck as directed by Architect.

1. Deck replacement will be paid for by adjusting the Contract Sum according to unit prices included in the Contract Documents.

G. Prepare and paint steel deck surface.

1. Painting and preparation for painting is specified in Section 099113 "Exterior Painting."

H. Replace plywood roof sheathing as indicated on Drawings.

I. Replace plywood roof sheathing as directed by Architect.

1. Roof sheathing replacement will be paid for by adjusting the Contract Sum according to unit prices included in the Contract Documents.

3.4 ROOF RE-COVER PREPARATION

A. Remove blisters, ridges, buckles, mechanically attached roofing fastener buttons projecting above roofing, and other substrate irregularities from existing roofing that inhibit new recover boards from conforming to substrate.

1. Remove loose aggregate from aggregate-surfaced, built-up bituminous roofing with a power broom.

2. Broom clean existing substrate.
3. Coordinate with Owner's inspector to schedule times for tests and inspections.
4. Verify that existing substrate is dry.

    a. Spot check substrates with an electrical capacitance moisture-detection meter.

5. Remove materials that are wet or damp.

    a. Removal will be paid for by adjusting the Contract Sum according to unit prices included in the Contract Documents.

B. Remove blisters, ridges, buckles, mechanically attached roofing fastener buttons projecting above roofing, and other substrate irregularities from existing roofing that inhibit new recover boards, roofing, from conforming to substrate.

1. Remove loose aggregate from aggregate-surfaced, built-up bituminous roofing with a power broom.
2. Broom clean existing substrate.
3. Coordinate with Owner's inspector to schedule times for tests and inspections.
4. Verify that existing substrate is dry before proceeding with installation.

    a. Spot check substrates with an electrical capacitance moisture-detection meter.

5. Remove materials that are wet and damp.

    a. Removal will be paid for by adjusting the Contract Sum according to unit prices included in the Contract Documents.

3.5 BASE FLASHING REMOVAL

A. Remove existing base flashings.

1. Clean substrates of contaminants, such as asphalt, sheet materials, dirt, and debris.

B. Do not damage metal counter flashings that are to remain.

1. Replace metal counter flashings damaged during removal with counter flashings of same metal, weight or thickness, and finish as existing. Specified in Section 076200 "Sheet Metal Flashing and Trim." Specified in Section 077100 "Roof Specialties."

C. Inspect parapet sheathing, wood blocking, curbs, and nailers for deterioration and damage.

1. If parapet sheathing, wood blocking, curbs, or nailers have deteriorated, immediately notify Architect.

D. Remove existing parapet sheathing and replace with new parapet sheathing to comply with Section 061600 "Sheathing."

1. If parapet framing, wood blocking, curbs, or nailers have deteriorated, immediately notify Architect.

E. When directed by Architect, replace parapet framing, wood blocking, curbs, and nailers to comply with Section 054000 "Cold-Formed Metal Framing." Section 061000 "Rough Carpentry." Section 061053 Miscellaneous Rough Carpentry."

END OF SECTION 070150.19

DIVISION IX TRAFFIC CONTROL DEVICES

34 MISCELLANEOUS TRAFFIC CONTROL DEVICES
34-1 GENERAL

1-1.01 GENERAL
Section 81-1 includes general specifications for fabricating, installing, and placing miscellaneous traffic control devices.
Traffic control devices must comply with the California MUTCD.

34-1.02 MATERIALS
Not Used

34-1.03 CONSTRUCTION
Not Used

34-1.04 PAYMENT
Not Used

34-2 DELINEATORS

34-2.01 GENERAL

34-2.01A Summary

Section 34-2 includes specifications for fabricating and installing delineators.

34-2.01B Definitions
Reserved

34-2.01C Submittals
Submit a certificate of compliance for:
1. Metal target plates
2. Enamel coating

34-2.01D Quality Assurance
When tested under California Test 671, the enamel coating on a metal target plate must have satisfactory resistance to weathering, humidity, salt spray, and chemicals. The enamel coating must have:
1. Satisfactory adherence and impact resistance.
2. Pencil lead hardness of at least HB.
3. 60-degree specular gloss of at least 80 percent.
4. Excitation purity of no more than 3 percent:
4.1 As received.
4.2 After 1,000 hours in an artificial weathering device when tested under ASTM G155, Table X3.1, Cycle 1.
5. Daylight luminous directional reflectance (Y value) of at least 70.
The Department may sample metal target plates for testing

a Flat sheet stock must be identifiable with parent coil stock.

The Department rejects the entire lot if any sample does not comply with section 81 or zinc-coated steel sheets show any evidence of damage to or removal of the zinc coating.
If the Department chooses to resample, the sample quantity may be twice the number shown in the table titled "Metal Target Plate Sampling."

34-2.02 MATERIALS

34-2.02A General
A delineator must be on the Authorized Material List for signing and delineation materials. A delineator consists of a post and 2 target plates.

34-2.02B Wood Posts
Wood posts must comply with section 82-3.02C.

34-2.02C Metal Posts
The steel for a metal post must comply with ASTM A36/A36M.
A metal post must be galvanized under section 75.

34-2.02D Flexible Posts
A flexible post must be:
1. White except where shown as yellow
2. Free from burns, discoloration, contamination, and other objectionable marks or defects that affect appearance or serviceability

34-2.02E Target Plates
Galvanize steel sheets under section 75. Zinc-coated steel sheets must comply with ASTM A653/A 653M, Commercial Steel, Types A, B, and C.
The nominal thickness of a zinc-coated steel sheet must be at least 0.038 inch.
Prepare zinc-coated surfaces to produce optimum adherence of the enamel coating without damaging or removing the zinc coating.
An aluminum target plate must be aluminum alloy 3003-H14. You may use other alloys having equivalent properties if authorized.
The nominal thickness of an aluminum sheet must be at least 0.050 inch.
Prepare the aluminum sheets for the enamel coating by cleaning to remove contaminants and uniformly applying an acid-chromate-fluoride, acid-chromate-fluoride phosphate, or equivalent chemical anticorrosion conversion coating.
Cut each target plate to size and shape and punch the mounting bolt holes. The surfaces and edges of each target plate must be free from fabrication defects.
Coat the pretreated metal target plate with an opaque white coating on both sides using a 1-coat or 2-coat system. When tested under California Test 671, the dry film for the:
1. 1-coat system must be uniform and have an average thickness of at least 0.75 mil with no individual measurement less than 0.65 mil.
2. 2-coat system must consist of 0.10- to 0.20-mil-thick primer and have an average thickness of at least 0.75 mil, including primer and top coat, with no individual measurement less than 0.65 mil.

For a 1-coat painting system, fabricate the zinc-coated steel target plate, including shearing, cutting, and punching, before starting the enameling process.
The enamel coating on a metal target plate must be the product of a commercial manufacturer. Apply the enamel coating by spray, dip, roller, continuous roller coating, or other authorized method.
The coating must be smooth and substantially free from flow lines, paint washout, streaks, blisters, and other defects that might impair serviceability or detract from the general appearance.

A finished metal target plate must be free from dents and defects. The maximum edge-to-edge surface deviation from a horizontal plane must not exceed 1/8 inch.

34-2.02F Hardware
Attach a target plate with either (1) 1/4-inch galvanized steel or aluminum nuts and bolts or (2) 3/16-inch blind aluminum rivets and washers.

34-2.02G–81-2.02L Reserved
34-2.03 CONSTRUCTION
Drive the post in place where soil conditions allow if the driving method does not damage the post. Drill pilot holes if ground conditions are such that the post cannot be driven without being damaged.
Install the target plates after the post is set in place.
After setting the post, fill any space around it with rock-free earth. Thoroughly tamp and water the fill material such that it holds the post securely in position.
Unless the surplus material is hazardous, uniformly spread it along the adjacent roadway where designated by the Engineer.
Before Contract acceptance, spot paint any exposed areas where the paint is damaged and clean any exposed areas that are soiled.
34-2.04 PAYMENT

SECTION 48141312 – SOLAR SYSTEM SPECIFICATIONS

PART I – GENERAL

1.1 SUMMARY

A. This section includes the design of the on-site solar PV system will be the responsibility of the Contractor; however, the system must be compliant with applicable County design guidelines. This Exhibit delineates the minimum technical and installation specifications required by the University for this Project. It is the intent of these specifications to insure that the PV systems installed are consistent with and adhere to any and all California Building Codes and standards, the California Solar Initiative program, applicable utility rules and tariffs, and any and all CEC technical and installation specifications and guidelines as may developed and established.

PART 2 - PRODUCTS

A. PV modules must be listed on the California Energy Commission's PTC list and must qualify for eligibility under the California Solar Initiative (CSI) Program.

B. System must comply with IEEE 1262 "Recommended Practice for Qualifications of Photovoltaic Modules".

2.1 – ELECTRIC POWER REQUIRMENTS

A. Power provided must be compatible with the onsite distribution system.

B. Power capacity should be measured at the inverter AC output using the PVUSA Test Conditions (PTC), i.e. 1,000 Watts/m220 degree C ambient temperature and wind speed of 1 m/s.

C. The System must include all the hardware needed for the solar PV.

D. All systems must be installed in accordance with all applicable requirements of local electrical codes and the National Electrical Code (NEC), including but not limited to Article 690, "Solar Photovoltaic Systems" and Article 705 – "Interconnected Electrical Power Production Sources".

E. Systems must be designed and installed using UL or ETL listed components, including mounting systems.

F. Modules must be certified to UL 1703 – "Flat-Plate Photovoltaic Modules and Panels".

G. Inverters must comply with the following requirements:
   1. IEEE 929-2000 – "Recommended Practice for Utility Interface of Photovoltaic Systems"
   2. UL 1741 – "Standard for Static Inverters and Charge Controllers for use in Photovoltaic Systems"

H. Listed on the CEC list of eligible inverters

I. Other technical codes that will apply include:

1. AMSE PTC 50 (solar PV performance)
2. ANSI Z21.83 (solar PV performance and safety)
3. NFPA 853 (solar PVs near buildings)
4. NEPA 70 (electrical components)
5. IEEE 1547 (interconnections)
6. National Electrical Safety Code – ANSI C2 - 1999
7. All applicable State Building Codes and requirements

J. All Balance of Systems (wiring, component, wiring, conduits, and connections) must be suited for conditions for which they are to be installed. It is the preference of the University that when possible, inverters are located inside out of the weather in a minimum NEMA 12 enclosure. If inverters are in exterior locations, they shall be installed in all-weather NEMA 4X enclosures. An interval data meter must be installed to measure the AC output of the inverter. This meter should be located in a location accessible to University facilities personnel.

K. Interconnection must comply with electrical utility provider rules. Contractor will assist the University in preparing and submitting appropriate interconnection agreements with SDG&E. This shall be done at no cost or liability to the University.

2.2 - METERS

A. Contractor will provide revenue grade Interval Data Recording (IDR) meters complete with industry standard telemetry for communication with Ethernet, cellular or other common output capabilities.

B. Contractor will provide connection to the County's Energy Management System (EMS) if any, for the purposes of metering, monitoring and data collection of solar production.

C. Meters must connect to a monitoring/data collection recording solar production through Time of Use (TOU) increments applicable to the local utility standards, with a minimum 15-minute intervals.

2.3 - STRUCTURAL REQUIREMENTS

A. All structures and structural elements, including array structures, shall be designed in accordance with all applicable California Building Codes and standards pertaining to the erection of such structures.

B. The Contractor shall provide structural calculations, stamped by a licensed professional structural engineer in good standing with the State of California.

C. All structural components, including array structures, shall be designed in a manner commensurate with attaining a minimum 30-year design life. Particular attention shall be given to the prevention of corrosion at the connections between dissimilar metals.

D. The structural design should provide for easy and cost-effective repair or replacement of the roof. Contractor shall expect to remove and replace roof mounted solar systems no more than one timeduring the contract period at no expense to the County, to allow for major roofing maintenance, including installing a new roof.

E. Any roof penetrations must be designed and constructed in collaboration with the roofing professional or manufacturer responsible for the roof and roofing material warranty for the specific site, to ensure that the existing roof warranty is not invalidated by the installation of the PV system.

F. For rooftop installations where there is no parapet or the parapet is less than 42", a 6' safety zone from the roof edge to the PV system must be maintained. A 3' clear path of travel must be maintained to and around all rooftop equipment.

2.4 - LIGHTING REQIREMENTS

A. The Contractor will be responsible to carefully remove and return to County any light standards that conflict with PV parking canopy / trellis systems. During the term of the agreement, the Contractor must install and maintain a lighting system that provides a minimum of 5 foot-candles on the pavement under the canopy / trellis and a minimum of 1 foot-candle on pavement outside the canopy / trellis footprint.

2.5 - OPERATION AND MAINTENANCE

A. The Contractor will be responsible for the operation and all maintenance of the solar PV system at the Contractor's own cost. The Contractor shall operate and maintain the solar system so as not to disrupt the operation of the facility per the Contract.

B. The Contractor shall provide notification to the County as early as practical, but in no event less than five days, prior to any planned maintenance and repairs. The Contractor will provide a minimum of ten days notification to the County if any planned repairs or maintenance that will result in any disruption to campus electrical load.

C. The County will use reasonable efforts to maintain the facilities in good condition and repair so as to be able to receive and utilize the solar electricity supplied by the proposed project.

D. All parking canopy PV systems shall include night lighting as part of the design. The amount of lighting required will be in accordance with the County design guidelines.

E. As part of the acceptance of the solar PV system the Contractor shall instruct and provide operations manuals on how to shut down the solar PV system in the event of an emergency. The Contractor shall insure that campus emergency first responders can easily identify what to do in the event of an emergency and able to perform these tasks quickly and safely.